Design principles to create an enabling game-based learning environment for the development of 21st century skills

by

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PHILOSOPHIAE DOCTOR

in the Faculty of Education

at the

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Supervisor: Prof Linda van Ryneveld

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Declaration

I declare that the dissertation/thesis, which I hereby submit for the degree PHILOSOPHIAE DOCTOR in the faculty of Education at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

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Anna Sophia Robberts

29 November 2019

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Ethics statement

The author, whose name appears on the title page of this thesis, has obtained, for the research described in this work, the applicable research ethics approval. The author declares that she has observed the ethical standards required in terms of the University of Pretoria's *Code of ethics for researchers and the Policy guidelines for responsible research*.

Dedication

I dedicate this research to all of my loved ones, you inspire me.

Acknowledgements

Today I feel humbled and do not have enough words to express my gratitude to everybody that contributed and supported me during this project. Without the help of everybody and especially the people that I mention below, I would not have achieved this milestone in my life.

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Abstract

Learning environments that intrigue the Generation Z learner while transferring communication, collaboration, creativity and critical thinking skills are what is needed to prepare this generation for the challenges that they are going to face in the 21st century. This research focuses on design principles that would help educators and students in designing (and co-designing) game-based learning environments conducive to not only transferring content knowledge, but also of the most applauded skills that new graduates are compelled to possess. Employers agree that the students do not have what it takes to be successful in the 21st century workplace. Especially in South African context, the focus of higher education institutions can therefore not only be on content delivery, but has to also be on the development of the 4Cs, communication, collaborations, creativity and critical thinking.

The research was conducted at the University of Pretoria where an existing reality game, The Amazing Race, was adapted and re-conceptualised for educational purposes. The overarching search for design principles that could be beneficial in the implementation of a game-based learning environment was guided by an investigation of the elements of the game implemented, the characteristics of games and finally the opportunities afforded to develop the 4Cs. The freshman engineering students' experiences are discussed using the students' own voices, and the design principles that surfaced are discussed. It seems as if there are distinct principles that could ease the efforts of practitioners in the implementation of similar learning environments. Further research is needed to refine the principles to other learning environments.

Key Terms:

Game-based learning environments, design principles, 21st century skills, ill-prepared, Amazing Race.

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TO WHOM IT MAY CONCERN

This is to confirm that the thesis titled "Design principles to create an enabling game-based learning environment for the development of 21st-century skills" by Anna Sophia Robberts has been proof read and edited by me for language usage.

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Kind regards

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List of abbreviations

ABET	Accreditation Board for Engineering and Technology (USA)
AMA	American Management Association
ARCS	Attention, Relevance, Confidence, and Satisfaction
ASEE	American Society of Engineering Education
CCFOs	Critical Cross-field Education and Training Outcomes
DEST	Department of Education, Science and Training (Australia)
DET	Department of Education and Training
DHET	Department of Higher Education and Training
ECSA	Engineering Council of South Africa
GBL	Game-Based Learning
MTSF	Medium Term Strategic Framework
NCREL	North Central Regional Educational Laboratory
OECD	Organisation for Economic Co-operation and Development
P21	Partnership for 21st century Skills
PBL	Problem Based Learning
RSA	Republic of South Africa
SAQA	South African Qualifications Authority
TUEE	Transforming Undergraduate Engineering Education
USA	United States of America

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1. CHAPTER ONE: GENERAL ORIENTATION

1.1 INTRODUCTION

We live in an ever-changing world. The structure of the workplace as we know it is not immune to the changes that we experience every day. Climate change, automation, generational differences, and societal changes are only a few of the challenges faced by the industry in the 21st century. Bakhshi, Downing, Osborne and Schneider (2017) identified seven key diverse and interactive technological and non-technological sources that reconfigure the workplace: increasing inequality, political uncertainty, technological change, demographic change, globalisation, environmental sustainability and urbanisation.

A flurry of research and numerous reports signalled attempts to outline the new working environment. The skills and knowledge required to succeed in this new landscape differ from those needed by previous generations. If we only consider the changes afforded by the use of computers especially with regard to the automation of numerous tasks, it becomes evident that "what makes us human is what will make us employable" (Deegan & Martin, 2018, p. 7). Frey and Osborne (2017) state that "for workers to win the race; however, they will have to acquire creative and social skills" (p. 269).

The challenges of an ever-evolving workplace have a ripple effect forcing higher education institutes to carefully reconsider the tuition offered to ultimately deliver graduates that will satisfy the needs of the 21st century workplace. Deegan and Martin (2018) call this wave of postsecondary education reform, demand-driven education. They point out that during the first wave, the emphasis fell on access to postsecondary education, whereas the second wave centred on the academic success of the students (Deegan & Martin, 2018). Demand-driven education implies that the students need to be competent not only with regard to the content knowledge but also with regard to the workplace in the 21st century.

New York Times columnist and best-selling author Thomas Friedman, talks about the "Flat world" where people are more connected globally as never before.

Interpersonal communication and connectedness are but only two of the attributes needed to be successful in this scenario (Friedman, 2006). Numerous studies looked into the attributes that students need to be successful in their studies and also in the workplace (Clarke, 2018; Jääskelä, Nykänen, & Tynjälä, 2018).

In the context of the engineering profession, it is said that higher education institutes prepare their engineering graduates for the object world and not for the social processes (such as discussion, negotiation, knowledge exchange, integration, and consensus-building) that form an integral part of the design phase of any project (Bucciarelli & Kuhn, 2018). In some cases, stakeholders offered advice regarding the focus of educational programs; it should aim to develop critical thinking skills, to optimise the students' communication skills, and to foster the ability to apply fundamental knowledge in the everyday tasks that they encounter (Wyman, 2018).

Dismay regarding the ability of new graduates to cope in the workplace is voiced publicly (Berr, 2016; Early Stage Careers, 2018; Wood, 2018). Multiple sources claim that colleges are not delivering critical thinkers (Arum & Roksa, 2011; Erikson & Erikson, 2018; McCarter, 2019) even though it is said that the principal aim of undergraduate education is to teach students to think critically (Wyman, 2018).

Career readiness is an all-inclusive term that is not easy to define. Tony Wagner called the attributes needed to succeed in the 21st century workplace "survival skills" (Wagner, 2008). The seven attributes that he identified correspond with research done by numerous other organisations such as the North Central Regional Educational Laboratory (NCREL) and Metiri Group (2003) and the Partnership of 21st century learning (NCREL and Metri Group, 2015, p.21). The fact of the matter is that Higher Education Institutions face the challenge of not only delivering students that are experts in their study fields but that are also able to navigate the 21st century workplace, the "flat world" in the words of Friedman (2006).

In the South African context, Professor Tawana Kupe, as the new Vice-Chancellor and Principal of the University of Pretoria, stressed the role of higher education institutes in his statement of intent, by saying that:

> *Universities have a responsibility to develop educated, well-informed and professionally skilled people who can address local and global challenges and contribute towards creating successful and thriving societies.* (University of Pretoria, 2018a, para 7)

There are growing appeals for new pedagogies that would aid in preparing our graduates to be job-ready (Deegan & Martin, 2018; Duderstadt, 2009; Thompson, et al., 2018). A challenging problem that arises in this domain is the fact that lecturers have limited contact time with the students. Lecturers do not only have to deliver content that stems from an already overloaded curriculum but now also have to teach the so-called "soft skills" needed to be successful in the 21st century workplace. To teach "soft skills" is easier said than done. Friedman stated in this regard:

> *That said, I am not sure how you teach that as part of a classroom curriculum, but someone had better figure it out.*
> (Friedman, 2006, p. 106)

The problem is even further exuberated by the fact that many institutions accept students who are not adequately prepared for higher education into their study programs (Butrymowicz, 2017). In South Africa, the problem of ill-prepared students dominates the educational arena. Socio-economic factors coupled with historical factors (Kraak, et al., 2013) and an educational schooling system that fails the majority of the learners (Griesel & Parker, 2009; Spaull, 2013), forced institutions to develop special degree programs engineered for underprepared South African students (Department of Higher Education and Training [DHET], 2012). These foundational programs were designed to accommodate students that would under normal circumstances not have been accepted into higher education studies. One of these programs is the ENGAGE program at the University of Pretoria. This program provides a five-year engineering degree option for students that do not qualify for admission to the regular four-year engineering degree study (Grayson, 2010).

Another well-known problem with the structure of the tuition offered at higher education institutes is that it does not take into account the demographic cohort of the students. Generation Z students have distinct tastes for how they want to be taught. Keeping in mind that they can find anything they want to know instantly (Seemiller & Grace, 2017), learning environments need to be crafted to provide hands-on activities where students are actively engaged in their learning process (Hussin, 2018). Generation Z students crave out-of-class learning environments in which they could actively collaborate and see different approaches and solutions in action (Kozinsky, 2017; Seemiller & Grace, 2017). All things considered, they still need more guidance, especially with regards to soft skills since they arrive at campus less seasoned than other generations (Pousson & Myers, 2018; Selingo, 2018).

1.2 PROBLEM STATEMENT

Higher education institutes are in the business of delivering graduates that satisfy the needs of the industry. The problem faced by these institutions could be described in three phases. On the input side, ill-prepared generation Z students enter higher education. The expected outcome of tuition is job-fit students, not only subject experts but also graduates who are well-schooled in the competencies needed to be successful in the 21st century workplace. The process followed to lead the students in the system to proficiency poses another problem and the processes followed in the attempt to realise the expectations of industry are of importance in this study. Lecturers face not only the challenge of an already overloaded curriculum but also the expectations of the industry, coupled with ill-prepared Generation Z students.

1.3 AIMS OF THE RESEARCH

It is of interest to know whether there are specific design principles that could be followed in the design of an enabling learning environment. The overarching aim of the study is, therefore to establish the specific design principles that influence the successful implementation of any game-based learning environment. For this purpose, I first wanted to establish the suitability of a game-based environment in an academic higher education scenario. Second, I wanted to know if a game can be modified to serve an educational purpose, while at the same time still have the benefits of student engagement posed by a game environment. And finally, I wanted to investigate the influence of the game-based learning environment on the exposure and attainment of the 4Cs, namely communication, collaboration, critical thinking, and creativity.

1.4 PURPOSE OF THE RESEARCH

The research was conducted to find specific design principles that could be followed in the design of an enabling learning environment. I wanted to investigate how to enhance any game-based learning environment specifically developed to expose students to opportunities to attain and develop communication, collaboration, creativity and critical thinking skills.

The learning environment and its influence on the students were explored and evaluated to shed light on the research problems and to recommend good practices in designing enabling learning environments for generation Z students. This research generated new insight into the design of enabling learning environments and specifically into the use of existing games in an academic arena. Prensky (2007) notes that students learn by questioning phenomena, by exploring different solutions, by constructing their own knowledge collaboratively and most of all, through having fun. The insights gained from the research study is therefore valuable in any educational context, and it could empower other individuals to change their approach to the content delivery in their study fields. These design principles have the potential to solve contemporary problems in every educational setting.

1.5 RESEARCH QUESTIONS UNDER INVESTIGATION

This thesis reports on the principles that could be employed to design an enabling game-based learning environment in higher education. The questions that led the inquiry in this research study were:

> *Which design principles can be used to create a game-based learning environment in higher education that promotes the development of communication, collaboration, creativity and critical thinking skills in ill-prepared students?*

1. *How can an existing game be adapted to suit an academic purpose in a higher educational environment?*
2. *To what extent are the characteristics of games still present, once an existing game has been adapted to serve an academic purpose?*
3. *To what extent does a game-based learning environment provide the opportunity for the development of the 4Cs (21^{st} century skills)?*

The key constructs that will receive attention among the wide variety of information provided in the discussions in the thesis are listed in Table 1. These questions and constructs will be the focus of the discussions in the thesis and will limit and delimit the research project.

Table 1: Research questions and Key constructs

Research Question	Construct	Chapter

How can a game such as The Amazing Race be adapted to suit an academic purpose in a higher educational environment?	• Design of the learning environment
	• Elements of the Amazing Race game
	  ○ Destinations in the game
	  ○ Clues
	  ○ Roadblocks
		4

To what extent are the characteristics of games still present once a game has been adapted to serve an academic purpose?	**Game characteristics** • Fun for enjoyment and pleasure • Form of play for intense and passionate involvement • Rules for structure • Goals for motivation • Interactive for doing • Adaptive for flow • Outcomes and feedback for learning • Win states for ego gratification • Conflict/competition/challenge/opposition for adrenaline • Problem-solving for creativity • Interaction for social groups • Representation and story for emotion (Prensky, 2001b)	5
To what extent does a game-based learning environment provide the opportunity for the development of the 4Cs (21st century skills)?	• Communication • Collaboration • Critical Thinking • Creativity	6

1.6 VALUE OF THE RESEARCH

The research is conducted to find design principles for the development of a game-based learning environment that promotes the development of communication, collaboration, creativity and critical thinking skills. Romero, Usart, and Ott (2015) already looked into the influence of serious games on the development of 21st century skills and proposed the investigation of the influence of entertainment games on 21st century skills. It would therefore be of interest to illustrate that it is possible to adapt an existing entertainment game to a learning environment conducive to the development of 21st century skills and for content mastery. In addition, I wanted to see whether there are certain design principles that, if implemented, could help in the seamless execution of the learning environment.

An existing game is changed to suit an academic purpose. I aim to provide a detailed description of the process followed and of the logistical challenges that surfaced during the first three years. It could potentially streamline the course of action followed by other lecturers during the adaptation of any existing game for educational purposes.

In the South African context, an important factor to consider in the design of any learning environment is the differences in the levels of competencies of the students. I needed an environment that would level the playfield and ensure student engagement. If the chosen learning environment proves to be beneficial to all of the students and the students still experience it as a game, the adaptation of an existing game could be a valuable addition to the educators' toolkit.

Learning environments that further the 21st century skills and at the same time provide opportunities to deliver subject-specific content are much sought after in the educational arena. The influence of the learning environment on the development of communication, collaboration, creativity and critical thinking forms part of the investigation launched during this research project. The discussion of the drive behind the inclusion of certain activities and the student responses could potentially sensitise lecturers to similar problems that they face in their classes and could inspire them to address these in a playful but memorable manner.

1.7 RESEARCH DESIGN AND APPROACH

A qualitative and interpretivist stance was used in the approach to this study. This approach afforded me the opportunity to use a variety of data sources (Denzin & Lincoln, 2000) and as such enabled me to provide a rich description of the scenario at hand (Creswell, 2013). The main objective of the study was to find design principles that could be used to create a game-based learning environment that promotes the development of communication, collaboration, creativity and critical thinking skills in ill-prepared students. Three sub-questions were employed to explore the scenario: the process followed during the adaptation of the game, the presence of the characteristics of games (Prensky, 2001b) and the influence of the game on the attainment of the intended learning outcomes. The qualitative interpretive stance provides the opportunity to understand the phenomena through the meanings that all of the stakeholders assigned to them (Merriam & Tisdell, 2016).

The inquiry into the learning environment consists of two stages. The design of the learning environment is initially treated as an action research project as defined by McNiff and Whitehead (2010) and described over three years. Changes were employed to improve the implementation and execution of the game and enhance the influence of the learning environment on the attainment of the learning outcomes. The resultant learning environment could provide rich data regarding the research questions. During this time, I realised that the principles discovered in the process of constantly adapting the learning environment could be of value in many other contexts as well. Therefore, in 2018, I changed the approach to the study from action research to a fully fletched design experiment (Colb, Confrey, DiSessa, Lehrer, & Schauble, 2003, McKenney & Reeves, 2014).

A cross-sectional case study (Longhofer, Floersch, & Hartmann, 2017; Merriam & Tisdell, 2016), *The Amazing Race*, was employed in 2018 to look into the suitability of a game-based environment for academic purposes in a higher education environment. The case study was the first step in the design experiment. The data garnered could shed light on the student experiences of the game and aid in the evaluation of the influence of the learning environment on the acquisition of communication, collaboration, critical thinking and creativity skills. Since I wanted to understand the interplay of different elements in the learning environment, a qualitative interpretive stance (Denzin & Lincoln, 2000; Janesick, 2000; Merriam & Tisdell, 2016) will suffice.

1.8 TARGET POPULATION AND SAMPLING

Since I have used a case study to answer the research question, two levels of sampling were needed (Denzin & Lincoln, 2000). First, I had to identify the case, the specific learning environment that I wanted to investigate in terms of the research question, and then the student cohort that would participate in the learning environment.

1.8.1 Population

All of the learning environments that constitute the curriculum of Professional Orientation were considered before the specific case of “the Amazing Race” learning environment was chosen.

The first-year engineering students of 2018 at the University of Pretoria acted as the population from which the sample has been chosen. All of the students that were enrolled for Professional Orientation in 2018 acted as the sample of the study. Furthermore, tutors, the lecturing team and an assistant lecturer that formed part of the teaching team in 2018 were also included in the sample. The population could be described as a research group of convenience but for the purpose of this study was referred to as the population and sample.

1.8.2 Sampling

Since the case study of the Amazing Race was specifically chosen based on the suitability thereof to shed light on the research questions at hand, it resonates under purposeful sampling (Patton, 2015). It was specifically designed to expose students to the 4Cs and as such, could be seen as the best choice to establish the design principles followed in the design of a learning environment. The students were not necessarily the best cohort of students to ascertain the value of the environment; therefore the sampling methodology followed was convenient (Salkind, 2010).

1.9 DATA COLLECTION

Data for the research was obtained from observations and informal reflective discussions, reflective essays, surveys and a focus group interview with some of the stakeholders.

1.9.1 Observations and informal reflective discussions

I wanted to design a game-based learning environment and investigate the appropriate design principles presented during the process of renewal and change in the different iterations of the activity. The influence of this environment on the students with regards to the attainment of specific soft skills was also under scrutiny.

As such, my observations provided useful information in the first place regarding the design of the learning environment during the first three iterations of the activity and then secondly in terms of student experiences during and after the Amazing Race. I acted as a participant-observer in the research setting (Maree, 2007) and had first-hand information that enabled me to develop an understanding of the scenario at hand (Glesne, 2006). Descriptive and reflective field notes garnered by multiple observations over three years allowed for a better understanding of the scenario and insight into the experiences of the individuals (Creswell, 2008).

The informal reflective discussions with other stakeholders also provided insightful information that could be employed to enhance the process of designing the activity and pinpointing the design principles that could be followed in structuring a game-based learning environment.

1.9.2 Reflective essays

The students had to write a reflective essay after the Amazing Race activity since it reinforces learning, especially in competency-based modules (Berdrow & Evers, 2011). By reflecting on experiences, students have to articulate the intuitive knowledge gained during the activities in which they were involved (Hetton & Smith, 1994). In these reflections, written only one month after they had participated in the learning environment, students had to reflect on “what happened?”, “so what?” and “now what?” (Reed & Koliba, 1995). These reflective essays provided useful information regarding the students’ experiences during the Amazing Race activity.

1.9.3 Surveys

Surveys, that is, structured questionnaires (Lavrakas, 2008), provide useful demographic information regarding the sample (Collins, Joseph, & Bielaczyc, 2004) and could be used to interpret a set of circumstances (Kothari, 2004). Students enrolled for Professional Orientation had to complete two surveys during the first semester. The first survey provided useful demographic data and data regarding the students' IT proficiency levels. This data can be useful for the description of the sample. Students could reflect on their experiences in their different modules by completing the second survey at the end of the semester. As such, student comments regarding the learning environments encountered in Professional Orientation might be of value.

1.9.4 Focus group interview

Morgan and Hoffman (2018) stated that focus group interviews provide the forum whereby different perspectives and experiences could be uncovered while the interviewees are interacting with each other and with the interviewer. The focus group interview with the tutors and the assistant lecturer involved in the module in 2018 were conducted to gather more insight into the principles that constituted a successful game-based learning environment and to gain further insight into the student experiences of a game-based learning environment.

1.10 **DATA ANALYSIS**

The data collected by means of the observations and informal reflective discussions, reflective essays, focus group interviews, and the surveys was organised in a case study database (Creswell, 2007). The case study database consists of field notes, transcribed interviews, documents and data obtained by the two surveys. All of these data sources were perused repeatedly to develop an understanding of the data as a whole. The data was analysed according to different categories (Onwuegbuzie, Dickinson, & Leech, 2009) that were derived based on the research questions and the information revealed by each of the data sources. After integrating the data obtained by the different data sources, it was summarised into the different categories that crystallised during the research process (Patton, 2015). At this stage, I could evaluate the data, considering the interdependence of the whole and the parts, and compare it with information gained during the review of the literature. This process resulted in answers to the research questions, and I could voice my findings and recommendations based on the data analysis process.

1.11 METHODS TAKEN TO ENSURE VALIDITY AND RELIABILITY

The validity and reliability in qualitative research according to Merriam and Tisdell (2016), depend on the ethical manner in which the research was conducted. The conceptualisation of the study, the procedures followed during data collection, the integrity displayed in the analysis and interpretation of the data and the presentation of the findings are aspects of interest in the evaluation of the validity and reliability of a research project (Merriam & Tisdell, 2016).

1.11.1 Sampling

The sample was chosen based on the light that it could shed on the research questions at hand (Patton, 2015). Maxwell (2002, p. 13) cautioned that a researcher should take special care in the choice of a sample "to make sure one has adequately understood the variation in the phenomena of interest in the setting, and to test developing ideas about that setting by selecting phenomena that are crucial to the validity of those ideas".

The sampling process started with the sampling of the specific case, a game-based learning environment. The Amazing Race learning environment was a typical game-based learning environment where an existing game was adapted to suit an academic purpose. This could be typified as purposeful sampling since it was the best choice to aid in the identification of the design principles imperative for a successful learning environment (Merriam & Tisdell, 2016). The participants, the lecturing team, tutors and students selected as a result of the purposeful sample could further the understanding of the scenario in its totality.

1.11.2 Literature

The subject under research was investigated by using a wide range of newly published books, seminal sources, journal articles and other sources of information based on the relevance to the study at hand. I have used the information garnered responsibly, not manipulating the information, and awarded recognition to the authors of the literature in the thesis. In some instances, the actual words of an author were used to accentuate the point made; special care was taken to ensure that these quotes were recorded correctly. I was attentive not to plagiarise, and a comprehensive list of all of the references used was compiled.

1.11.3 Data collection

The data was collected as described above. I have reviewed the consent forms completed by the students to ensure that I could use all of the data obtained by their responses. The interview questions were aimed at uncovering the data needed to answer the research questions. The transcript of the interview was checked to ensure its accuracy after the quality of the data obtained from the interview was reviewed.

1.11.4 Analysis of data

The data obtained during the research process can be authenticated by comparing it with findings in the literature and by personal experience. I have used a technique suitable for the analysis of qualitative data to analyse the data gathered to answer the research questions. To further promote the validity and reliability of the research, I have provided a “rich thick description” to ensure that the reader would be able to relate to my findings (Merriam & Tisdell, 2016). In this way, the transferability of the scenario and the applicability of the findings to the readers' contexts would be easily visible.

1.12 DELIMITATIONS

This study was conducted at the University of Pretoria, a contact university in an engineering study field in South Africa. It would, therefore, focus on the transition of the game to the scenario at hand, the design principles that surfaced during the process and the student experiences during the activity. The purpose of the study was to identify design principles that could be used in the adaption of any game for educational purposes. The influence of a game-based environment on the exposure to the 4Cs: communication, collaboration, critical thinking, and creativity was also investigated.

The study will not include a discussion of the adaptation of an existing game to an educational scenario other than that of higher education institutes. The design principles can, however, be implemented across different institutions. Furthermore, only the adaption of existing games is under the spotlight. No online games, training games, PC and video games or other forms of interactive games are discussed in this study. The focus is on one case study, the possibility of multiple case studies is, therefore, not in the scope of this research study.

1.13 ETHICAL CONSIDERATIONS

Three basic principles should be considered in any research project: informed consent; privacy and confidentiality and protection from harm (Norton, 2018). Details regarding the research project were provided to all of the participants. The aims of the research, a description of each party's involvement and for what purpose the research is undertaken were discussed before the participants signed a consent form in which they granted permission to include their contributions. Before the focus group interview, I informed the attendees that the interview would be recorded and transcribed to ease the data analysis process. The transcription was also proofread to ensure that it was a true reflection of the scenario at hand.

Anonymity and confidentiality are two concepts used to ensure ethical conduct. According to Norton (2018), anonymity refers to the concealment of the identity of the stakeholder, whereas confidentiality refers to the right to access the data garnered from the participants in the study. I have used a coding system where codes were allocated to each participant based on the time that they have submitted their reflective essays. The class list could, therefore, not be used to identify individual contributions. The data was downloaded and kept in a database to which only my supervisor and I had access. During the execution of the game and the research process followed thereafter, special care was taken to ensure the safety and psychological, financial or social well-being of the participants. The research process was followed, paying close attention to these three ethical considerations.

1.14 RESEARCH STRUCTURE

The report was structured according to the process followed in the investigation. Each chapter describes a part of the puzzle and the chapters follow a logical sequence where a chapter is devoted to each of the research questions. The outline is as follows:

Chapter 2: Literature review

This chapter will first look into the expectations of employers and then move to a body of literature that discusses the skills needed to operate in a 21st century workplace. Different frameworks are discussed after which the skills that will guide this study will be outlined. The role of higher education institutes, the generational cohort of students and conducive learning environments receive further attention. The focus then turns to games, and their educational value and the chapter concludes with the theoretical framework of the study, a discussion of the input, process, output gaming model as proposed by Garris, Ahlers, and Driske (2002).

Chapter 3: Methodology

The study is situated in an interpretivist, qualitative paradigm. In this chapter, the paradigm used in this study is unpacked. After that, the research design followed to investigate the scenario at hand, is discussed. The focus is on important aspects regarding the method followed that includes the sampling of the first year ENGAGE students, the instruments (reflective essays, surveys, focus group interview and the observations) and the data analysis procedures. The trustworthiness of the research is discussed. The chapter concludes with a discussion of the limitations of the research project and the measures taken to ensure ethical integrity.

Chapter 4: The intervention

In this chapter, the background to the educational setting, starting with foundational programs to paint the scene in which the game had to feature, is presented. Then the transformation of the activity into a game with different destinations, clues to these stops and roadblocks are described by using actual examples and pictures of the different activities that students encountered. Finally, student voices are used to shed light on their experiences of the Amazing Race learning experience in terms of the elements mentioned above. This chapter aims to answer the first research question: *How can a game such as Amazing Race be adapted to suit an academic purpose in a higher educational environment?*

Chapter 5: Findings and recommendations

The second question that guided this inquiry: *To what extent are the characteristics of games still present once an existing game has been adapted to serve an academic purpose?* is addressed in this chapter. The twelve game characteristics that Prensky (2001b) used as a guideline in the development of digital games, was used to determine whether students still experienced that scenario and a game environment. Student comments confirmed the fact that they still experienced the educational setting as a game.

Chapter 6: Amazing Race as a platform to develop the 4Cs

There is a clear advantage of following a game-based approach in any learning environment. This chapter brings the reader up-to-date with what was ascertained during the research. The focus is especially on the value of the environment through students' eyes in terms of the exposure to the 4Cs. I just remind the reader that the students were not asked to reflect on the activity in terms of the development of their communication, collaboration, critical thinking, and creativity. The comments used to elaborate on the influence of the environment on the attainment of these skills were spontaneous reactions in their responses to the value of the destinations, clues, and roadblocks. As such, I see them as extremely valuable to answer the third research question: *To what extent does a game-based learning environment provide the opportunity for the development of the 4Cs (21st century skills)?* This chapter concludes with a discussion of the design principles that surfaced during the inquiry.

Chapter 7: Findings and recommendations

This chapter summarises the research findings and includes a methodological, substantive and scientific reflection on the process followed during the research journey. Recommendations for further research into similar learning environments are discussed before the study concluded with the design principles that surfaced during the enquiry and a few final remarks.

2. CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

"Our students have changed radically. Today's students are no longer the people our educational system was designed to teach" (Prensky, 2001a, p. 1). The problem according to Prensky (2001c), is that our learners, the "Digital Natives" of the age of computers, video games and the Internet, are taught by "Digital Immigrant": educational practitioners. Although lecturers, some with more rigour than others, constantly upgrade their knowledge especially with regards to the use of technology and teaching methods, the digital immigrant accent and pre-digital age mannerisms often still obstruct the transfer of knowledge and skills in the learning environment (Prensky, 2001a). In other words, our students, 21st century natives, do not learn like we used to learn, they do not appreciate the "step-by-step", logical presentation of content in a formal classroom setting that we as instructors were trained to deliver. Also, as employees, they display characteristics unfamiliar to the traditional workplace and, as such, are perceived as being under-prepared for the needs of the 21st century industry.

Engineers are typically pioneers in a dynamic, ever-changing, competitive working environment. As such, they have to be equipped with skills that enable them to meet international demands and be at the forefront of new developments and fast-changing products and processes. Apart from the technical expertise needed to be successful, engineers also have to be competent team players in a workplace that often require participative management (United States [US] National Academy of Engineering, 2004).

It is becoming increasingly difficult to ignore the disparity between learning environments, the needs of students, and the expectations of the ever-evolving workplace. With this study, the researcher explores learning environments conducive to the development of the skills needed to be successful as an engineering student, and eventually, as a University graduate. As such, the demand for learning environments that appeal to 21st century students, and prepare students to meet the expectations of employers, necessitates an investigation into the employability skills (21st century skills or graduate attributes), the characteristics of the "Digital Native" (our students), supportive learning environments and finally, game-based learning.

2.2 EMPLOYABILITY

Due to multiple economic challenges and globalisation, there is a need for newly appointed engineering graduates to demonstrate quality, commitment, and comprehensive knowledge of the field. Employers appear to expect that newly appointed engineers contribute from their first day in their new work environment (Zaharim, Yosoff, Omar, & Muhamad, 2009). Employers assume that new graduates will be "work ready", that they can play a productive role in achieving the organisation's objectives based on their knowledge, skills, attitudes and commercial understanding of the workplace (Mason, Williams, & Cranmer, 2009). The pace of technological development changes the economic and social environment and gives rise to the need for a workforce that displays the so-called 21st century skills (Voogt & Roblin, 2010). These skills "cut horizontally across all industries and vertically across all jobs from entry-level to chief executive officer" (Sherer & Eadie, 1987, p. 16).

There seems to be a short supply of the skills needed to be successful in an engineering environment. Headlines such as the following voice the employers' quest for "job-fit" engineering graduates.

> *"Many graduates lack the essential skills required to get by in the workplace" (Dathan, 2013, para. 1).*
>
> *"…inadequate skill levels & poor work readiness…" (DHET, 2013, p. 19) and*
>
> *"Only 7 per cent engineering graduates are employable: What's wrong with India's engineers?" (Chakrabarty, 2016, para. 1).*

Katie Bardaro, vice president of data analytics at PayScale elaborated by saying that:

> *"The data we've collected show that even though their education may make recent college graduates feel prepared to enter the workforce, only half of hiring managers agree with them; managers feel crucial skills in recent graduates are frequently lacking or absent."* (Berr, 2016, p. para 4)

Another study has shown that graduates lack the "soft skills" such as emotional intelligence, complex reasoning, and collaboration skills such as the ability to negotiate with other team members and to persuade them of your opinion (Wood, 2018). The ManpowerGroup (2016) found in surveys completed by employers globally that 40% of employers experience difficulty in finding suitable candidates for the positions that they advertise as companies.

The industry's expectation that higher education institutions will deliver engineering graduates that play a productive role from the first day of their employment (Case, 2011), compels a search into the skills that new graduates need to be labelled as being employable.

2.2.1 Employer expectations

Job skill demands have changed. This could be the result of numerous dynamic factors that influence everyday life. Bakhshi et al. (2017) outline seven key sources of change that reconfigure the workplace. Climate change, automation, globalisation, generational differences, urbanisation, inequality and societal changes are only a few of the challenges faced by the industry in the 21st century. Computers replace workers that perform cognitive and manual tasks where explicit rules regulate the actions taken by the workers (Autor, Levy, & Murnane, 2003). Individuals are employable because of non-cognitive skills such as social and leadership skills (Bakhshi et al., 2017), creativity (Frey & Osborne, 2017), non-routine problem-solving and the ability to communicate effectively (Autor et al., 2003).

A flurry of research (Mathews & McKay, 2003; Osmani, et al., 2015; Saad & Majid, 2014; Tong, 2003; Zaharim et al., 2009) concerning the expectations of employers revealed noticeable similarities between the expected attributes for employability. The results of a survey on employer expectations in Australasia revealed that the esteemed skill attributes are the ability of new graduates to communicate effectively, to plan their activities, manage people, work effectively in a team, solve problems and do cost control (Mathews & McKay, 2003). The outcome of this survey is confirmed by data obtained by a survey regarding the most sought after "skill attributes" in Malaysia (Tong, 2003). Added to these skills are lifelong learning, the application of basic knowledge and the cognisance of professional, social and ethical obligations (Zaharim et al., 2009). Osmani et al. (2015), after an extensive literature review of employability, agreed that the qualities that new graduates should display to satisfy the needs of the market and industry generally include "communication, teamwork, problem-solving, technological skills, creativity, interpersonal skills, leadership skills, self-management and flexibility/adaptability" (Osmani, et al., 2015, p. 376). Similarly, De Castro, Penda, Dolot, Laguador, and Dotong (2016) found that employers of computer engineering graduates in an Asian academic institution value newly appointees that take the initiative to complete tasks in a reasonable time, display the ability to think critically and analytically and are able to present their findings effectively.

A large and growing body of literature has investigated the skills and graduate attributes needed in the industry. Already in 1963, the Robbins report highlighted that higher education institutions should supply "instructions of skills suitable to play a part in the general division of labour" (Robbins, Lord, 1963, p. 6). In the United States of America, the Secretary of Labour appointed the Secretary's Commission on Achieving Necessary Skills (SCANS) to identify employability skills and to provide support and guidance with the implementation of special measures to enhance these skills (United States [U.S.] Department of Labor, 1991). The SCANS report emphasised five competencies that rest on the foundation that encompasses three parts: “Basic skills (reading, writing, mathematics, listening and speaking), Thinking skills (creative thinking, making decisions, solving problems, seeing things in the mind’s eye, knowing how to learn, and reasoning) and personal qualities (Individual responsibility as well as self-esteem, sociability, self-management, and integrity)” (U. S. Department of Labor, 1991, p.13). The following competencies were highlighted:

- “Identifies, organises, plans and allocates resources;
- Work with others;
- Acquires and uses information;
- Understands complex inter-relationships;
- Works with a variety of technologies”.
  (U. S. Department of Labor, 1991, p.11).

In the same fashion the Australian Chamber of Commerce and Industry, in collaboration with the Business Council of Australia, specified in a report for the Department of Education, Science and Training (DEST) that students should reflect the ability to communicate, manage themselves by planning and organising their activities, be effective team players that display initiative and enterprise, use technology and be a life-long learner in order to be employable (Department of Education, Science and Training [DEST], 2000).

In South African context, the South African Qualifications Authority (SAQA) identifies seven Critical Cross-field Education and Training Outcomes (CCFOs) as guidance for student development, regardless of the specific study field followed by the student (South African Qualifications Authority [SAQA], 2000).

- “Identify and solve problems in which responses demonstrate that responsible decisions using critical and creative thinking have been made.
- Work effectively with others as a member of a team, group, organisation, community.
- Organise and manage oneself and one's activities responsibly and effectively.
- Collect, analyse, organise and critically evaluate information.

- Communicate effectively using visual, mathematical and/or language skills in the modes of oral and/or written presentation.
- Use science and technology effectively and critically, showing responsibility towards the environment and health of others.
- Demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation" (SAQA, 2000, p. 18).

The emergence of Information Computer Technology in the 21st century changed the working environment and consequently, the skills needed to be successful as a student and also as an employee (Dede, 2010). Levy and Murnane (2004) summarised these competencies needed to be successful in the 21st century workplace by stating that students have to be able to perform tasks that computers cannot do. They have to think critically (leaning on their prior knowledge) to be able to recognise emerging patterns; they have to be adept to change their strategy in the problem-solving process based on the scenario; they not only need to interpret and use the information received verbally and non-verbally, but they also have to respond instantaneously in a volatile environment (Levy & Murnane, 2004).

It is evident from the studies and the outcomes specified by numerous organisations that the term "employability" encapsulates not only the cognitive knowledge and technical skills needed to survive in the workplace but also "tasks that computers cannot do". Professional councils further delineated competencies needed in specific study fields.

2.2.2 Professional Councils

In the USA, the American Society of Engineering Education (ASEE) has, since its founding in 1893, continually studied engineering education with the focus on the professional development of engineering students (Ernst, 1996). The quest for engineering graduates who satisfy the demands of the 21st century industry once again compelled the American Society of Engineering Education (ASEE) to launch a project called Transforming Undergraduate Engineering Education (TUEE). The objectives of TUEE were to establish the relevant qualities required by engineering graduates and to foster new approaches to engineering education, especially in terms of curriculum development and academic culture, to impress these qualities upon engineering students (Agrawal & Harrington-Hurd, 2016). After a two-day workshop (where industry perspectives were also integrated) the following attributes were documented as important for all engineering graduates: "good communication skills, persistence, curious learning capability, drive and motivation, economics and business acumen, high ethical standards, critical thinking, and willingness to take calculated risks" (2016, p. 12).

The Engineering Council of South Africa (ECSA) similarly specified 11 exit level outcomes for engineering graduates. These exit level outcomes are in line with specifications of the Washington Accord for accreditation (Engineering Council of South Africa [ECSA], 2017) The ECSA outcomes are focussed on the role of the individual in the execution of engineering projects and problem-solving. Engineers need to:

- "Communicate effectively, both orally and in writing, within an engineering context;
- Demonstrate knowledge and understanding of engineering management principles and apply these to one's own work, as a member or leader in a diverse team and to manage projects;
- Apply engineering principles to systematically diagnose and solve well-defined engineering problems;
- Apply knowledge of mathematics, natural science and engineering sciences to defined and applied engineering procedures, processes, systems and methodologies to solve well-defined engineering problems;
- Conduct investigations of well-defined problems through locating and searching relevant codes and catalogues, conducting standard tests, experiments and measurements;
- Use appropriate techniques, resources, and modern engineering tools, including information technology, prediction and modelling, for the solution of well-defined engineering problems, with an understanding of the limitations, restrictions, premises, assumptions and constraints;

- Demonstrate an understanding of workplace practices to solve engineering problems consistent with academic learning achieved;
- Use science and technology effectively and critically, showing responsibility towards the environment and health of others;
- Demonstrate knowledge and understanding of the impact of engineering activity on the society, economy, industrial and physical environment, and address issues by defined procedures;
- Comprehend and apply ethical principles and commit to professional ethics, responsibilities and norms of engineering practice within own limits of competence;
- Perform procedural and non-procedural design of well-defined components, systems, works, products or processes to meet desired needs normally within applicable standards, codes of practice and legislation;
- Engage in independent and life-long learning through well-developed learning skills" (ECSA, 2017, para.5).

The outcomes specified by the engineering councils concentrate on engineering practice. Engineers have to collaborate to execute projects, and as such, effective communication is an imperative attribute for engineering graduates. Creativity, in combination with critical thinking, is of the essence in the problems that engineers are confronted with. All of these skills are regarded as 21st century skills that are widely discussed in the literature.

2.2.3 Frameworks for 21st century skills

Various frameworks were developed to organise the skills deemed necessary to be successful in the 21st century. The Metiri Group and NCREL developed a 21st century skills framework focussing on Digital-Age Literacy, Inventive Thinking, Effective Communication and High Productivity (NCREL & Metiri Group, 2003). The skills listed under inventive thinking include creativity and critical thinking and communication and collaboration are categorised as effective communication. The other two categories focus on subject-specific content knowledge and self-directed conduct in the workplace. A visual presentation (People, Information, and

Communication Technologies [pICT], 2003) of this comprehensive framework is presented in Figure 1.

Figure 1: EnGauge Framework from Metiri/NCREL (adapted from pICT, 2003)

The Organisation for Economic Co-Operation and Development (OECD) defined three areas that are critical for employability: delivery related competencies, interpersonal competencies and strategic competencies (OECD, 2005). Employees need to be able to use tools and technology effectively allowing for a two-way transfer between language, symbols and text, knowledge and new information (Organisation for Economic Co-operation and Development [OECD], 2005). With regards to interacting in heterogeneous groups, the OECD (2005) denotes the ability of an individual to connect with people, collaborate successfully with others and to manage and resolve conflicts. The OECD (2005) emphasises the individual's ability to act independently, focussing on the big picture, shielding and proclaiming rights, interests, limits and needs while also be attentive on their personal development and life plans.

The framework for 21st century skills developed by the Partnership for 21st century Skills (P21), is according to Dede (2010) the most comprehensive and accepted of all the other frameworks. Three major areas of skills development are defined: Learning and Innovation Skills, Information, Media and Technology Skills, and Life and Career Skills (P21, 2015). According to P21 (2015) the 4Cs: Critical thinking and problem solving, Collaboration, Communication and Creativity and Innovation, contextual learning skills, as well as information and media literacy skills are necessary learning and innovation skills needed in a multifaceted 21st century environment. Information, Media and ITC literacy skills are required to successfully manage the abundance of information available everywhere. It is also important to develop students into lifelong learners, especially about the rapid development of technology tools. The following life and career skills: Flexibility and Adaptability, Initiative and Self Direction, Social and Cross-Cultural Skills, Productivity and Accountability and Leadership and Responsibility (P21, 2015) have to be reflected by 21st century natives (Prensky, 2006). The 21st century skills can also be categorised in terms of foundational literacies, competencies and character qualities as illustrated in Figure 2 (Explora School for Design and Technology, 2017).

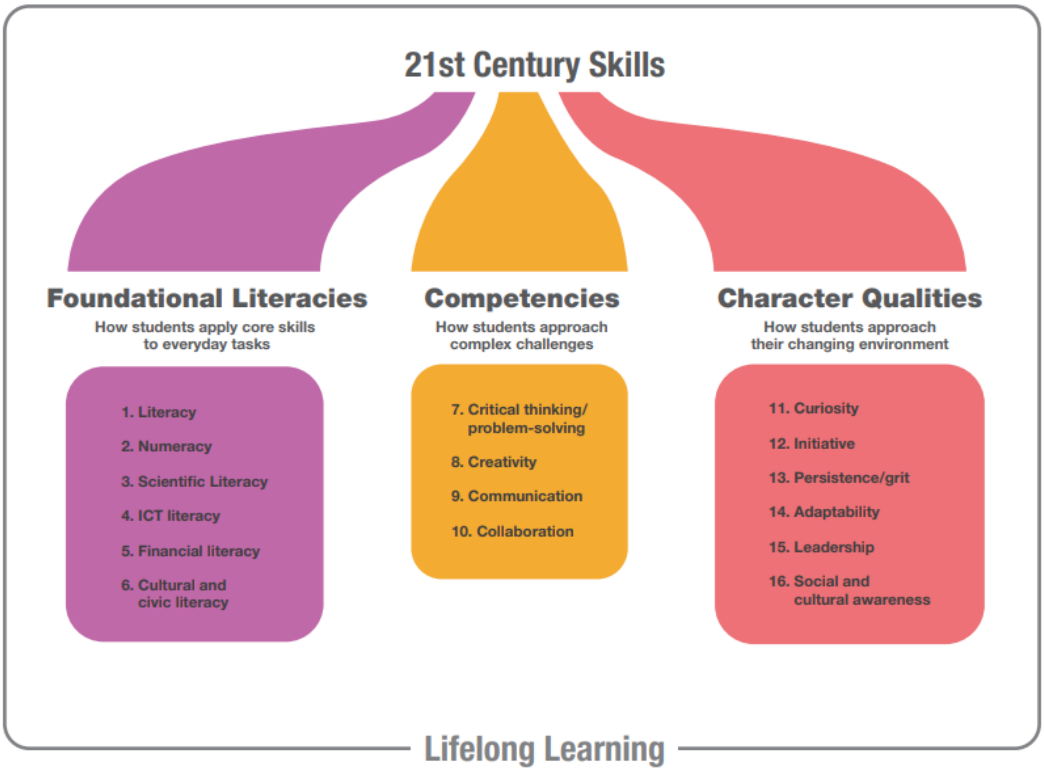

Figure 2: P21 framework (adapted from Explora School of Design and Technology, 2017)

After carefully considering the different frameworks and the body of literature in which these frameworks were discussed, it was found that proficiency in communication, teamwork, knowledge of ICT and social and cultural awareness were common attributes in all of the frameworks (Anderson, 2008; Dede, 2010; Trier, 2002). Added to these attributes are creativity, critical thinking, problem-solving and the ability to develop high-quality products (Voogt & Roblin, 2010).

The frameworks mentioned above, all provide guidance by identifying the 21st century skills needed to be successful as a student and also as a graduate in the workplace. P21 listed the competencies that students need in their approach to complex problems: communication, collaboration, creativity and critical thinking (P21, 2015). Since these attributes were present in all of the frameworks discussed and were also mentioned as key performance areas in both the CCFOs and the ECSA requirements for engineers, it will be used as crucial graduate attributes for this study. Higher education institutes are bound to deliver tuition that would instil these qualities in their students.

2.2.4 The role of higher education institutes

It is reasonable to expect that higher education, as a merchant of various competencies, would channel their efforts to deliver graduates that would fulfil the expectations of industry (Tomlinson, 2017). As Van Breda (2018, p. 1121) stated: "… higher education is in the business of developing the whole person, including all facets of their lives". But as discussed previously, the employers do not seem to be satisfied with the quality of new graduates (Kraak, et al., 2013).

The quest for higher education institutes to deliver graduates that are employable (Kode & Sutinen, 2017; Bridgstock, 2009), compels these institutions to employ special measures (Chadha, 2006) to, not only bridge the gap between secondary school and higher education but to also prioritise the development of 21^{st} century skills as required by industry (Kruss, 2002). The higher education system is bound to meet international standards regarding the acquisition of skills that prepares graduates to operate in a demanding fast-changing world (Murali & Rajaram, 2015; Pegg, Waldock, Hendy-Isaac, & Lawton, 2012).

Delivering employable graduates in South Africa is a formidable task when taking into account that South Africa is rated 146th out of 148 countries in terms of the educational system's quality (DHET, 2013). The challenges within the educational system are further convoluted by socio-economic and historical factors (Kraak, et al., 2013). As a result, ill-prepared learners enter tertiary institutes, the dropout rates are high, and the small number of skilled people emerging from these institutes does not satisfy the needs of the employers (Kraak, et al., 2013).

Surveys conducted by the Department of Higher Education South Africa revealed that employers value, amongst others, proficiency in English for effective communication and ICT skills (Griesel & Parker, 2009). Griesel and Parker (2009) furthermore elaborated on the expectations of the government and employers that the higher education sector should bridge the gap between the outcomes of an inefficient schooling system and deliver "thinking, responsive and intellectually well-grounded individuals who are flexible and can readily adapt to new demands and challenges" (Griesel & Parker, 2009, p. 5).

2.3 **EDUCATIONAL PLAYFIELD**

The question is: How can this be accomplished? How does one construct a learning environment that is conducive to the attainment of 21st century skills?

2.3.1 Students

Lecturers, teaching staff at the university level, are typically facing students who are not only diverse in terms of age, gender, ethnical, racial and religious associations, but also in terms of their academic preparedness for the tasks at hand. Furthermore, when considering the categorisation of the different generations (Consultancy.uk., 2015), they are part of the Z generation since they have been born after 1995, in the era of the social web. Singh and Dangmei (2016, p. 2) stated that they are "digital centric and technology is their identity".

Generation Z student loves image-rich and interactive learning environments (Duderstadt, 2009). Since they can find information seamlessly on the internet (Seemiller & Grace, 2017), they expect instant answers (Loveland, 2017) and similarly to Gen Y also instant gratification (Crappell, 2013). They think that they can accomplish and obtain anything they want (Wiedmer, 2015) and that they can multitask effortlessly (Giunta, 2017). And still, it is said that they lack critical thinking skills (Pousson & Myers, 2018). This generation is typified as being individualistic (Elmore, 2014); they are determined to find their own solutions (Bernstein, 2015). As a result, many of these students can be seen as self-educators (Giunta, 2017) that might not be inclined to enrol for advanced degrees because of many online alternatives (Jenkins, 2015).

It, therefore, comes as no surprise that they would challenge the traditional classroom learning process (Duderstadt, 2009) and change it to fit their personal style (Bernstein, 2015). With an attention span of 8 seconds (Elmore, 2014) and a highly non-linear approach to learning (Duderstadt, 2009), new pedagogies need to be employed to educate them, especially in a skills development environment. These students want to be challenged, actively engaged and motivated through a learning process that connects them to a different learning experience (Figueroa-Flores, 2016).

Prensky (2006) talks about the digital natives that long for learning environments that would suit their style of processing new information. Higher education institutes need to find strategies that would fulfil the needs of the new generation. At the same time it should prepare them for the challenges posed by the 21st century workplace since the students themselves are not confident that they have what it is going to take to be successful in the workplace (Early Stage Careers, 2018).

2.3.2 Learning environment

Delivering 21st century natives (consisting of Gen Z learners) that mirror the skills as proposed by the different scholars and organisations discussed earlier (Accreditation Board for Engineering and Technology [ABET], 2003; Dede, 2010; ECSA, 2017; Mathews & McKay, 2003; NCREL & Metiri Group, 2003; OECD, 2005; Osmani et al., 2015; Saad & Majid, 2014; Tong, 2003; Zaharim et al., 2009) and specifically the Partnership for 21st century Learning (P21, 2015), require an innovative, non-traditional approach to teaching.

In recent years, there has been an increasing body of literature on strategies to further student engagement and the exposure to 21st century skills (DeJarnette, 2012; Kennedy & Odell, 2014; Maas, Jochim, & Gross, 2018). One of these strategies is problem-based learning with a special focus on collaboration between students, as proposed by Voogt and Roblin (2010). Another is an all-inclusive approach where content is contextualised and active and cooperative learning strategies are employed (Shuman, Besterfield-Sacre, & McGourty, 2005). Redecker et al. (2011) state that the core of learning of the future lies in an informal, personalised learning environment in which collaboration between students and lecturers plays an integral part.

Skills development modules face the challenge of over-confident students on the one hand but also challenges with regard to the content used for instruction purposes on the other hand. As can be expected, many opposing views regarding the delivery of the attributes needed to be successful in the 21st century exist (Cranmer, 2006). Chadha (2006) distinguishes three strategies followed in skills development: embedded in the curriculum (with technical capability as focus area without directly addressing transferable skills), bolting on (transferable skills are developed autonomously) or skills are developed within the core discipline by integrating the development of transferable skills and the students' technical abilities.

All in all, any learning environment designed to further the development of 21st century skills needs to entice the digital natives, the generation Z students, in an experience that would instil or at least expose students to opportunities in which the necessary 21st century skills could be attained.

2.3.3 Motivation to engage

Generation Z students are changing the educational arena, and, therefore, strategies that motivate them to engage in learning activities need to be revised. A considerable amount of literature has been published on the value of motivated students as a precondition to meaningful learning experiences (Deci & Ryan, 1985; Malone & Lepper, 1987). The difference between extrinsic and intrinsic motivation is clearly outlined. Intrinsically motivated students do an activity because they are intrigued by it and find joy out of the activity whereas extrinsically motivated students are engaging for the sake of the prize or a desirable outcome (Deci & Ryan, 1985).

The value of students that engage in an activity “for its own sake” in the educational arena is commendable (Malone, 1981). Various characteristics of intrinsically motivating instructional environments are delineated. Deci and Ryan (1985) listed autonomy, competence, and relatedness as critical elements for intrinsically motivated students. Malone and Lepper (1987) identify challenge, fantasy, curiosity and control as common denominators to these environments. Another renowned model for motivation acknowledges Attention, Relevance, Confidence, and Satisfaction. (ARCS) in an intrinsically motivating learning environment (Keller, 1987).

Strategies to keep students engaged and motivated are widely discussed in the literature (Chang & Zhu, 2018; Cronje, 2018; Isidori, Chiva-Bartoll, Fazio, & Sandor, 2018; Johnson & Johnson, 1979; Shuman, Besterfield-Sacre, & McGourty, 2005). Cronje (2018) emphasises the use of variation and interest coupled with collaboration between students, individualisation, personalisation and a variety of open-ended assignments as productive strategies to keep students motivated and engaged. Chang and Zhu (2018) proposed a system of dividing contact sessions into phases, five (5) minutes elicit prior knowledge, 20 minutes introduce core materials, 20 minutes assessing knowledge gains from previous 20 minutes, 5 minutes summary and questions. The use of game-based learning and gamification are also widely advocated (Barab & Dede, 2007; Bergen, 2009; Bodnar, Anastasio, Enszer & Burkey, 2016; Garris et al., 2002) to name only a few.

It is clear that no stone is left unturned in the search for factors that could influence the learning attitude of learners with the common goal: a self-determined learner “driven by their own volition rather than external forces” (Garris, et al., 2002, p. 444). The influence of the learning environment designed to develop 21st century skills is subject to the engagement of the digital natives and to ensure engagement, students need to be motivated. The learning environment needs to be developed, keeping the features that could motivate students to commit in mind.

2.3.4 Active learning

Duderstadt (2009) stated that generation Z students are challenging the traditional educational strategies of delivering course content. He continued by claiming that, especially in a hands-on field such as engineering, a passive lecture-dominated system is not beneficial for student learning as it is not promoting student motivation and especially not the tendency for life-long learning. The old Chinese proverb: “I hear and I forget. I see and I remember. I do and I understand” will reverberate in opportunities to learn in discovery-orientated, interactive and collaborative environments (Duderstad, 2009).

Active learning implies that students engage in the learning process, they are actively involved and do not passively receive information in a traditional classroom setting (Prince, 2004). Active learning methodologies are using engagement and challenges in the design of activities to accomplish the intended learning gains (Romero et al., 2015).

In recent years higher education started to lean towards an approach where a student-centred inquiry was harnessed as a teaching strategy, the lecturer acted only as a facilitator of the learning process (Perrenet, Bouhuijs, & Smits, 2000). Self-directed learning in authentic environments coupled with collaborative learning formed the backbone of innovative educational models such as problem-based learning (PBL) and project work (Perrenet et al., 2000). The concepts of PBL (student-centred, teacher as facilitator, organised around real-life problems (Barrows, 1984) according to Perrenet et al. (2000) relate to the experiential learning theory of Kolb (2014), “The Reflective Practitioner” of Schön (2004) and constructivism and social learning as promoted by Piaget (1964), Vygotsky (1978) and Lave and Wenger (1991). De Graaf and Colmos (2003) stressed the fact that activity-based learning activities could serve as student motivation and the opportunity to acquire deeper learning. These include doing research, the need to make decisions and to communicate it through writing that is crucial in a problem-based learning environment,

Other benefits of implementing active learning strategies are highlighted by Astin (1999). He stated that the success of any program depends on the ability of educators to increase student involvement. Tinto added that “…involvement matters and that it matters most during the critical first year of college” (Tinto, 2007, p. 3). It is even said that the connection between people and their environments are important to ensure perseverance (Bottrell, 2009). Usually, retaining students was one of the major challenges of student affairs professionals, but Tinto (2007) suggests that activities aimed at student retention should be integrated within the academic environment. Since the classroom is central to students’ interaction with each other and with faculty (Tinto, 2007), classroom activities need to be structured to, apart from delivering the academic content, also enhance student retention.

These statements promote the design of a learning environment where student involvement is one of the focus areas for more than one reason. But, active involvement is only one of the measures that could be implemented gainfully. Meyers and Nulty (2008) noted that students are constantly questioning the relevance of the compulsory courses that they have to attend for degree purposes. They recommend that the course material should be authentic, giving a student a bird’s eye view of the challenges that they might face in a professional environment.

The value of establishing authentic educational settings is widely supported in the literature (Brown, Collins, & Duguid, 1989; Choi & Hannafin, 1995).

Prensky (2005) accentuated that it is crucial to find ways to engage students if we as educators want to be relevant in the 21st century. Dewey already pointed out in 1916 that “education is not an affair of ‘telling’ and being told, but an active constructive process” (Dewey, 1923, p. 46). The problem faced by engineering educators is two-fold: apart from delivering students that are competent concerning content knowledge, they also have to ensure that their students are 21st century attuned.

Niman (2014) emphasises in his book *The Gamification of Higher Education* that education is a process preparing students not only to be masters in their study fields but also optimise personal development to be happy, productive and successful in their lives. He continues by indicating that the higher education industry is in the business of providing transformative encounters to students that could be similar to the goals of the gaming industry and it would, therefore, be beneficial to draw on the insights of the gaming environment (Niman, 2014).

Educators in the 21st century are facing generation Z students, the “net generation” (Oblinger, Oblinger, & Lippincott, 2005) that differ, as previously discussed, in more than one way from previous generations. Van Eck (2006, p. 1) pointed out that “they require multiple streams of information, prefer inductive reasoning, want frequent and quick interactions with content, and have exceptional visual literacy skills”. As a consequence, to positively engage them, educators have to innovatively combine features such as interesting choices, desirable outcomes, instant feedback on performance and opportunities where students can develop and evaluate their own progress in the learning environment (Prensky, 2005). All of these traits are calling for games-inclined activities, game-based learning strategies (de Freitas, 2006a). Garris et al. (2002) recognised that learners are provided with the opportunity to “learn by doing” in authentic environments when they are playing instructional games. Garris and Ahlers (2001, December) argued that the game scenario could also lead to further student participation that could result in greater learning gains.

Game-based learning is a good example of an active learning methodology (Romero et al., 2015). Lepper and Cordova (1992) said that learning that is fun appears to be more effective. They continued by stating that motivated students with a desire to learn and be taught could be the result if “work” is turned into “play”. Game-based learning concepts and approaches are especially beneficial in learning environments that aim to further critical thinking, the ability to work effectively in groups that entail, amongst others, the capability to communicate and solve problems through debate and to make informed decisions (Pivec, Dziabenko, & Schinnerl, 2003). The skills listed by Pivec et al. (2003) correspond with the much applauded 21st century skills that could imply that the learning environments that they propose might be a plausible option that would combine the generation Z student’s needs, the need of the employer (21st century attuned workforce) and also the motivational issues surrounding student engagement in the learning environment.

2.4 **PLAYING GAMES**

But what is play? And how could the different games prepare students for the demands of the 21st century? How can a game be adapted to suit an academic purpose in a higher educational environment?

2.4.1 Play

Play is the focus area of much of the research conducted in the past. Huizinga (1955) defined play as an activity that humans engage in for its own sake. Initially, play was only associated with activities that children engage in to further their development and learning (Bergen, 2009). Rieber (1996) noted that play is not seen as commendable when you have reached adulthood because hard work is valued as being respectable and not play. People believe that play is easy, another misconception pointed out by Rieber. Play is described in the literature as a voluntary activity that people participate in since it is pleasurable (intrinsically motivating), it involves a level of active engagement and has a make-believe quality

(Csikszentmihalyi, 1990; Rieber, 1996). Stuart L. Brown, the founder of the National Institute for Play in California, when prompted to define play said that:

> *Play is an ancient, voluntary, inherently, pleasurable, apparently purposeless activity or process that is undertaken for its own sake and that strengthens our muscles and our social skills, fertilizes brain activity, tempers and deepens our emotions, takes us out of time, and enables a state of balance and poise*. (Brown, 2009a, p. 412)

The fact that participants are fully absorbed by the “play” while being aware that the outcome would not influence their lives outside the play scenario (Huizinga, 1955), heightens the value of “play” in the educational arena. We aim to have fully motivated students that are eager to participate in the learning environment, and since play enables a “state of balance and poise” (Brown, 2009b), it can enhance the learning environment.

2.4.2 Games

While play is an unstructured, free form activity as described in the previous section, games have defined goals and are governed by rules (Crawford, 2003). Even though Kronisch (2016) remarked that games are playful activities that persons engage in, games differ from play in that a game has a formal system containing specific goals and rules, and it has a quantifiable outcome that influences the effort that each player bring to bear to influence the outcome of the game (Juul, 2003).

Prensky (2001b) distinguished factors that engage and motivate us while we are playing a game. These include the goals of the game coupled with the effort to achieve them; the choices that we make while playing the game and the feedback received; the obstacles and opponents faced in the process; and the feelings of joy and despair and finally also the connectedness with other players. This feeling of extreme happiness and satisfaction is the result of the experience of flow

(Csikszentmihalyi, 1990). Games can capture the players' interest, and they lose track of time spent on the activity and are unaware of the effort that they have exerted to learn to excel in the game (Rieber, 1996). Gamers experience a feeling of urgent optimism with extreme self-determination (Mallory & Guadagno, 2016); they develop the ability to build social fabric since people playing together build relationships, and they trust each other.

Games lead to blissful productivity since people are happier when they work hard, and gamers experience a desire for epic meaning (McGonical, 2011). As stated by Presky (2007), games afford opportunities through which the learning process could be enhanced by unleashing the power of fun and play. Mallory and Guadagno (2016, p. 6) agree by stating that "games are not mere distractions, but engaging learning experiences for students". No wonder that education specialists are seriously considering game-based approaches to enhance learning experiences.

The gaming environment provides an educational sphere consisting of sound principles and models of learning. In the following discussion the characteristics of games are linked to well-bespoken characteristics (added in italics for clarity) of conducive learning environments: Games provide a meaningful learning environment where the context in which the learning occurs also provides the opportunity to apply and practice newly gained knowledge (*Situated cognition and contextualised learning*) (Kiili, 2005; van Eck, 2006). While playing, students learn without even realising it (Gee, 2005; Marsick & Watkins, 2001) by being actively involved (*Active learning*) in an enabling learning environment (Astin, 1999). To be successful in the game, students have to recall previous encounters with the game (*Activating prior knowledge)* (Gijselaers, 1996) and build on these experiences (*Scaffolding of learning gains)* (Hmelo-Silver, Duncan, & Chinn, 2007) to excel in the game *(Construction of new knowledge)* (Novak, 2010). These cognitive activities correspond to Jean Piaget's concepts of assimilation and accommodation resulting from a cognitive disequilibrium (van Eck, 2006). Koster (2005) says that students enjoy playing games because they experience a sense of mastery that arises from their ability to perform in the game. He claims that "learning is the drug" (p. 40) that stimulate curiosity to continue playing. Games are designed to accommodate players with different levels of competency (*Individualisation)* (Gardner, 2000) and players move to a more advanced level through discovery learning while they are experimenting (*Discovery and Experiential learning*) (Kolb, 2014) with alternative solutions to the scenarios presented (Oblinger, 2004).

Furthermore, since the gaming encounters are experience-based or exploratory, it could be categorised as resonating with experiential, problem-based or exploratory learning approaches (de Freitas, 2006a). Games are social encounters (*Social and Participatory*) where players can assess and compare (*Assessment*) their performance based on the immediate feedback (*Feedback*) on their performance in the game (van Eck, 2006). Knowledge gained in the game is transferred (*Transfer of knowledge*) to other scenarios outside the gaming environment (Oblinger, 2004).

Games provide a platform for learning, especially since the repetitive cycle of decision making, action taken and feedback provided, typical of the gaming environment, can strengthen the perception that the player is in control of the outcomes. It could change the player's assessment of his/her level of competency, and since the generation Z students value gaming, it can elevate the learning experience to something worthwhile to engage in (Garris et al., 2002). Perhaps the most compelling benefit of the use of games in education is its motivational power, even the idea of play has the potential to increase engagement in the activity (Prensky, 2006).

In literature, the attributes of successful games are widely discussed. A summary of the characteristics of games, as communicated by researchers, is provided in Table 2. These characteristics pertain not only to games in general but also to digital/computer games.

Table 2: Game characteristics

Author(s)	Characteristics
Baron (2012)	• concrete goals and manageable rules • fits the player's capabilities • provides clear and timely feedback • eliminates distractions

Author(s)	Characteristics
Driskell and Dwyer (1984)	• goals • challenge • fantasy • mystery
Garris et al. (2002)	• fantasy • rules/goals • sensory stimuli • challenge • mystery • control
Thiagarajan (1999)	• conflict • control • closure • contrivance
Juul (2003)	• rules • variable quantifiable outcome • player effort • valorisation of the outcome • attachment of the player to the outcome • negotiable consequences
Malone and Lepper (1987)	• challenge • curiosity • control • fantasy
De Felix and Johnson (1993)	• dynamic visuals • interactivity • rules • a goal

All games consist of a goal, rules, a feedback system, and voluntary participation (McGonical, 2011). The goal can be equated to the intended outcome of the game, and as such, orientate the gamers while playing the game. Rules provide the gamers with the limiting conditions under which the game should be played, and as such could trigger tactical and creative thinking to overcome these limitations. Continuous feedback keeps the gamers on track and serves as motivation to stay in the game. Since gamers voluntarily choose to participate in the game, a sense of fun in a safe environment surrounds the challenging and stressful environment (McGonical, 2011). All of these characteristics serve to promote flow and intense immersion in the game.

Prensky (2001b) provided a condensed description of the characteristics appealing to the playing of computer games and video games. Most of these qualities apply to all types of games:

> *1. Games are a form of fun. That gives us enjoyment and pleasure.*
> *2. Games are a form of play. That gives us intense and passionate involvement.*
> *3. Games have rules. That gives us structure.*
> *4. Games have goals. That gives us motivation.*
> *5. Games are interactive. That gives us doing.*
> *6. Games are adaptive. That gives us flow.*
> *7. Games have outcomes and feedback. That gives us learning.*
> *8. Games have win states. That gives us ego gratification.*
> *9. Games have conflict/competition/challenge/opposition. That gives us adrenaline.*
> *10. Games have problem-solving. That sparks our creativity.*
> *11. Games have interaction. That gives us social groups.*
> *12. Games have representation and story. That gives us emotion.*
> (Prensky, 2001a, p. 1)

Sica, Veneri and Miglino (2012) identified three dimensions that should be taken into account when constructing a good educational game: gaming aspects, learning aspects and technical aspects. Within the gaming dimension they identified amongst others, goals (the final objective but also short-term goals); rules; level of difficulty; fun, positive feedback and rewards. The learning aspects related to the fit between the game and the educational objectives and the technical aspects included aspects such as the game interface and the graphics used in the presentation (Sica et al.,2012).

Two strategies, game-based learning and gamification, are widely implemented in the educational environment. Game-based learning (GBL) refers to a pedagogy that uses games to enhance the learning experience (Isaacs, 2015). The actual game acts as the learning environment. Gamification, in contrast, refers to the use of game elements to enhance the appeal of an educational event (Kirillova, Vinichenkoa, Melnichuka, Melnichuka, & Vinogradovaa, 2016). These game elements are add-ons to the instructional event.

In GBL, knowledge and skills are transferred by using the actual game in an instructional event, with a definite start, the play of the game, and a feeling of accomplishment at the end (Kapp, 2014). Game-based learning provides an opportunity whereby students are actively engaged by providing challenges that stimulate "flow" (Kiili, 2005). GBL also facilitates opportunities to solve problems by putting the student in control of the activities in the game to achieve the learning objectives (Romero et al., 2015).

Prensky (2006) remarked in his book *Don't bother me, Mom, I'm learning*, that games attract children as they learn about the future, and in this context, they are subjected to 21st century attributes that range from collaboration, risk-taking, the devising of a strategy to solve problems, to even making decisions on moral and ethical grounds.

The research question of this study is whether it is possible to create an enabling learning environment that is conducive for the development of 21st century skills. GBL and gamification seem to be appropriate strategies to use in the design of the learning environment since it is engaging, fun, and it allows students to develop the skills needed to be "job-ready" in an intuitive way.

2.5 CONCEPTUAL FRAMEWORK

The educational setting in this study consists of engineering students on their journey to becoming professional 21st century graduates. These students need learning environments that are non-traditional since they are part of Generation Z.

The module under scrutiny is structured to contribute to delivering students that are 21st century attuned, that is to say, they will possess the skills to communicate effectively, think critically and creatively and have the ability to work in a team, collaborating with others. These skills, referred to as the 4Cs, are influencing the perception of the industry regarding the employability of the students (Dathan, 2013; DHET, 2013).

In the South African context, the problem of educating engineering students is even more complex than globally since the students have disparate educational backgrounds that influence their academic preparedness for tertiary studies detrimentally (Griesel & Parker, 2009; Kraak, et al., 2013). Lecturers (teachers on a university level) are under immense pressure to not only teach subject-specific content at the university level but to also address the gaps in the prior knowledge that was assumed to be in place. It is, therefore, understandable that lecturers are often reluctant to invest additional time and resources to create learning opportunities that allow for the development of 21st century skills or the graduate attributes that are so sought after by employers.

Research has shown that a lot of time, effort and motivation are needed to develop these skills (National Research Council, 2013) and there is simply not enough time to do so, apart from a packed curriculum, how to assess the attainment of these skills is also problematic. This leads to a question about how higher education institutions, usually only focusing on subject-specific content, can prime underprepared students (in the South African context) to graduate and be "job-fit" in a demanding 21st century environment. The question is whether it is possible to adapt an existing game to use as a learning environment in which students are exposed to, and given the opportunity to practice certain 21st century skills, without compromising the discipline knowledge that they need to master. The principles followed in the design process are of the utmost importance as educators need to capture the attention of the Generation Z students.

The Input-Process-Outcome model used in many educational contexts is suitable to capture the scenario described above. The students and context are part of the input, the process representing the learning environment developed to facilitate the process of learning, and the outcomes representing students that are 21st century attuned. However, this model is not fully representative of the challenges faced by the researcher and the processes followed to facilitate the learning process of the students.

The module under scrutiny needs to facilitate the development of the necessary skills to be successful as a student and to be employable professionals in the 21st century environment. Considering the sample of students (Generation Z students with dissimilar levels of preparedness for tertiary studies), the context and types of opportunities designed have to interest engineering students. Furthermore, it needs to be cleverly structured to attain the interest of all of the students regardless of the level of preparedness, so that it does not bore the better-prepared students nor lose the underprepared ones. In addition to the above mentioned, when considering the learning outcomes, the 4Cs (communication, collaboration, critical thinking, and creativity), the scenario is even further complicated.

The process could be compared to the process followed when constructing a traditional technology roadmap. In constructing the technology roadmap, an expert panel identifies the needs; then they map the currently available resources; do an analysis to identify the gap between the existing resources and the resources needed in order to succeed; and finally propose a plan or roadmap to aid in obtaining the desired outcome (Duderstadt, 2009). In the scenario, presented in this study, the requirements of the industry are assessed, then a "map" of the available resources (students and learning opportunities on the campus) are constructed, the gap between the educational arena and the industry expectations are evaluated, and finally a plan to overcome the obstacles is proposed.

A traditional lecture setting may typically not be conducive for the development of the attributes needed to be successful as a student and as a 21st century employee (Bodnar et al., 2016). In this domain where exposure to the 4Cs are of high importance, the learning concepts and approaches of game-based learning may be beneficial as pointed out by Pivec et al. (2-4 July 2003). Gamers need specific skills to win which, in return, prepare the gamers for real-life scenarios requiring 21st century skills (Romero et al., 2015).

Gamers are involved in a cyclic movement of hypothesis generation, testing of the decisions made, and then revising the hypotheses based on their experiences of the outcomes of their actions (van Eck, 2006). This continuous process driven by the cognitive disequilibrium and accommodation of new knowledge (van Eck, 2006), elevate the gaming scenario to an environment where critical and creative skills are fostered. Gamers need to experiment with different solutions to problems and as such, are involved in creative problem solving (Kiili, 2005). The gaming scenario furthermore provides opportunities to develop communication skills as well as the skill to work in multidisciplinary teams (Bodnar et al., 2016).

To fully represent the scenario described, the Input-Process-Outcome Game Model proposed by Garris et al. (2002) have been adapted for the study. The input refers to the ill-prepared Generation Z students, the ever-changing 21st century work place and the elements of the game, the Amazing Race, implemented to host the introduction to, and the attainment of, the learning outcomes, the 4Cs (communication, collaboration, critical thinking and creativity). The game cycle represents the process that the students follow while they are actively participating in the game. They receive a clue to a destination (delivering), after deciphering it (judgement), move to the destination (behaviour) and receive the roadblock challenge (system feedback) at the destination. After completion of the roadblock, once again by following the cyclic process illustrated below, they receive the next clue to a new destination. This cyclic process continues until they receive the last clue to the final destination of the race. The debriefing after the activity, the output of the model initially only pertains to the clues received and the challenges that the students had to overcome. The hidden agenda, the 4Cs, are only revealed after the students completed the first semester of the module. During the design process, principles surfaced that could be useful in the design of a similar learning environment. The adapted Input, process and output model can be seen in Figure 3.

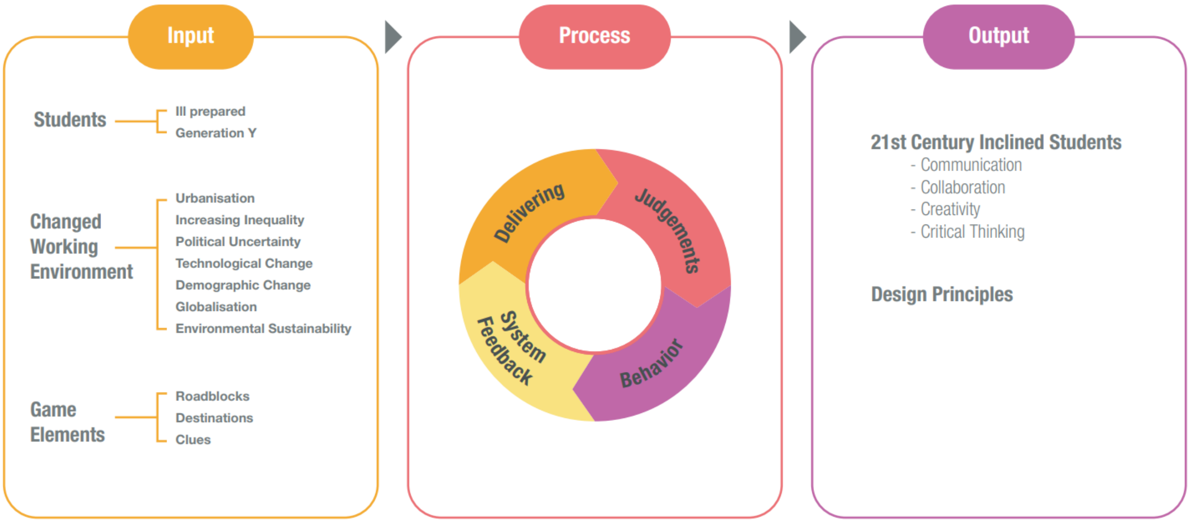

Figure 3: Input-Process-Outcome Game Model (adapted from Garris et al., 2002)

The researcher by no means implicates that students may obtain the 4Cs by being subjected to this one experience. Meyers and Nulty (2008) highlighted that no single experience would pioneer the desired changes in knowledge and Cranmer (2006) also stated that students need to be subject to numerous opportunities to develop the desired graduate outcomes. The activity developed serves as an opportunity in which students are exposed to the attainment of the 4Cs, and it is recommendable that students encounter more opportunities where they could attain these skills.

2.6 CONCLUSION

This chapter has kicked off with the statement that higher education institutes can no longer ignore the disparity between learning environments, the needs of students, and the expectations of the ever-evolving workplace. The literature review provided several key features pertaining to the industry's perception of employability and further elaborated on the skills needed by referring to the Framework for 21st century skills, the expectations of the professional engineering councils and finally concluded this section with the role of higher education institutes.

The discussion continued with literature about the educational playfield faced by educators in the 21st century. Learning environments that could be fostered to assist lecturers in their quest for motivated students were delineated. The role of play and then also subsequently the positive influence of game-based pedagogies concluded the review of the literature. The input-process-output gaming model proposed by Garris et al. (2002) was adapted as a conceptual guideline for this study.

The next chapter will focus on the research methodology and an explanation of the action research that developed into a design experiment with a specific focus on the case study of 2018.

3. CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION

As mentioned previously, there is a disparity between learning environments, the needs of students, and the expectations of the ever-evolving workplace. Since the researcher is intrigued by the influence of learning environments on the development of students' 21st century skills needed to be successful in the workplace: communication, creativity, collaboration and critical thinking (4Cs), the research questions that guided the study were:

Which design principles can be used to create a game-based learning environment in higher education that promotes the development of communication, collaboration, creativity and critical thinking skills in ill-prepared students?

- *How can an existing game be adapted to suit an academic purpose in a higher educational environment?*
- *To what extent are the characteristics of games still present, once an existing game has been adapted to serve an academic purpose?*
- *To what extent does a game-based learning environment provide the opportunity for the development of the 4Cs. (21st century skills)*

The study aimed to shed light on these questions by amongst others describing the construction of the game-based learning environment that posed an opportunity to the students for the development of 21st century skills. The action research focussed on improving the execution and ultimately, the impact of the learning environment on first-year students. This ongoing process already started in 2015. After realising the potential of the development of a learning environment conducive to the attainment of the 21st century skills in higher education, a cross-sectional case study consisting of data harnessed in 2018 was employed as the first step transforming the action research approach into a design experiment. In this way, knowledge regarding learning environments that influence the attainment of 21st century skills could be presented for more than just this one student project at one institution. The

Input, Process, Outcome Game Model adapted from Garris et al. (2002) as described in Chapter 2, was used to guide the research process.

This chapter describes the research approach that was implemented in this study. Special attention is given to the design of the learning environment, the Amazing Race and valuable design principles that could be implemented in the adaption of any existing game are pinpointed. The cross-sectional case study provides rich information on the Amazing Race learning environment as it stood in 2018. The researcher’s role and the bounding of the study in terms of the setting, participants, the event, processes and ethical considerations are discussed. Furthermore, attention is given to the data collection strategies and data analysis procedure and the verification of the use of these strategies. The chapter will also reflect on the method used to report the findings in terms of student experiences regarding the different facets of the race and the opportunities for the attainment of 21st century skills (communication, collaboration, creativity and critical thinking) will also be reflected on. The chapter concludes with a discussion of the trustworthiness of the research, the ethical considerations and the limitations.

Figure 4 shows the structure (adapted from Saunders & Tosey [2012]) of the discussion re the research framework, after which the course of action followed during the execution of the activity is interwoven to provide further information regarding the method followed in the research.

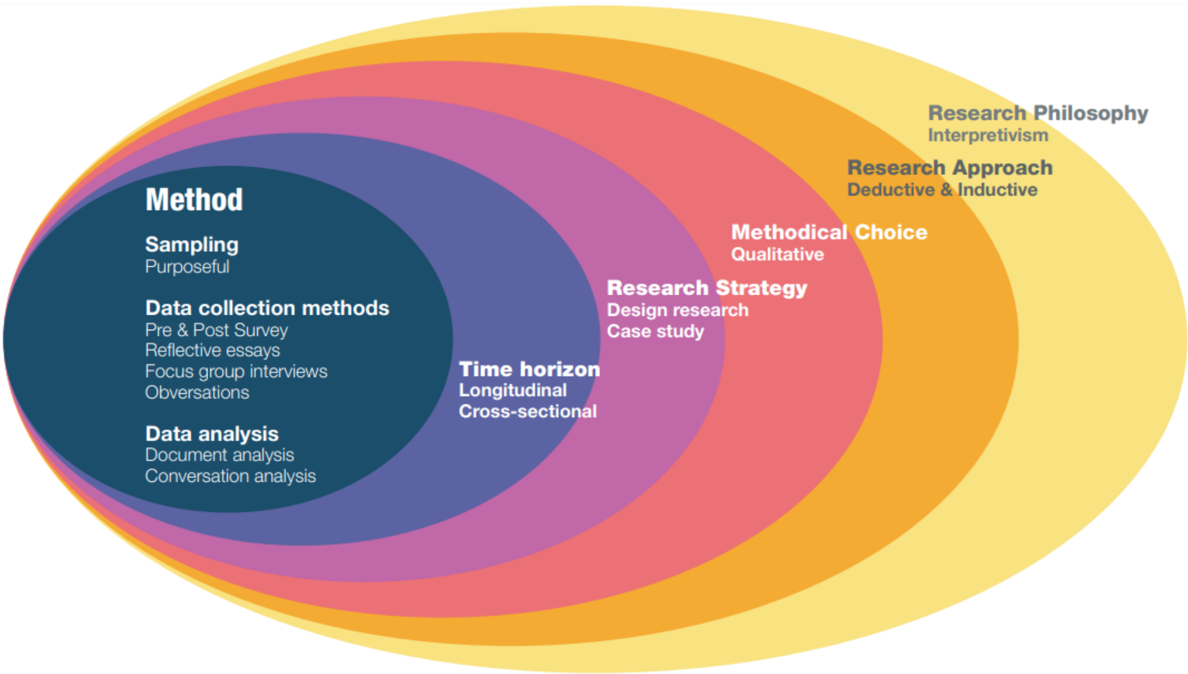

Figure 4: Research framework (adapted from Saunders & Tosey [2012])

3.2 RESEARCH FRAMEWORK

This section provides information that positions the research project in an interpretive qualitative paradigm that uses both an inductive and deductive approach.

3.2.1 Interpretivism

The research study focussed on deriving design principles that could be implemented in the construction of an enabling learning environment in which students can be exposed to, and get the opportunity to practice their 21st century skills. For this purpose, I describe the design of the Amazing Race learning environment. Apart from discussing the design and refinement of the environment since 2015, the student responses in 2018 to the design facets of the Amazing Race, how they have experienced it as a game, and the influence on the attainment of the 4Cs, were also considered. This study wanted to portray how the learning environment worked by on the one hand describing the design process and deriving the design principles imperative for success and on the other hand interpreting the

Amazing Race scenario in terms of the experiences assigned to it by the students. Since I am interested in the meanings that the role players assigned to the Amazing Race experience, an interpretive paradigm will suffice.

In the interpretive paradigm, the reality is seen as socially constructed and therefore what is experienced as “reality” can entail numerous viewpoints and interpretations of an event (Merriam & Tisdell, 2016). I wanted to understand and explain the gist of the participants’ experiences, yet another indication that an interpretative paradigm will be sufficient (Schwandt, 2000). Since individuals assign varied and multiple meanings to their experiences, in this case, the Amazing Race, I had to investigate complex, socially and historically negotiated realities (Creswell, 2013) that are multiple representations of the scenario that implied that I had to use an interpretive paradigm. I had to construct knowledge since it was not readily available, yet another characteristic of an interpretive approach, as noted by Merriam and Tisdell (2016).

Employing an interpretive approach in education is explained by Erickson (1986) as an attempt to understand the learning environment in terms of what the lecturers and students do, think, feel and say. The educational playfield is multifaceted, and as such, it is not possible to identify all of the variables beforehand. In the case of the Amazing Race, I had to focus on the emerging nature of sense-making. The research questions focussed amongst others on “how” to design a learning environment that is conducive for an introduction to and the attainment of 21st century skills. The study, therefore, encompassed numerous perspectives with many variables that should be investigated in-depth in an attempt to identify design principles applicable to an enabling environment. The interpretive paradigm would allow me to describe and find possible explanations for the experiences of the students that took part in the activity. Within this framework, I could reflect critically on the process followed in the design process and also focus on the interpretation of all of the different facets playing into the Amazing Race environment.

3.2.2 Inductive and deductive reasoning

The process of developing a conducive learning environment demanded a search through the literature to identify the types of learning environments that would be beneficial for the development of the 4Cs and that would engage generation Z students as discussed in Chapter 2. The learning environment was constructed as proposed by the literature. Observations and student experiences further shaped the refinement of the learning environment. The reasoning went from examining the existing theories (Gabriel, 2013) to proposing “hypotheses” that led the investigation. In this case, my hypotheses were that a gaming learning environment would provide an opportunity to develop 21st century skills and that there were certain design principles that could be employed to ensure the success of the learning environment.

The top-down approach (Byanjankar, 2016) results in either the confirmation or rejection of the “hypotheses” (the learning environment that was developed) based on the observations and data gathered regarding the influence of the learning environment, typical of a deductive process. While doing the research, certain patterns were discovered that complemented theories regarding game-based learning and the attainment of the 4Cs, an inductive reasoning process was followed. An inductive approach was used to establish the dominant or significant themes that occurred frequently in the raw data (Thomas, 2006). While the focus of the research was amongst others on the construction of the learning environment and thereafter examining the context with regard to the 4Cs, the dynamic, emerging design of the learning environment forced the use of inductive logical reasoning patterns (Creswell, 2007). The interaction between inductive and deductive reasoning processes followed during the design process is illustrated in the model proposed by Van Wyk (n. d.) that can be seen in Figure 5.

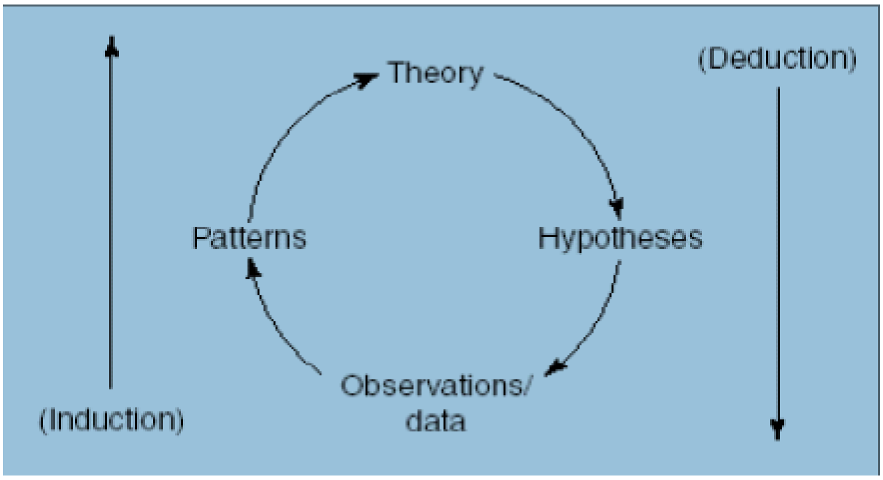

Figure 5: Deductive vs inductive reasoning processes (Van Wyk, n. d.)

3.2.3 Qualitative paradigm

This research project intended to provide an insight into the development of a learning environment and derive design principles useful in the execution of such an environment. In this case, the Amazing Race game was adapted to further 21st century skills in first-year engineering students. The design and development of the learning environment since 2015 were investigated. Furthermore, attention was given to the influence of the learning environment on the introduction to and the attainment of 21st century skills.

The learning environment was thus studied in a natural setting where the researcher attempted to describe the design process based on the experiences of the lecturers and students involved in the scenario. One of the intended outcomes of the learning environment, the introduction to and the attainment of the 21st century skills, communication, collaboration, creativity and critical thinking, were not easily measurable. The educational value of the Amazing Race depended on the meaning that the participants brought to it. This scenario corresponds to Denzin and Lincoln's (2000) first broad definition of qualitative research:

> *Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that make the world visible. These*

> *practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them.* (2000, p. 3)

Merriam and Tisdell (2016) note that research could be conducted with the intention to inform the reader (basic research), or with the intention "to improve the quality of practice of a particular discipline" (p. 3) (applied research). They continued by dividing applied research into evaluation research, action research and appreciative inquiry. Since the inquiry into the Amazing Race learning environment was amongst others focussed on establishing the worth or value of the environment in terms of developing students that were 21st century attuned and to improve the effectiveness of the environment, it could be categorised as evaluative research according to Patton (2015).

The definition of qualitative research provided by Creswell (2013) highlights the fact that this process of inquiry aspires to build an understanding of a social or human problem. The way that people interpret their experiences and construct their worlds are central to the interest of a researcher following a qualitative research approach (Merriam & Tisdell, 2016). Creswell (2007) noted that a qualitative research paradigm presupposes that there are numerous ways in which reality could be interpreted. The diversity of participants' perceptions and experiences solicits an understanding of multiple realities (Lincoln & Guba, 1985).

The research project intended to look at the Amazing Race learning environment in its entirety. I was looking for design principles that surfaced during the design process and wanted to understand the influence that the learning environment had on the introduction to, and the attainment of 21st century skills, by evaluating the first-year students' experiences. As a qualitative approach entails constructing an all-inclusive representation of the scenario by analysing the inputs of all of the role players in the scenario (Creswell, 2013), it seemed to be appropriate to use for the research study. Especially in the light of the fact that Janesick (2000) typifies the qualitative design process as being similar to choreographing a play: all of the aspects surrounding the presentation of the actual “screenplay” need to be considered.

The choreographer (Janesick, 2000) is closely related to the scenario under scrutiny. The Amazing Race activity was designed to encapsulate a game-based scenario, and I facilitated the activity since 2015. As such, I had built relationships not only with colleagues at the respective destinations over the years but also with the students in each cohort that took part in the activity. The activity was presented as an introduction to the campus, and formed part of one of the first sessions that the students enrolled for the module Professional Orientation, encounter. The close relationships with the students and tutors evolved even after the completion of the activity since I was part of the lecturing team for the whole semester.

I experienced tension about my objectivity toward the scenario since I was closely involved in the design and in the development of the activity. I have revisited the process and reflected on the value of each activity before the presentation of it in consecutive years. Changes were implemented after discussions with the colleagues that played a role in the execution of the activity. As such, the Amazing Race captured my imagination and I have put in a lot of hours perfecting the scenario. Creswell (2013) fortunately noted that the approach of each researcher in the description of a scenario under scrutiny would be different. I strived to reflect on the attitudes of a qualitative researcher as specified by Flick (2011): displaying an openness toward the scenario being studied, being flexible in my approach and being sensitive to existing structures rather than imposing my ideas into what was studied. Since a qualitative research design is often characterised as being focussed on personal, face-to-face and immediate contact between the researcher and the social scenario under scrutiny (Janesick, 2000; Creswell, 2013; Merriam & Tisdell, 2016), this approach is suitable for this study.

The scenario under scrutiny was investigated with regard to the design of the activity (the process followed over the period and design principles applied), the Amazing Race, as well as its influence (the product or outcome in 2018) on the exposure to 21st century attributes. As such, the state of affairs was value-laden (in the words of Creswell [2013]) and therefore too complicated to apply a quantitative model of inquiry. The data that stem from this inquiry was descriptive, the experiences were reported in the participants' own voices. The scenario had to be investigated by using intuitive and felt knowledge to be able to grasp the value of the nuances of the multiple realities (Lincoln & Guba, 1985). After considering the characteristics of the scenario in combination with the virtues of a quantitative and qualitative approach, a qualitative approach seemed the best fit for the study.

3.2.4 Research strategy

The research was focussed amongst others on the creation of a learning environment that would engage students efficiently to expose them to the 4Cs of 21st century skills. I was investigating the scenario by firstly looking at the design and development of the learning environment, initially purely to improve the student experience in this specific learning environment. After realising that similar interventions could be implemented in the broader higher education arena to expose students to 21st century skills, the action research approach was changed to a design experiment that kicked off with a case study in 2018. Since the function of the research was to refurbish an intervention in consecutive years to address the problem of "job-ready" graduates experienced by the industry, the research approach followed from 2018 can be typified as design research according to Plomp (2006). A cross-sectional case study in 2018 provided information on the experiences of the students in 2018 regarding the Amazing Race. A visual description of the research strategy, together with the time frame during which the design of the learning environment was refurbished and also the implementation of the cross-sectional case study can be found in Figure 6.

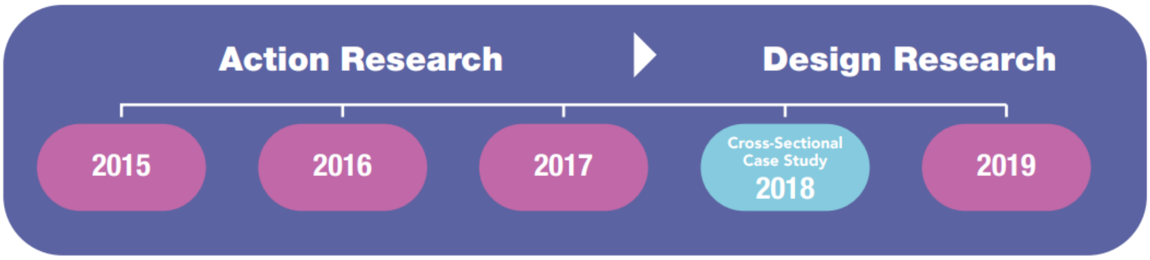

Figure 6: Timeframe

Three slants were used to analyse the student comments: how did they experience the different facets (destinations conducted, clues and roadblocks) of the race, how did they experience the environment as a game, and finally did they encounter activities that were conducive to the attainment of the 4Cs?

3.2.4.1 Research design

The research study was initiated since I wanted to explore the learning environment using different lenses. I wanted to investigate how an existing game could be changed into a learning event through which learning content could be delivered and which design principles could be used to streamline the process of adapting an existing game for educational purposes. I also wanted to know how this environment could serve as a vehicle to transfer the 21st century skills needed to be successful as a student and professional in the workplace.

I have facilitated the activity in three consecutive years, and I opted to change it after each iteration based on the student and lecturer feedback that I have received. Norton (2018) states that action research is conducted to reflect on one's own practice in the teaching and learning facilitation process and methodically find a plan of action to deal with issues that surface. Action research focusses on what you do (action) and an explanation of how and what you have done (research) to improve learning for improved practice (McNiff & Whitehead, 2010).

The research project was initially only practice-based where I, as a designer and facilitator, stand in the research scenario and look at the scenario from the inside as an active participant. This is a typical characteristic of action research where I was exploring the scenario to better understand the interplay of different elements and their influence on each other (Greener, 2008). Moreover, I wanted to change the status quo. Kaplan (1998) talks about innovation action research to describe the experimental process of implementing a new theory regarding existing practices. I wanted to learn more about the emerging design principles that could be implemented to adapt an existing game for educational purposes. As such, this action research project could be labelled as innovation action research.

This scenario fits in the two-stage action research cycle that Coghlan and Brannick (2009) describe. They argue that while you are engaging in the project, planning and taking action, diagnosing problems and evaluating the process, you are also holistically looking at the action research project itself especially in terms of what you are learning during the process (Coghlan & Brannick, 2009). I did not only want to improve the learning environment but also wanted to find design principles that could be useful when an existing game is adapted for educational purposes.

After the first three years of following the action research route, the research design was changed to a design experiment. This activity echoes constructive learning theories in that active student participation was a crucial element in the authentic learning activities developed (Lebow, 1993) to expose students to the 4Cs. The educational design of the race in its entirety and of the clues and roadblocks could be tested and refined after each year, typical of a design experiment (Reeves, 2000). This study was dedicated to the investigation of the suitability of the game environment to acquaint students with the 4Cs. During the design of the educational setting noticeable design principles surfaced.

The design of this enabling learning environment is rooted in the educational problems faced by higher education institutions: how do you prime students to become “job-ready” graduates? The question surrounding the possibility that a practical and effective intervention could address an existing problem, and that an intended change in the real world could be affected in this way, as raised by Van den Akker (1999) in his contention for development research, was particularly valid in this context. Design experiments provide a platform where possible “solutions” to the educational problem could be moulded by an iterative process of review taking the alignment of instructional objectives and assessment into account in a collaborative setting between all of the stakeholders (Reeves, 2000).

McKenney and Reeves (2014) anchor their definition of educational design research in the fact that this type of research is focussed on the development of solutions to complex educational problems in an iterative process of scientific inquiry. Their definition is further explained by Colb et al. (2003) by adding that design experiments are innovative and design-based and looking for “theories” that provide solutions in practical educational contexts. Design experiments provide the forum for investigation of this diverse interactive system uniting different forms of data from various sources (Gorard, Roberts, & Taylor, 2004) aimed to support learning. Since design experiments offer the possibility of retrospective analysis: “what” works and “how”, “when” and “why”, instructional design can be improved to result in new forms of student learning (Colb et al., 2003).

The educational setting faced by university teachers in the Professional Orientation module involved numerous domains. Students needed to be developed to be successful in their studies in the short term and also as professionals in the workplace, especially concerning communication, and academic and IT skills. The diversity of the group of students, especially with regard to their academic preparedness for tertiary studies, complicated the scenario. One also had to evaluate teaching and learning opportunities concerning their appropriateness in the context of the university, in terms of facilities and lecture setting and most importantly, the time available for the learning activity. The design of the learning environment necessitated innovative thinking after the lecturers had analysed the practical problems.

A practical educational setting (being typical of a design experiment as noted by Colb et al. (2003), was identified to introduce the students, being new to the environment, to the campus. By practising the theory of game-based learning in the development of the learning opportunity, students were exposed to opportunities to develop the most applauded 21st century skills. The analysis of the practical problems and the development of possible solutions within the educational setting, embodied the first two phases in a typical development-based approach as summarised by Reeves (2006) and displayed in Figure 7. The phases fit into the design-based research paradigm.

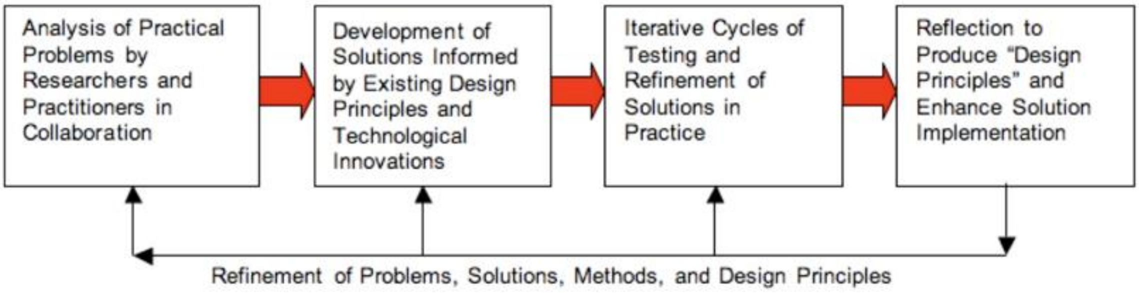

Figure 7: Phases in development-based research (Reeves, 2006)

The research was conducted from 2015 (as action research) up to date (as design research) and the destinations, clues and roadblocks were changed (phase 3 of design-based research) according to practical concerns that surfaced in the implementation of the activity and also based on the informal feedback of colleagues and other role players, and lecturer observations. Since the Amazing Race environment was structured to enable the attainment of 21st century skills, student engagement had to be ensured and student learning maximised. For this purpose, the activities designed as part of the Amazing Race environment were constantly reviewed and renewed and an iterative process was followed to improve the learning outcome of the event. The diverse interactive system could, therefore, be investigated as an experiment aimed at the design and development of a conducive learning environment (Gorard et al., 2004). Furthermore, the retrospective analysis of the design provided useful information and the methodology and teaching strategies were dynamically adopted based on the outcome of the investigation.

The design of the Amazing Race depended on the ability of not only the designers but also the students taking part in the activity (Amazing Race) to apply innovative thinking based on the theory of game-based learning. As such, and since a practical educational setting was used to practise the theory of game-based learning, the research can be seen as a design experiment, according to Colb et al. (2003). Numerous characteristics of design experiments are reflected in the Amazing Race environment. The environment was designed to focus student attention on an authentic problem, it enhanced the development of skills and not necessarily the acquisition of subject-specific knowledge (Severiens & Schmidt, 2009). The project kicked off with an activity that forced students to explore the campus (a real-life/naturalistic setting (Barab & Squire, 2004)). For example, the students visited the library, the student health centre the MakerSpace and other facilities on campus. The design of this activity involved the personnel at each of the facilities visited. Multiple role players (another characteristic of design experiments according to Barab and Squire [2004]) were involved in the development and refinement process due to the diversity of the 21st century skills needed to be "job-ready". An approach of progressive refinement in design, as mentioned by Collins et al. (2004) were followed to ensure the expected outcomes of the project. The process of constantly revising the design of the project involves four lecturers with varying expertise, the personnel at the facilities that students have visited and the tutors involved in the module (multiple role players [Van den Akker, Gravemeijer, & McKenney, 2006]). The Amazing Race activity also united different forms of data and used different resources in an interactive educational setting. As such it provided an opportunity to study the "case" in its totality especially if one could bound the "case" to include only the experiences of the participants enrolled for the module in a specific year.

3.2.4.2 Cross-sectional case study

Scholars across diverse fields of practice agree that case studies are especially useful since it provides us with the opportunity to reflect on our own practices and to theorise about these practices (Longhofer et al., 2017). Merriam and Tisdell (2016) state that case studies are qualitative in design: aimed at understanding a phenomenon, the researcher acts as an instrument of data collection and analysis, the investigation starts from investigating the data and concludes in a rich description of a scenario that could inform theory.

There are different viewpoints as to what a case study actually is. It is said that a case study could refer to a research method employed to investigate a phenomenon, but also that it could refer to a unit of analysis. Stake (2000) defines a case study as not being "a methodological choice but a choice of what is to be studied" (p. 435). Creswell (2009) further elaborates by stating that a case is usually confined to a specific time frame and a specific activity. Thomas and Myers (2015) provide perhaps the most comprehensive explanation of the demarcation of cases by stating that "the parameters of particularity are set by spatial, temporal, personal, organizational or other factors" (p. 6). A case study approach according to Yin (2014), is especially suited in a situation where the phenomenon's variables cannot easily be separated from their context.

The natural surroundings in the university context were used as a platform for the Amazing Race, another characteristic of case studies as proposed by Yin (1984). The study focussed on the Amazing Race scenario as a learning environment. It took into account all of the contextual issues and the experiences of the respective participants, to build an understanding of the case. The "case" was restricted to a specific activity, the Amazing Race. The time frame was limited to the lecturing sessions in which the activity was completed during 2018.

Simons (2009, p. 21) elaborates on the definitions of a case study by adding that a case study is "an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, program or system in a 'real-life' context". Case studies provide an opportunity to study human behaviour holistically to understand the interaction and meanings that are constructed in the social context (Feagin, Orum, & Sjoberg, 1991). A case study approach was an ideal methodology to implement in the investigation of the Amazing Race environment since the activity could be investigated in its totality. Since a case study usually centres on a problem within a real-world context (Yin, 1984), this methodology fits the Amazing Race scenario. The problem faced by the engineering educators was that the students were ill-prepared for tertiary studies and that the employers were not satisfied with the competency that newly graduated engineers had in the 21st century workplace. The Amazing Race activity could be described using the perspectives of all of the role players in its development and execution in an attempt to reconstruct and analyse the learning environment from an educational perspective.

Thomas and Myers (2015) described the value of the case study methodology by saying that conducting a case study can be seen as being similar to "painting pictures in fine-grain detail about the encounters that occur between people" (p. 130). The case study offers researchers the opportunity to study a topic of concern. They refer to the case as being the subject that provides an analytical framework within which researchers could study the object, i.e. the topic of concern. The case (subject), therefore enlightens and explicates the topic of concern (object) (Thomas & Myers, 2015). The subject, the Amazing Race activity in 2018, was used as an analytical framework to investigate the influence of the learning environment on the introduction to and the attainment of the 21st century skills (4Cs) that students needed to be successful in their studies and as future professionals. The question: "is it possible to create an authentic enabling learning environment in which the attainment of 21st century skills could be furthered", could be investigated using multiple perspectives since it could be studied as a case study. Not only the views of the students but also the perspective of the tutors involved during the activity, the experiences of my colleagues tending to the respective destinations and my perspectives and reflections on the activity could be used to investigate the setting holistically.

In a case study approach, different kinds of methods to collect data on the case in the specified time frame can be used (Creswell, 2009). Since case studies are not fenced-in by different considerations as is the case when other methods of enquiry are used, evidence from a variety of sources could be used to support arguments (Thomas & Myers, 2015). To investigate the dynamics of the Amazing Race activity, numerous viewpoints were considered. The reflections that the students had written after the activity provided richly layered information on their experiences during the race. Lecturer observations and tutor interviews further crystallised the dynamics of the environment. The purpose of using the case study methodology was not to be able to generalise the findings but to gain insight into the student experiences and be able to communicate the lessons learned during the process. This objective is in line with Merriam and Tisdell's (2016) view that the single case study has been selected to develop an in-depth understanding of the particular, not what is true in many other circumstances.

3.3 METHOD

This study is focussed on two aspects regarding the Amazing Race case study. The first concerns the design and refinement of the activity, the subject in the case, over the years of implementation. The introduction to and the attainment of the 4Cs in the enabling environment, the object of the study, is the second aspect that needs to be investigated. The Amazing Race learning environment was chosen as the “subject” in this case study since I was closely involved in the design and development of the learning environment over several years. It could thus be said that since I was involved in the process of refining the Amazing Race learning environment, it would be inevitable that I would be interested in evaluating the expected value of the case in terms of the attainment of 21st century skills. For it to be labelled as a case, I had to limit the activity to a specific time frame (Creswell, 2009). In 2018, the activity was already in its fourth cycle of refinement. I was quite confident that the logistics surrounding the “case” were ironed out. Since we did not experience any problems regarding student unrest in this year, it seemed to be the appropriate time frame to conduct a study on the “object”, the opportunities rendered through this activity to attain the much needed 21st century skills.

3.3.1 Sampling

Since I have chosen the case study approach, two levels of sampling were necessary. First, I had to select the case based on the research question. Thereafter, as a second level in the sampling process, the participants in the selected case needed to be selected. Salkind (2010) notes that if a sample is selected based on the fact that the choice has implications regarding the time needed to complete the research, the money needed to conduct the investigation, the accessibility of the site and respondents and the location of the inquiry, the sample could be labelled as a convenient sample. The choice of the Amazing Race activity could thus be seen as being convenient since it complied with all of the abovementioned conditions. But I would rather label the selection of the Amazing Race activity as being purposeful. In the first place because when you have used convenience sampling, the problem is that the selected sample is not necessarily the best source of information regarding the research problem (Merriam & Tisdell, 2016). In this case, however, the Amazing Race was specifically designed to expose the students to the much needed 21st century skills. Patton (2015) labelled the choice of information-rich cases as being purposeful since the researcher could "learn a great deal about issues of importance to the purpose of the inquiry" (p. 53). The case of the Amazing Race in 2018 could provide rich information regarding the problem faced by engineering educators. I wanted to discover, understand and gain insight into the attainment of 21st century skills by students that disregard the virtue of these attributes. This activity was designed with the purpose on the one hand to serve as an ice-breaking introductory experience on the campus, but it also served as a first exposure to the development of the 4Cs. Therefore in the words of Patton "the logic and power of qualitative purposeful sampling derives from the emphasis on the in-depth understanding of specific cases" (2015, p. 53).

As a consequence of the choice of the Amazing Race activity as it panned out in 2018 as the "case", the students that were enrolled for the module for 2018 in which this activity was hosted, formed part of the sample of the study. The information garnered from these participants could shed light and further the understanding of the scenario in its totality. Once again, the sampling could be labelled as being purposeful. All of these students, 139 in total, took part in the activity and had to write a reflective essay on their experiences during and after the activity that was used in the data analysis process.

3.3.1.1 Description of the sample

I, as designer, facilitator, observer and researcher, was closely involved in the execution of the activity and also in the data collection procedures. To reduce the idiosyncratic biases of my involvement, the input of the tutors [T], assistant lecturers [AL] and lecturers [L] involved in the module were also employed. The tutors were all students who have completed the module successfully before 2018. They have been contracted by the university to assist the first-year students in the module's lecture sessions. These senior students could provide useful information regarding the scenario from more than one viewpoint. One, they could reflect on their own experiences during the respective years that they have done the activity since all of them have completed the module with flying colours. Two, being a student with more experience, they could provide insight into the first years' experiences by revealing typical questions and comments made by the students of 2018 while participating in the activity. Their contribution was especially helpful with regards to a different perspective rendered on the activity. This was not only because of their maturity but also regarding their responses on the focus group interview questions that were focussed on more than only the activity under scrutiny.

The assistant lecturer also took part in the focus group interview [AL1]. He/she had a major in English and was appointed to facilitate the development of the communication skills of the first-year engineering students. He/she had already experienced the Amazing Race activity in 2017 and 2018. I chose the assistant lecturer [AL1] since she had experienced a previous version of the activity and since it was not her first encounter with the scenario, she could provide rich information based on her observations during the activity in 2018 and also on her reflections on the activity in the previous year. In both years, she was stationed at one of the destinations. Her input could shed light on comments that the students made in their reflections regarding their experiences and could also, given her academic background, improve understanding of the process of the attainment of communication skills as one of the 21st century required competencies.

All the first-year engineering students at the University of Pretoria in South Africa in 2018 served as the population of the study (n=1500). As explained, the sampling procedure followed for this study could be considered as being both convenient (Salkind, 2010) and purposive (Patton, 2015) by nature. Students [S] that had enrolled for, and were accepted into the ENGAGE program at the institution in 2018 (n=145), and the five tutors [T], together with the assistant lecturer [AL] and three lecturers (I am one of them) [L] involved in teaching the module Professional Orientation in this year (n=2), were sampled. The colleagues [C] stationed at the destinations visited during the Amazing Race also formed part of the sample. The ENGAGE students applied for admission or were placed, based on their results, into the ENGAGE program since they did not qualify for access into the main-stream four-year program. A few students, who chose to register for the ENGAGE program, despite having met the minimum requirements for the main-stream Engineering program, were also included in the sample. These students consciously and voluntarily chose to enrol in the foundation program because of its supportive nature.

In the first lecture session of the module, Professional Orientation, students had to complete a survey to enable the lecturers to customise the tuition to meet the needs of the particular year-group. Apart from items that provided information on the student's age, gender, school attended and more, other items shed light on their proficiency regarding their exposure to, and use of, Information Technology. The assembled quantitative data were analysed using IBM SPSS Statistics 24.0.

The students in the sample had diverse interests, as demonstrated by the choice between the nine fields of study offered in the engineering faculty. Descriptive statistics performed on the 2018's dataset revealed that the sample was diverse. This was not only in terms of age (the majority of the students were between 18 and 19, 5 students were younger than 18, and 6 were 20 years of age) and gender (118 males and 27 females) but also in terms of ethnicity that could be detected by the language indicated as the students' mother tongues (14 different languages). Students furthermore originated from nine different provinces. Even the area where the students attended school whether city, town, rural or township, added to the diversity of the group of students especially in terms of their level of preparedness for tertiary studies. The initial sample consisted of 145 students, of whom six did not complete the reflective essay.

The tutors [T], five in total, were appointed as students that have completed the module previously. The four female and one male student came from three different study fields in the engineering faculty. Two of them were already in their third year of studies in the ENGAGE program (meaning the full second year in relation to the main-stream students) and the rest of them in the second year of studies. The assistant lecturer had completed a Master's degree in English. A summary of the participants can be found in Table 3.

Table 3: Sample

Stakeholder	No	Gender		Code assigned
		M	F	
Students	145	118	27	S
Tutors	5	1	4	T
Assistant lecturers	1		1	AL
Lecturers	5		5	L
Colleagues at destinations	6	2	4	C

3.3.1.2 Role of the researcher

The case study research, that I was involved in, investigated the design of a learning environment conducive to the exposure to and attainment of the 21st century competencies (the 4Cs). Apart from looking into the design principles that surfaced during the process of designing the learning environment for this purpose, the influence of this environment on the attainment of the 4Cs formed an integral part of the study.

I had been involved in the module Professional Orientation within which the learning environment was developed, since 2010. In the first years of my involvement in the module, I experienced the “Campus walk” activity as one of the lecturers of the module. This activity was presented to the students as campus orientation and included tasks where students had to use different types of navigational information to guide their walk to the different facilities. After this activity became my responsibility, I had refurbished it to include game characteristics because the students did not seem motivated to partake and to heighten the exposure to the 21st century skills needed to be successful. It could thus be said that I was closely involved in the development of the Amazing Race learning environment and as such, I had to be aware of my own biases toward the activity (Denzin & Lincoln, 2000).

As a qualitative researcher, I was constantly aware of the paradoxical perspective that Maykut and Morehouse (1994) highlighted when they stated that the researcher has to be “acutely tuned-in to the experiences and meaning systems of others to indwell-and at the same time be aware of how one’s own biases and preconceptions may be influencing what one is trying to understand” (p. 123). According to Adler and Adler (1994), the roles of the researcher vary from being a complete member of the research setting (an insider), to be an entire stranger (outsider). In this particular research setting, I consider myself as an outsider. As far as the students that partook in the Amazing Race activity were concerned, I was an outsider to the setting according to Dwyer and Buckle (2009). They refer to an insider as a person that shares certain commonalities with the other participants in the research setting. These commonalities could be based on, not only the shared experience, but also the age, gender, sexuality, ethnicity, race, and more. Since I shared only a few of these characteristics and that I was, as an “older” person in a position of “power” in my role as the facilitator of the activity, I considered my position as that of an outsider.

I could, however not claim neutrality since I was closely involved in the design and execution of the activity. Especially since I was passionate about teaching and driven by a desire to make a positive contribution, I had to be extremely cautious about my interpretation of the scenario. I had to be aware of my own biases and intentions, and for this reason, I included the tutors, the assistant lecturer, lecturers, and other colleagues to authenticate my observations. I shared, in part, commonalities with the tutors and assistant lecturers since I was also actively involved in the same capacity, to assist the students to complete the activity successfully in the given time frame. The students’ experiences could also be better understood by the comments that the tutors had made in the focus group interviews. These two groups also shared commonalities: all of them being students that had experienced the activity.

Lichtman (2013, p. 15) points out that constructivists or interpretivists believe that “reality is constructed by the researcher” and as such plays the main part in the data collection and analysis. Merriam and Tisdell (2016) say that one of the advantages of a “human instrument” is that it responds immediately to inputs, may it be anticipated or unanticipated ones, and can verify the accuracy of his/her interpretation with the respondents. For this purpose I was using not only verbal responses but also the non-verbal communications to further my understanding of the scenario (Merriam & Tisdell, 2016).

There were, however, shortcomings and biases that had to be taken into account. Longhofer et al. (2017) note that the fallibility of the reflective practitioner is one of the characteristics in a qualitative inquiry, the intention is not to tell only one story, but to elaborate on the scenario from many different viewpoints. Peshkin (1988) actually sees the researcher's subjectivity as being virtuous. He explains by saying that "it is the basis of researchers' making a distinctive contribution, one that results from the unique configuration of their personal qualities joined to the data they have collected" (p. 18).

I full-heartedly echoed Peshkin's (1988) wish to be aware of the enabling and disabling potential of my own biases and orientations that shaped the observations that I made and the subsequent interpretations. Since I was involved in all of the aspects of the research, I had to reflect on my values, my view of how the world is known and also on the suitability of the context and the consent of the participants, the types of reflexivity, or self-awareness identified by Lichtman (2013). I consequently had to carefully and critically analyse myself especially in light of the fact as pointed out by Mertens (2018), that I, as a constructivist researcher, had to be acutely aware of the influence that my values and biases might have on the research scenario.

3.3.2 Instruments

The Amazing Race activity was designed to host the development of the most applauded 21st century skills needed to be successful as a student and also as a professional in the workplace. A qualitative approach was employed to investigate the effect of the environment on the students, I could merely get an indication that a student could communicate effectively, that he or she could collaborate with others and could think creatively and critically, pointing towards a qualitative interpretive stance.

Creswell (2013) defines case study research (a qualitative inquiry methodology) as the investigation of a bounded system over time to build an in-depth understanding of the scenario. He continues that this approach necessitates extensive data collection by employing multiple sources of information. Possible sources of information include observations, interviews, audio-visual material, documents and also reports. The data collected could consist of direct quotations in which people describe their experiences, opinions, feelings, and knowledge that have been garnered from interviews; comprehensive reports of people's behaviours that surfaced in the researcher's observations; and extracts that were mined during the analysis of various types of documents (Creswell, 2013).

For this study, data was collected using my observations and informal discussions with stakeholders, reflective essays that were written by the students, focus group interviews with the tutors and assistant lecturer and surveys completed by the students at the start and end of the semester.

3.3.2.1 Observations and informal reflective discussions

Observations serve as a major source of information regarding the case. By being an observer, the researcher can immerse into the social setting (Glesne, 2006). Four types of observation are defined: the researcher as a complete observer (non-participant); the observer as a participant (focus on the role of the observer); participant as an observer (researcher is part of the research process) and complete participant (totally immersed in the setting) (Maree, 2007).

Observations as a participant in the learning environment afford opportunities to learn first-hand whether the actions of the participants are in line with their words and whether there are certain patterns of behaviour amongst the participants (Spradley, 2016). He/she can obtain inside information on the expected and unexpected occurrences in the period and has an understanding of the development of trust, relationships and obligations with others (Glesne, 2006).

In 2018, the Amazing Race activity took place in the first week of lectures in February. Students had a double lecture session to complete the activity. The learning environment was, as previously mentioned, and designed as a game-based activity. The rules and instructions had been discussed at the beginning of the session, after which the students commenced with the activity. I was facilitating the activity and at the same time critically observing the dynamic interplay amongst the students and between the students and the scenario in which they had to operate.

The dual focus of the observation was on the progression of the race and on the student behaviour and responses to the different stimuli. I wanted to find design principles that could be employed in any game-based learning environment to enhance the learning experience of the students.

One of the benefits of these observations was that the phenomenon was observed in its natural setting while it was taking place (Creswell, 2013). As such, these observations could provide knowledge of the context and specific incidents or behaviours. These could be further explored as reference points in the follow-up interviews (Merriam & Tisdell, 2016). The observations could, in effect, be labelled as fieldwork as suggested by Merriam and Tisdell (2016) since it was interwoven with conversations with the students and the other involved parties.

I also had to, once again, consider my own subjectivity since I was aware of the fact that my perception of the activity could be very different from that of the other role players. For this reason, I also relied on the observations that the other persons involved made and their perceptions of the event to shape my own (Stake, 2000). After the completion of the activity, I had informal follow-up discussions not only with my colleagues and the tutors but also with the personnel at the facilities visited during the race. I wanted to obtain a holistic picture of all of these role players' observations during the race. Their perceptions regarding the successful completion of the activity and the impact that the activity had on the students would shape the design of the activity and provide useful information on the principles that could be implemented to further the successful execution of the learning environment. For this purpose, I had used informal semi-structured discussions to prompt for feedback. The term semi-structured is used since the questions were based on the same topics, but I did not necessarily use the same sequence in my approach (Roulston & Choi, 2018).

The Amazing Race activity had been refined and updated annually after the execution of the activity and again before implementation in the next iteration, the typical cycle followed in action research (Norton, 2018). For this purpose, I had relied on my own observations, the input of the tutors and the team of lecturers involved in our module and the colleagues at each of the destinations visited during the activity. Numerous factors such as the time that students used to complete the activity, problems that they had experienced with regard to the navigation throughout the race, typical questions that they had asked regarding the roadblocks, to name a few, played a role in the revision of the activity. In this regard, the input of colleagues and tutors stationed at strategic points in the route followed on campus provided useful information. I have evaluated all of the students' comments critically and discussed it with the team to validate the inputs and search for a workable midway considering the educational objective.

It could thus be argued that my observations were triangulated by the inputs of my colleagues, the tutors or persons at the destinations. I also informally asked for feedback from the students as they arrived at the final destination of the activity. During this stage of the inquiry, I had used my own observations and field notes together with those of the other stakeholders, as described.

I conducted informal discussions after the activity each year. Before the implementation of the activity in the following year, every destination was revisited to ensure that changes made to the facility or the route were incorporated and that new developments in and around these facilities that could possibly serve the purpose of enhancing the student's exposure to the 4Cs, could be included in the activity. Once again, informal discussions were used to gain information. Given the time frame in which the Amazing Race activity needed to be completed, only a double lecture setting, I had to rely on my experience as an educator in deciding on the value that each activity would add to the influence of the final product.

After following this process a few years, I realised that the learning environment and the process followed to refine the final product, even though not generalisable, could be used in other contexts as well. Therefore, I adapted my approach from only action research to a fully-fledged design experiment. This was possible since design experiments provide a forum for the investigation of a diverse interactive system where different forms of data from various sources can be united (Gorard et al., 2004).

In summary, in the phase of designing the research setting, I made use of my own observations and field notes coupled with the informal reflective discussions with the other stakeholders.

3.3.2.2 Reflective essay

As another source of data in qualitative data collection, documents could refer to a wide range of written, visual, digital and physical material that could be used to inform the case under scrutiny (Merriam & Tisdell, 2016). The final leg of the Race entailed the completion of a final task in a different team composition based on the students' place in the competition. During this lecture setting, I had given concluding remarks and general feedback on the Amazing Race activity. After this activity, students moved into the next phase of the module, being subject to workshops on time management skills, teamwork and critical thinking. I, however, wanted to know how the students had experienced the Amazing Race learning environment.

Reflection on learning experiences is essential, especially in competency-based modules (Berdrow & Evers, 2011). Rolfe (2001) notes in his work *Reflective practice: where now?* that reflection as a source of knowledge was established already by Socrates. He continues by adding that John Dewey, educationist and philosopher, in 1938 already claimed that students learn by doing and by the realisation of the results of their actions. In other words, the solution to problems is closely linked to reflective thoughts. Reflection could thus be seen as a profitable action in relation to learning, it may be seen as intuitive knowledge that stems from an action (Hetton & Smith, 1994). Reed and Koliba (1995) note that reflections begin with reconsidering the particulars of the experience, “what happened?” Then the description moves toward the interpretation of the meaning of the scenario, “so what?” where after this experience was placed into context, (“now what?”) students had to write a reflective essay on the Amazing Race activity. This was not their first attempt at reflecting on learning experiences since they were guided before this assignment to reflect on their high school time management and their first weeks as engineering students.

I asked that the students start their discussion by rating the Amazing Race experience on a scale from 1 (extremely negative) to 9 (extremely positive). This scale was developed by Rensis Likert (1932) to measure respondent attitude. Thereafter, students had to recollect their experiences of the Amazing Race by referring to the specific destinations that they visited, the clues to the different destinations and the roadblocks that they had to execute. To clarify, the feedback that I had expected from the students was not focussed on the benefits of the activities towards being a successful student and professional.

The documents that the students created and handed in electronically were used as data that provided information regarding the student experiences of the event. It could, therefore, be classified as researcher-generated documents (Merriam & Tisdell, 2016) since they wrote these to shed light on the Amazing Race activity. The reflective essay was written a month after the activity, implying a “reflection-on-action” and not “reflection-in-action” (Schön, 1987). The guidelines to write the reflective essay can be seen in Addendum A.

3.3.2.3 Focus group interviews

Interviews are conducted to obtain information that we cannot directly observe. This includes, as explained by Patton (2015), information regarding previous experiences (not accessible to the researcher), how the interviewees see their world and the meanings that they attach to certain events. A focus group interview with the tutors and the assistant lecturer was employed to gather information regarding the experiences of these role players and their perception of student experiences.

The data was used to triangulate the information garnered by the reflective essays and the observations and informal discussions. The characteristics inherent to a "focussed interview" as described by Merton and Kendall (1946) applied in this instance: the persons that were invited to partake in the interview had been involved in a certain concrete social situation (the Amazing Race). This situation had previously been analysed by the researcher and the resultant hypotheses regarding the significant elements, patterns and structure of the situation gave rise to the major areas of enquiry that would be the focus of the interview.

The main purpose of the interview, therefore, was not to build an objective recollection of the situation but to elicit more detail regarding the subjective interpretations of the participants (Merton & Kendall, 1946). Focussed group interviews provide the stage to "detect the causally significant aspects of the total stimulus situation" (p. 542), to investigate opposing viewpoints and the views of subgroups to reach a better, holistic understanding of the scenario. The focus group interview had the potential to provide the forum for uncovering a variety of perspectives and experiences during the process of sharing and comparing in the interactive discussions (Morgan & Hoffman, 2018). Morgan and Hoffman (2018) proposed the use of a "funnel" approach to interviewing because it could further a positive attitude amongst the persons interviewed since the interview progresses from less-structured, open-ended questions to more structured, targeted questions.

At this stage, after taking the information that surfaced during the analysis of the essays into account, I wanted to add another dimension to the inquiry. Even though I specifically have asked the 2018 students to reflect on their experiences of the activity in terms of the destinations, clues and roadblocks, some of them commented on the value of the activity regarding the attainment of skills needed in the 21st century workplace. The fact that the students recognised the ability of the environment to transfer 21st century skills, even though it was not part of the focus specified in the instructions of the assignment, raised my curiosity regarding the way that the tutors and assistant lecturer experienced the activity. For this purpose, in the focus group interview with the tutors and assistant lecturer, I had asked them to comment on the same aspects as the students and then prompted them to comment on the usefulness of the activity with regard to the attainment of 21st century skills.

As suggested by Creswell (2008), open-ended questions were used to allow the interviewees to express their opinions and describe their experiences. I had also included questions regarding strange occurrences during the race that I wanted to explore. The interview data was audio-recorded and thereafter transcribed. The transcription can be found in Addendum B.

3.3.2.4 Surveys

Surveys are conducted to gather information from a sample of a population often by means of a structured questionnaire (Lavrakas, 2008). The information gathered could inform a study regarding the demographic information of the sample and can be transformative since critical aspects to guide the design of a study can be identified (Collins et al., 2004). Survey data is used to describe, record, analyse and interpret the state of affairs and their relationship, if any, with past events (Kothari, 2004). Students enrolled for the module had to respond to two surveys during the first semester. The first questionnaire, conducted in the first contact session, concerned the student's demographic information and IT proficiency. The second survey, at the end of the first semester, was related to the student's experience throughout the semester regarding the subjects encountered in the semester. Both of the questionnaires can be found in Addendum C.

3.3.2.5 Summary

In summary, the events during which data was gathered were discussed in this section. All of the data collected was combined in a comprehensive case record, called the case study database. Yin (2014, p. 238) defined the case study database as a "systematic archive of all of the data…from a case study". All of the information harnessed and added to the case study database was edited, the parts were fitted together, and the redundant material was sorted out (Merriam & Tisdell, 2016). The case record, the word that Patton (2015) uses to describe the database, could be accessed either chronologically or topically after it had been organised. The procedures followed in the data analysis process will receive attention in the next section.

3.3.3 Data analysis

During the investigation into the value of the learning environment, the researcher looked into the scenario questioning the merit of the Amazing Race learning environment in terms of the value of employing a game-based approach to further the exposure to and the attainment of the 4Cs. Four methods of data collection were used: observations and informal reflective discussions, reflective essays, focus group interviews and, finally, surveys. The case study database, therefore, consisted of field notes, transcribed interviews, documents and data from the two surveys.

The process of qualitative data analysis is described by Flick (2014, p. 5) as "the classification and interpretation of linguistic (or visual) material to make statements about implicit and explicit dimensions and structures of meaning-making in the material and what is represented in it". Willig (2014) explains that to understand, a qualitative researcher needs to ask questions regarding people's experiences, their thoughts on these experiences, the feelings that they have about their experiences and the social practices facilitating these experiences. She continues that the meaning and significance that these people assign to their experiences need to be connected with different components and aspects of the data, thereby increasing our understanding of the scenario. To arrive at this understanding, we need to follow a process of interpretation of the data (Willig, 2014) taking the interdependence between the whole and the parts (the hermeneutic circle) into account.

3.3.3.1 Analysis of observations and informal discussions

The process of analysing the data regarding the Amazing Race activity itself commenced early in the investigation. I had analysed the comments of the different role players in the execution of the Amazing Race as soon as I had informally discussed the activity with the colleagues at different destinations. Using my own observations coupled with those of the other parties, I obtained useful information regarding the development of the activity and the refinement of the scenario, especially in the context of the design experiment. Based on a comparison between the input of the various parties and my own observations and by taking the limitations and constraints of the learning environment into account, I had listed the refinements that proved to be realistic and implementable. The results of the analysis at this stage was used to improve the learning environment by implementing subtle changes based on the inputs of the other role players together with my observations and the boundaries of the scenario.

The data analysis of the observations and informal discussions focussed on answering the first sub-question of the study: How can a game such as the Amazing Race be adapted to suit an academic purpose in a higher educational environment?

3.3.3.2 Document analysis-reflective essays

Krippendorff (2019) has remarked that data should not be regarded as physical events but rather as communications concerning the meanings that recipients have created and disseminated regarding their experiences. These meanings are open to interpretation and provide an opportunity for reflection on the multiple perspectives of different stakeholders. He states that content analysis is concerned with the interpretation of communications in the form of texts within their social context (Krippendorff, 2019).

Data mined from documents can reveal useful descriptive information, emerging hypotheses can be verified, new categories and hypotheses could surface, and it can provide historical understanding (Merriam & Tisdell, 2016). The reflective essays were analysed by using a hybrid approach, where the data was analysed first by using coding categories established by investigating the data deductively; these coding categories were expanded by re-reading the data, this time inductively (Morgan & Hoffman, 2018). The six steps in conducting a thematic analysis as proposed by Braun and Clarke (2006) include the repeated reading of the transcripts to establish a thorough comprehension of the data before the data is systematically coded and preliminary themes are developed. Thereafter, these themes are revised and a final set of themes identified around which the final report is organised (Braun & Clarke, 2006). These steps provide a systematic procedure that corresponds with the procedure proposed by Creswell (2008) that will be valuable during the analysis phase of the documents.

The analysis of the reflective essays could commence after it has been organised as a complete set of data. For this purpose, I saved it electronically in a folder, and I printed a hard copy of every contribution. I numbered the essays as I printed them. In this way, the numbers were not allocated according to the students' surnames in alphabetical order but randomly since the time at which the students handed in the assignment are used as ordering principle of the downloaded submissions on ClickUP. Thereafter, the numbers as they were allocated to each student were recorded on the class list. This was done so that I could easily manage each contribution and ensure the anonymity of the participants. To make sense of the data obtained by the reflective essays, I was scanning the information revealed by the students in the 139 essays searching for meaning (Merriam & Tisdell, 2016), reading and re-reading bits and pieces of the information to build a holistic view of the data. I was specifically looking for themes by which to categorise the data. At this stage, I used different coloured highlighters to accentuate phrases that referred to the destinations, the clues and the roadblocks as these were the topics on which I solicited comments from the students. I soon realised that the students commented on a lot more than anticipated and had to expand these categories to include teamwork, critical thinking, communication, fun and much more.

The problem that I faced was that there was an overwhelming amount of information, and the comments regarding the themes were intertwined. One comment could be used to elaborate on more than one theme. The hermeneutic approach (Flick, 2011) was followed in the analysis, whereby an understanding of each part in relation to the whole and the whole as a sum of the different parts was applied to develop an understanding of the text.

I changed my strategy, first opting to summarise the content of each essay by using an MS Excel workbook. The worksheet contained information by which a participant could be identified, the participant's student number, surname, initials and title and then the participant number for the purpose of this study. Since I asked the students to score the activity on a scale from 1 to 9 (1 being extremely negative and 9 being extremely positive), I recorded the mark allocated by every participant to the value of the activity on the spreadsheet. Unfortunately, of the 139 students that completed the assignment (essay), 33 did not score their experience of the activity. The average score allocated by the rest of the students (106 of them) was 6.28 out of 9. For easier interpretation a score of approximately 7 (6.98 to be precise) out of 10. This score just served as an indication of the attitudes of the students towards the Amazing Race activity.

I also tried to value whether the student's overall position towards the activity could be regarded as being positive or negative by reading through the essay before analysing it. This proved to be extremely difficult, and I realised that my own biases could surface and skew the results, especially since the students commented on both the positive and negative experiences they encountered. It did, however, give me the opportunity to grasp the fact that the most of the students reacted overwhelmingly positive to the environment and confirmed the outcome of the evaluation of the activity on the Likert scale as described previously.

The MS Excel worksheet was also used to record the detailed content of each contribution. References to any of the destinations, be it the library, Old Arts building, the Sci-Enza, Student Health, the MakerSpace and the Mining Study centre, were indicated in columns created for each of these destinations. Furthermore, columns were created for references to the roadblocks and clues. As I worked through the data, other columns were added. For example, columns to record references to the value of teamwork, instances where critical thinking and creativity were mentioned, comments regarding fun experienced, students that commented that they have learned about campus and the help available at the facilities were added. In total, the worksheet contained 24 columns to embody an overall impression of the data. These columns were then used to identify the initial codes that I was going to use in the coding process. The number of categories correlates with what Creswell (2013) proposed when he said that he preferred to start with between 25 and 30 categories that are, in the end, reduced and combined to five or six themes to be used in the report. By using these categories to code the data, I was confident that the research questions could be addressed (Merriam & Tisdell, 2016) since not only was it representative of the Amazing Race activity but it also reflected the use of the game as a learning environment, and finally it also referred to the attainment of the 4Cs. Furthermore, the categories appeared to, as indicated by Merriam and Tisdell, encompass all relevant data, were mutually exclusive, and the categories' names captured a sense of the nature of the category. Since the study was concerned with different facets of the environment, the level of abstraction differed between the categories. This contradicts to the final suggestion of Merriam and Tisdell (2016) that the categories should be "conceptually congruent".

It is evident from this discussion that the process of data analysis, searching for themes, patterns or categories that are representative of the data, was inductive and comparative (Merriam & Tisdell, 2016).

During the next phase, I used the colour-coded hard copies to compile a Word document on each of the themes identified. I copied the relevant phrases from the students' documents and pasted it together with their participant codes in the respective documents. This proved to be a long and extensive process that I could have been done much more effectively by using AtlasTi. The problem arose when I wanted to shuffle the student comments around after carefully evaluating each document. Using the electronic version, I felt that I could not see the overall picture regarding each theme. As a result, I printed out the documents compiled per theme, cut the different student comments loose and used an A3 size paper per theme to be able to comprehend all of the comments (with the reference to the participant number) stapled on the paper. By using this method, I was able to see the emerging structure in the data better and it was also easy to transfer the comments between the different themes. This process was very time consuming, and I am sure that there are more effective ways to analyse the data. I used these A3 compilations to comprehend the "storyline" that emerged from the data. The data collection and analysis process that I followed during my studies could, therefore, be labelled as being typical to those of a qualitative study, as being recursive and dynamic (Merriam & Tisdell, 2016).

3.3.3.3 Conversation analysis-focus group interviews

As the focus group interview was audio-recorded, it first had to be transcribed. Kowal and O'Connell (2014) said that in the process of transcribing an interview, the person/persons involved have to be aware of the fact that the transcription has to represent the scenario in such a way that it would give the researcher a comprehensive and accurate narrative of the whole event. They propose three different approaches: a transcription of the words spoken, the way in which it was spoken and finally recording the non-verbal vocal behaviour that accompanies the words (Kowal & O'Connell, 2014).

Since this is a complex procedure, these transcripts preferably have to be generated and checked by more than one person. I listened to the audio recording while reading the transcription repeatedly to familiarise myself with the data and ensure that the data was an accurate representation of the interview. I had to be open to the possibility that I could uncover data that could provide alternative pathways and new insights, as cautioned by Merriam and Tisdell (2016) since I was the primary instrument in the gathering and analysis process.

The focus group interviews with the tutors and the assistant lecturer were analysed by basically using the same process as described for the document analysis. I once again allocated numbers to each participant to ensure their anonymity. This time around, I used the categories that surfaced in the document analysis as a basis and once again added new ones as I was busy working through the transcription of the interview. Since I was scrutinising the data for more evidence to confirm the final set of categories, I was operating from a deductive stance (Merriam & Tisdell, 2016) while still being open to the uncovering of unexpected new insights.

The data that was obtained during this stage was used to triangulate the data obtained in the document analysis and provided insight into the three research sub-questions.

3.3.3.4 Analysis of data garnered by the surveys

The data gathered by means of the two surveys was downloaded from ClickUP and saved in the case study database. Since the data was obtained in the form of an MS Excel workbook, demographical information could be extracted and analysed either in MS Excel or by using IBM SPSS Statistics 24.0. The codes used to identify the instruments and the respective participants are listed in Table 4.

Table 4: Codes assigned to different instruments

Instrument	Code assigned	Participants
Reflective essay	RE	139 Students [S]
Focus group interview	FI	5 Tutors [T] 1 Assistant lecturer [AL]
IT survey	ITS	84 Students [ITS_S]
ENGAGE survey	ES	89 Students [ES_S]
Observations	Interwoven in discussions	1 Lecturer

The final write-up of the Amazing Race learning environment contained a great portion of the description to provide a comprehensive understanding of the scenario. The observed data was described after which the focus moved to a more abstract level where concepts were used to describe phenomena. The actual words of the participants were used to elaborate on their experiences to enable the reader to grasp a holistic view of the case scenario. To be able to evaluate my interpretations of the scenario, I relied on my "own sense-making, understandings, intelligence, experience and judgement" (Patton, 2015, p. 572) and on the responses evident in the comments of the participants after they had read my interpretation of their experiences. I did this since Patton (2015) suggests that the reactions of the people that read and review the results of the study could provide further insight into the meaningfulness of a researcher's interpretation.

The discussion of the document analysis integrated with the data that was mined from the focus group interview, my own observations and those of the other role players can be found in Chapters 5 and 6. The focus in these chapters was in the first place on the student experiences of the destinations, the clues and roadblocks in an attempt to answer the first research question: How can a game such as the Amazing Race be adapted to suit an academic purpose in a higher educational environment? Then the game features were investigated to shed light on the second question: Why can this learning environment still be categorised as a game-based learning environment? Finally, attention was paid to the environment's influence on the attainment of the 4Cs in answering the third question: To what extent does a game-based learning environment provide the opportunity for the development of the 4Cs (21st century skills)?

3.4 THE TRUSTWORTHINESS OF THE RESEARCH

The trustworthiness of qualitative research as scientific inquiry is a topic of frequent debate. In experimental designs, the validity and reliability of the research could already be established in the design phase of the study. The rigour in a qualitative study, however, depends on numerous factors. Merriam and Tisdell (2016) state that the validity and reliability in qualitative research depended on the ethical manner in which the research was conducted. This means that careful attention must have been given to the conceptualisation of the study, to the data collection procedures, to the thoroughness of the analysis, the interpretation process and the presentation of the findings (Merriam & Tisdell, 2016). Lichtman (2013) further clarifies that the value of a piece of research depends on the relevance of the topic. The measures that he indicates are ensuring that the method followed to investigate the problem makes sense, that the information provided regarding the study is enough to allow the reader insight into the study and that the new knowledge that stem from the study could be used to the benefit of everybody (Lichtman, 2013).

Researchers' opinion regarding the use of the concept "validity" in qualitative inquiry range from denying the applicability of the concepts normally used in a quantitative paradigm (Guba & Lincoln, 1989) to arguing that different procedures are applicable in determining the validity of qualitative research (Kirk & Miller, 1986). Maxwell (2002, p. 43) argues that "validity pertains to the kinds of understanding that accounts can embody". He refers to five broad categories of understanding typical to qualitative research and identified five corresponding types of validity that could be used in determining the validity of the research study: descriptive validity, interpretive validity, theoretical validity, generalizability, and evaluative validity.

From an interpretive-constructivist perspective, the validity and reliability of the research project can be ensured by using triangulation (Merriam & Tisdell, 2016). Patton (2015) explains that triangulation increases the credibility and quality of a research project by addressing the concern that the research findings are based on only one case by using only one method and source. Triangulation, according to Flick (2011) should promote the quality of the research by providing a surplus of knowledge at different levels. In the case under scrutiny, the data was gathered by means of observations, semi-structured interviews, documents and a focus group interview. The issues addressed differed, the documents revealed student insights on the activity itself whereas the focus group interview, using a different sample to investigate the scenario, focussed only partly on what the student experiences were. Data garnered in this interview revealed another perspective on the activity. Not only because of the participants' differing status but also with the focus being on the attainment of the 4Cs.

Triangulation poses the opportunity to increase not only the descriptive validity of the study (multiple sources could be used to make an accurate representation of the scenario) but also the interpretative validity (the understanding of the experiences of the students) and the theoretical validity. Theoretical validity, as defined by Maxwell (2002), goes beyond the concrete description and interpretation of the scenario, it encompasses the researcher's explanation of the phenomenon. This explanation has to take the different parts (construct validity) in relation to the whole picture (internal or causal validity) into account. My description and the interpretation of the Amazing Race scenario were shaped by the inputs from multiple sources of information. The fact that the participants in every data collection situation differed in stature and that the data collected provided different views on the same scenario, provided multiple views that could inform my description and the interpretation of the meaning that I derived from the participants' inputs.

The explanations that I opted to offer to the different occurrences could be validated in the informal reflective discussions by bouncing it off of the other participants in the study. This is consistent with another method of heightening the validity and credibility of the research: member checks or respondent validation (Merriam & Tisdell, 2016). I had to look into different perspectives regarding my explanation and re-evaluate the validity of it. I spent many hours planning the event and collecting enough data to allow the construction of a sensible picture of the event. The data analysis process was extensive. I looked and looked again, as described earlier. I tried to validate the conclusions that crystallised in the research process by discussing it with my colleagues (it can be seen as peer review), in this way, I was trying to establish the validity of my evaluation of the scenario.

The description of the scenario and the students' experiences in Chapters 4, 5 and 6 is done using the students' and interviewee's own voices in a comprehensive account of every detail that surfaced during the enquiry. By providing a "rich thick description", I wanted to make sure that the reader would be able to relate to my findings and that the transferability of the scenario and the findings to the readers' contexts would be easily visible. This was another strategy proposed by Merriam and Tisdell (2016) to promote the validity and reliability of the research.

3.5 LIMITATIONS

One of the limitations of any qualitative research project is the question of generalisation. Scofield (2002) stated that generalisation refers to the action of taking "what is", to what "may be" and then to what "could be". Another definition of generalisation: "assertions of enduring value that are context-free" (Lincoln & Guba, 2009), raised questions regarding the use of the generalisability of research as a measure of its value to the body of knowledge and as a measure of external validity. Especially in the context of social inquiry where the context and event are inseparable, the focus should rather be on the internal generalisability, defined as generalisability within the same type of community or settings that were not directly observed or interviewed (Maxwell, 2002).

The fact that a qualitative, interpretive research approach was followed in the Amazing Race study already revealed my intention: I did not want to discover what was true for everybody, the focus was on an in-depth understanding of the particular (Merriam & Tisdell, 2016). Nonetheless, the findings of this research project might be useful in other contexts where the educators also aim to instil certain qualities in their students. The game-based learning environment created to expose students to opportunities to develop 21st century skills could easily be adapted to fit into any institution's environment. The concept of the Amazing Race, for instance, is already implemented in many other contexts. It is used as an introduction into the facilities offered in the library, in the hostels and the initial orientation of first-year students on the campus. The educational slant has to be purposefully designed and customised. I believe that it is possible to replicate the outcomes of the project (that it was possible to create an environment conducive to the development of 21st century skills in engineering students) by applying the design principles that I discuss in future chapters. I acknowledge the fact that the conclusions drawn from case study research are provisional; they are accepted until a better explanation for the phenomenon could be found as indicated by Thomas and Myers (2015). The case of the Amazing Race could be repeated in other circumstances, with another game as a basis and other educational objectives by following the principles that surfaced during this study.

3.6 ETHICAL CONSIDERATIONS

Beneficence, respect and justice, these three ethical principles are imperative in any research environment (Mertens, 2018). Mertens (2018) explained that research should be aimed at maximising the good and minimising the harm for science and humanity; people in any population with different standings in the society should be treated with respect. She continued that justice refers to the sampling process followed, the good that stems from the research should be beneficial for the participants in the research. Justice is also concerned with the fairness displayed in the researcher’s conduct: how disputes are resolved, decisions made and rewards allocated (Mertens, 2018).

It is evident that every decision that a researcher makes is subject to ethical considerations. In determining the sample, researchers have to be aware of the possibility of excluding persons based on certain characteristics. Participants in the research have to be informed of the purpose of the research. The privacy and anonymity of the participants, and also the confidentiality of the information harnessed need to be ensured (Lichtman, 2013). Mertens (2018) emphasised that qualitative data collection is burdened with numerous ethical considerations throughout the process. The researcher should at all times be aware of the influence of his or her behaviour, whether conducting interviews, recording the data, also with regard to his or her interpretation of the events and the circumstances surrounding it. Truthfulness in the reporting process and accuracy in reporting the data are two more factors that need attention (Lichtman, 2013).

Furthermore after the data has been collected, the original research team is responsible for the ethical interpretation of the data (Mertens, 2018). This includes the use of the data for other purposes by other researchers, to answer other questions than the original research question. Access to the data set should be restricted and controlled by the researcher, ensuring the participants’ confidentiality. The researcher is ultimately responsible for all of the ethical issues surrounding the research.

Research quality could be increased by the ethical conduct evident in the research (Guba & Lincoln, 1989). Criteria listed by Guba and Lincoln (1989) that could be used to evaluate the ethical conduct of a study include credibility (accuracy of findings), transferability (rich descriptions provided to enable judgements regarding applicability in another context), dependability (substantiation of hypothesis and changes in understandings), confirmability (link between data and conclusions) and authenticity (multiple perspectives provided).

Every institution has ethical guidelines by which researchers should abide. At the University of Pretoria, ethical clearance had to be obtained from the EBIT faculty and from the Faculty of Education. The guidelines focus on the participants, the organisation and also the integrity of the research. Participation in the research has been voluntary. The participants have been treated with respect and have not been exposed to psychological, financial or social harm in any way. Anonymity and privacy of the participants (individuals and the organisation) were safeguarded and possible conflicts of interests stated. Special consideration was given to the language used in the data gathering instruments, it was not offensive, discriminatory or unacceptable. Research data was handled with discretion. Discussions and analysis will be objective and unbiased, aimed to be honest and transparent. The researcher will give credit to other authors by using the appropriate referencing system. Permission from the ethics committee of the faculty of Education and the faculty of Engineering was obtained before the study could be initiated.

3.7 SUMMARY

The Amazing Race learning environment was specifically designed to further 21st century skills in first-year engineering students. As such, the process was labelled as action research that was changed to a design experiment in 2018. The design process is discussed in Chapter 4. At the inception of the design experiment, a case study was conducted by limiting the research to the Amazing Race activity that took place in 2018. All of the research activities were planned to aid in the construction of an in-depth understanding of the scenario based on relevant information. The students, tutors and assistant lecturers that were part of the scenario in 2018, were sampled as they could provide inside information that could enable me to provide a rich, detailed description of the case. The data collection strategies were focussed at providing information on the research questions. Since I view research as a set of interactive components that is a non-linear process, I intentionally allowed different paths to develop and have been flexible in my approach to explore every new avenue. I tried to describe the methodology in enough detail that it would be possible for the reader to transfer the knowledge gained to other environments.

The data collection and analysis was done carefully and attentively recognising the impact of ethical conduct at every stage of the case study. As being part of the

Amazing Race activity from the conceptualisation to the analysis stage, I was acutely aware of my own perceptions and biases and opted to use an approach whereby I triangulated and validated every opinion and perception that I encountered in the data analysis process, be it my own or that of the other participants. The conclusions reached and the design principles communicated cannot be generalised to any broader population, the intention of the research was, after all, to reach an in-depth understanding of the interplay of all of the parts of the Amazing Race to reach to an understanding of the whole. However, the design principles could be applied to other educational platforms, especially when considering the characteristics of our students. I believe that any existing game could be transformed to fit an educational scenario while most importantly realising the intended learning objectives. This is possible with careful planning and most importantly, with an enthusiastic, dedicated educator.

4. CHAPTER 4: THE INTERVENTION

4.1 INTRODUCTION

In this chapter, the background of the scenario in which the Amazing Race was deployed as orientation on the campus and first introduction to the 4Cs (communication, creativity, collaboration and critical thinking) is described. Thereafter, the development of the assignment from a “Campus Walk” orientation to an “Amazing Race” is delineated. The adaptation of the game to the UP context and how the game elements, such as the different legs of the race, the clues and roadblocks, the final leg of the race and the grand prize were introduced to the students are described. Finally, student comments are used to explore the suitability of this learning environment in higher education to further 21st century skills.

4.2 BACKGROUND

Faced with the expectations from industry on the one hand, and on the other, challenged by the level of competence of first-year students that came through the South African educational system, the presentation of content in a multi-faceted higher education environment could be problematic. After an evaluation of South Africa’s matric results, especially in mathematics, for the period after the transition to democracy in 1994 up until 2011, it was found that “there is an ongoing crisis in South African education, and the current system is failing the majority of South Africa’s youth” (Spaull, 2013, p. 2). Even today, statements such as “South Africa’s real 2017 Matric pass rate – 39.25%” (Mybroadband.co.za, 2018) intensify the awareness of the educational challenges with which South Africa have to deal. The Department of Basic Education (a department that directs primary and secondary education in the Republic of South Africa – [RSA]) acknowledged that learners leaving the basic educational system are ill-equipped for university studies (Bateman, 2016).

Within this context, the problems that higher education institutes are facing are exacerbated even further, when policies regarding access to training opportunities in South Africa (SA) are taken into account. On the one hand, access to post-school training and education have to reflect South Africa's quest for economic growth (DHET, 2012) while the learners, on the other hand, after attending the South African school system, are not equipped to be successful in this environment (Pinnock, 2013). Still, according to the Green Paper for Post-School Education and Training (DHET, 2012), post-school training and education should also be aligned with South Africa's "goal of inclusive economic growth and development, and [should] contribute to fundamentally reducing unemployment and poverty" (p. x). Regardless of the level of proficiency of learners leaving the educational system, it is envisioned that the graduate numbers in engineering should increase from 9974 in 2012 to 57000 over the five years as stated by the medium-term strategic framework (MTSF) 2014-2019 (Republic of South Africa, 2014).

The expansion of access to education and training opportunities is, therefore, a priority for higher education institutions (DHET, 2012) with the overarching goal of creating learning opportunities for a large number of young people between the ages of eighteen and twenty-four. Since many school leavers do not comply with the minimum entry requirements mentioned earlier, higher education institutes had to employ additional strategies to allow bright students who may have been disadvantaged by the failing school system, entry into higher education.

4.3 FOUNDATION PROGRAMS

Taking the unfortunate situation regarding the challenges faced by the secondary school system to deliver students that comply with entry requirements into account, higher education institutes in SA designed academic development programs (AD) in an attempt to address the issues relating to the under-preparedness of students (Engelbrecht, Harding, & Potgieter, 2014). Academic Development is "an open set of practices concerned with improving the quality of teaching and learning in higher education" (Volbrecht & Boughey, 2004, p. 58). Originally, in the early 1980s, Academic Support Programs (ASP) aimed at supporting and developing the students' learning, were implemented. As Torr (1991, p. 624) remarked, these ASPs were "developed to assist students without the necessary background to be able to benefit immediately from lectures and tutorials". For this purpose, educational specialists worked hand in hand with counsellors and psychologists, "filling the gaps left by students' impoverished educational experiences" (Boughey, 2013, p. 5).

From 1990, there has been a movement away from traditional add-on programs towards the integration of the support programs with the mainstream teaching programs (Boughey, 2007). Curricula development and teaching methodologies to address the needs of the increasing number of underprepared students were the focus during the Academic Development phase (Engelbrecht, Harding, & Potgieter, 2014). In 2000, Foundation Programme Grants changed the playfield and signalled the Institutional Development phase: students had to enrol in "Extended Programmes" where accredited programmes were extended by a year of study in which additional support and development could be provided (Boughey, 2013).

The naming conventions for programs offered at higher education institutes aimed at the broadening of opportunities for underprepared students differ from one institution and faculty to another. These programs could be categorised as foundation, augmented or extended programs (Grayson, 2010). Foundation programs are often structured to prepare students within a year by offering modules to prepare students for the science modules of the mainstream while instilling the academic literacy necessary to be able to enter into a specific study field (Engelbrecht, Harding, & Potgieter, 2014; Foundation Programmes, 2018). There are also specific bridging programs structured to assist students in upgrading their final year marks to gain entry to undergraduate studies (EduConnect, 2018), or to gain the prior knowledge assumed to be in place before starting their studies. Both of these models entail a period where the student prepares to enter a specific study field.

Extended curriculum, or extended degree programs, in contrast, are designed to support students to be successful while they are already enrolled for their undergraduate studies (DHET, 2012). These programs are, therefore, structured to help students with the transition from school to university by spreading the first year of the study program (scheduled for the mainstream) over two years (CHE, 2013). Furthermore, these programs are providing additional academic support, while also concentrating on the development of skills needed to be a successful student. While it is acknowledged that there are other definitions of extended degree programs as well, this study will only focus on the one mentioned here.

4.3.1 The UP context

Students that aspire to study engineering in a four-year degree program at the University of Pretoria have to comply with strict entry requirements. To offer students who do not comply with the minimum requirements to enter the four-year engineering degree, the opportunity to access an engineering study programme, the University of Pretoria introduced a five-year-long extended programme, called the ENGAGE program. This program is designed so that students can "acquire the background knowledge and develop the cognitive and metacognitive skills and behaviours needed to succeed in an engineering degree" (Grayson, 2010, p. 15.465.2) while being enrolled for their engineering studies.

In this extended programme, the mainstream first year of engineering studies is spread over two years. In the first year of their engineering studies, ENGAGE students face familiar areas of study (Mathematics, Physics and Chemistry) presented in three different modules. These modules are supported by supplementary modules focussing on each of these disciplines presented to fill in conceptual gaps and overcome possible deficiencies in the schooling system. Professional Orientation, a module aimed at the development of a variety of attributes needed to be successful as an engineering student and graduate (Steyn, 2005), is a supplementary module also presented to the students in the first year of study.

The second year of the ENGAGE program then comprises of the typical engineering modules (that the mainstream students already encountered in their first year), but these are also supplemented with additional modules aimed at the conceptual understanding of each subject (ENGAGE Student Guide, 2018). The ENGAGE program is designed to improve the throughput and retention rate of engineering students, especially in the first and second year of their studies. Therefore, the program is structured in such a manner that the difficulty and volume of work increase through the five years of study, while the support decreases systematically (Grayson, 2010).

The admission requirements for the ENGAGE program allow students that “show academic potential”, but did not obtain the required matric results for entrance into the four-year degree program, to enter engineering studies at the university (University of Pretoria, 2018c, p. 1). On entrance, these ENGAGE students are regarded as being at risk academically. This is not only because they enter the system with a lower Admission Point Score (APS), but also because of an interplay of factors such as restrained educational backgrounds, motivational difficulties, wrong career choices and the demands of tertiary education (Du Plessis & Steyn, 2006). The ENGAGE students do not only have to cope and adjust in a new environment but also manage significantly higher academic expectations than in high school.

There is no denying that engineers are a breed all their own (English, 2016). Moreover, when taking into account that there are currently nine different fields of engineering offered at the University, the ENGAGE students are not only diverse in terms of their demographics, but also in terms of personalities and interests. ENGAGE students are poles apart in some instances in terms of the level of competency they possess in various fields. Some of the students have never even touched a computer, while their counterparts may have had computer science, or computer application technology, as school subjects.

Another factor that has to be considered is the fact that the students (part of the convenience sample of the longitudinal study) are, according to the generation typology, Generation Y and Generation Z learners. As discussed in Chapter 2, Generation Y students are born between early 1980s and early 2000s according to most scholars (Gözükara & Çolakoğlu , 2016) while Generation Z students are born from the mid 90s (Consultancy.uk., 2015). Since the study is a design experiment in the development of the intervention coupled with a cross-sectional case study of the 2018 cohort's experiences of the intervention, the generational differences need to be acknowledged in the discussion of the results. This is especially in the light of the fact that Generation Z, according to Jenkins (2015) is the "extreme version and the opposite of Millennials" (Generation Y students, para. 4).

Within the ENGAGE cohort, a mix of well- and underprepared students (due to the circumstances described above), complicate the educational playfield. They are not only diverse in terms of demographical, personal, and generational characteristics but also regarding the preparedness for tertiary studies. All of these factors have to be considered in the construction of an enabling environment (Chadha, 2006). Especially in the module, Professional Orientation, since students do not realise the importance of the skills addressed in the module. Ideally, learning opportunities should be personalised, "shaping and combining many different learning resources and sources of support around personal progression" (Bentley & Miller, 2006, p. 117).

4.3.2 Professional Orientation

Professional Orientation is a compulsory, credit-bearing module presented over two semesters in the first year of the ENGAGE students' engineering studies. It is, in essence, a foundation module that focuses on the development of the student's communication skills, provides them with an introduction to IT and technology and aims to enhance specific life skills that are regarded as imperative for students' success (Grayson, 2010). Active learning, face-to-face interaction, cooperative learning, continuous assessment and extensive feedback, are a few of the underlying educational standards followed in structuring the module (Steyn & Du Plessis, 2007).

The curriculum is tailored to accommodate the compilation of the specific learning gains intended for students with different interests, personalities and attitudes toward learning (Steyn, 2005). The curriculum design of the module further accommodates the fact that students each learn at a different pace, and the learning content is consciously malleable to address the fluctuating and varied needs of the students. Tuition is based on a number of projects that enables lecturers to follow a holistic and integrated approach in developing student capabilities.

The projects are guided by the exit level outcomes of ECSA, a council similar to ABET in America (Du Plessis & Steyn, 2006). As indicated in Chapter 2, the exit level outcomes translate to a certain extent into the 4Cs (communication, collaboration, creativity and critical thinking) as presented by the P21 movement. The development of 21st century skills expressed as the 4Cs are blended with the learning content and elements thereof are included in each of the project activities.

The curriculum of Professional Orientation is designed around *Engineering Reading and Writing*, *Academic Practices* and *IT*. The focus of the *Engineering Reading and Writing* section is to improve the students' communication skills, specifically concerning reading and writing. The second section *Academic Practices* focusses on academic proficiencies needed to be successful as both an engineering student and a graduate and includes, amongst others, topics such as time management, teamwork and study skills. The objective of the *IT* section is to develop the students' expertise in the use of Microsoft Office products: MS Word for report writing, MS Excel for calculations and project management, MS Visio for flow diagrams and sketches, and MS PowerPoint for oral presentations.

The educational playfield of Professional Orientation changes frequently. Originally, the students enrolled for Professional Orientation were previously, disadvantaged students that had little or no exposure to technology and the educational resources available to students today. Professional Orientation lecturers faced the challenge of addressing the shortcomings in their educational backgrounds, develop the personal, academic and communication skills and introduce them to IT (Steyn, 2005). Today, students in Professional Orientation are still perceived as being underprepared but not necessarily for the same reasons as in earlier years. In terms of generational typologies, the students that enrolled for Professional Orientation changed from being Generation Y students to being part of Generation Z. Professional Orientation is, therefore, a module that is constantly being reviewed and renewed to address the needs of the students in a particular cohort.

The difference between individual students regarding their levels of proficiency in communication, IT and their ability to manage their time and work in teams is starkly noticeable in the first semester of the students' engineering studies. As such, the curriculum for the first semester needs to accommodate both those students who are competent in the skills mentioned above and those who are not. Learning activities are structured to ensure the active engagement of all students as promoted by Astin (1999), despite their diversity, and embed the opportunity to practice the basic skills that they need to survive in the transition from school to university. Research has shown that active engagement in activities acted as a barometer of student performance that reflected in the grades obtained by first-year students (Kuh, Cruce, Shoup, Kinzie, & Gonyea, 2008). All of the teaching and learning activities of Professional Orientation are designed to actively engage students in activities that are focussed on providing opportunities to develop the 4Cs of the 21st century skills.

The educational arena, with differing student personalities and differing fields of interest and above all the fact that the students are categorised as generation Z, is complicated. Added to this, the lower grades and differing backgrounds of extended program students emphasise the urgency of activities that would strengthen the student's academic position. Since the purpose of higher education involves the development of the whole person (van Breda, 2018) to fulfil the expectations of the working environment (Tomlinson, 2017), the focus is not only on student retention but also on the levelling of the educational playground, academically speaking to be successful. The quest for student retention on the one hand and delivering graduates that display not only content knowledge but also the 4Cs on the other led to the question: How can a game such as the Amazing Race be adapted to suit an academic purpose in a higher educational environment? The focus was to create a learning environment that would be beneficial for the development of the 4Cs.

4.4 **THE INTERVENTION**

Students entering higher education institutes benefit from information regarding the location of classes, support services and other structures that could assist them to cope in their new environment. It could support them to actively open up to possibilities presented by the facilities available on campus and the opportunities offered by the campus community with the added advantage of a positive influence on their learning (Lau, 2003). Since I was in search of an activity to expose the students to opportunities to develop the 4Cs, the Amazing Race scenario provided a platform to combine the quest for campus orientation with an opportunity to develop the 4Cs, communication, collaboration, creativity and critical thinking. One of the first activities that students encounter upon entering the first-semester tuition is the Amazing Race. This game is based on the popular reality TV show with the same name: *The Amazing Race*© that is broadcast by CBS, an American television network. (*The Amazing Race*-CBS.com, n.d.).

4.4.1 The Amazing Race

The Amazing Race©, created by Elise Doganieri and Bertram van Muster and hosted by Phil Keoghan, premiered in September 2001 (*The Amazing Race*-CBS.com, n.d.). Teams of two people partake in a race around the world for a grand prize of $1 million awarded to the first team to arrive in the final leg of the race. The teams travel to several continents by using different transportation modes such as aeroplanes, boats, trains, buses, taxicabs and more to chase after clues on the activities to be completed in each leg of the race. The clues could either direct teams to their next destinations or could be instructions for the completion of a task by one or both of the team members. These tasks, referred to as “Road Blocks”, “Speed Bumps” and “Fast Forwards” are usually related to the location where the challenge is received. Teams strive to complete each leg ahead of the other teams to win a prize at the pit stop (end of the leg of the race) and to avoid elimination from the race. Only three teams remain to compete in the final leg of the race for the grand prize.

4.4.2 Amazing Race for Professional Orientation

One of the first activities that students encounter upon arrival in the Professional Orientation lectures is the Amazing Race activity, which provides the students with an opportunity to explore the campus environment and serves as a first introduction to the 4Cs needed to be successful in their studies and as future engineering graduates. It is an interactive game-based activity in which students receive instructions that call on the students' creativity and experiences to find solutions to the challenges posed in the game.

The design champions student-centred, inquiry-based learning in small teams where the lecturer only features as a guide in the problem-solving journey on the campus. As such, it can be typified as problem-oriented learning. By using a game setting, student engagement is ensured in a constructive, innocuous learning environment without the presence of any intimidating factors (Kirillova et al, 2016). During the activity, apart from being habituated with their new environment, students have the opportunity to work with a few of their counterparts, they meet new students and have to communicate effectively to be able to solve the clues and roadblocks provided to complete the race. The development of the 4Cs, communication, creativity, collaboration and critical thinking, are taken into account in the pedagogical design of the activity. The activity is revised after every iteration, and practical issues are addressed to fine-tune it to suit the needs of our students. The process of transformation and development of the activity is described in the rest of this chapter.

4.4.2.1 Teams

The basic principles of the Amazing Race were implemented in the design of the learning activity: Teams of two receive clues to a set of destinations. In the television program, teams featured usually had pre-existing relationships. In the Amazing Race for Professional Orientation, students could choose with whom they wanted to complete the race. Since this activity was one of the first activities that the students encountered, they usually knew only a few of their peers. The choice of one person to work with forced them to collaborate with at least one other student in the class.

4.4.2.2 Destinations

The destinations in the television program are usually located on different continents with exciting challenges regarding the diverse languages and cultures through which the contestants have to navigate. The destinations in the Amazing Race were selected based on the relevance of a specific destination to the student's academic environment to motivate the students to use the resources available, as recommended by Kuh et al. (1994). Students were, amongst others, introduced to services in the Library and the Mining Study Centre, a building that serves as an example of the implementation of green engineering on campus. In a similarly playful way, the locations of multiple other services available on campus (e.g. health services, food quarter, bookshop, MakerSpace) were revealed. Students were also exposed to some historic buildings on campus, e.g. the Old Arts building and the Musaion.

The clues led students to the Sci-Enza, the oldest interactive science exhibition in South Africa (University of Pretoria, 2018b), and the last clue returned students to the starting point of the race. Apart from addressing common resources and services available to the students, the Amazing Race was designed to expose the students to other "non-engineering" contexts as well. Students are sensitised to phenomena and newsworthy spaces on the campus by the differing instructions and in this way could develop a sense of belonging at the university. A few of these destinations can be seen in Figure 8.

Figure 8: **Destinations visited in The Amazing Race (Wikimedia, n. d.)**

4.4.2.3 Roadblocks

The roadblocks, speed bumps, fast forwards and detours that contestants in the television series encountered at their destinations and that had to be completed by one or both of the team members, were customised for the Amazing Race for Professional Orientation. Upon arrival at a destination in the Amazing Race for Professional Orientation, a “roadblock” had to be overcome after which the team received their next clue.

Teams had to complete four roadblocks, one at each destination before they received the final clue that led them back to the starting point. The roadblocks at each destination were designed to stimulate students’ observations and problem-solving capabilities on different levels. In some cases, the activities specified in the roadblock familiarised students with the services offered at the destination (finding a book in the library). They had to explain scientific phenomena in the science exhibition (Sci-Enza), interpret photos in the history exhibition and find green elements (for which the designers of this building were awarded international recognition) in and around the study centre.

These activities were designed to ensure student engagement in the race and to stimulate interaction between team members. Furthermore, apart from teamwork and general orientation, students were prompted with problems that are not academically or field-specific angled and as such, forced the students to think “outside the box” to generate unique solutions. The images in Figure 9 serve as examples of the roadblocks encountered.

In one of the roadblocks, students had to identify energy saving devices employed in the Mining Study centre (picture from [Wikimedia, n. d.]). The pulley system used in Camera Obscura (Arc Architects, n. d.) was another example where the students had to recognise the use of science in adjusting the height of the table. Students had to use the Lissajous pendulum (harmonograph) (Sims, n.d.) to create an image and had to describe how the image created could be changed by altering the weights connected to the pen. Yet another roadblock consisted of a mirror maize (ScienceSation, n. d.) that can also be seen in Figure 9. For logistical purposes, there were at least three different roadblocks at each destination. Furthermore, the roadblocks were designed to encapsulate different fields of interest and a variety of experiences. The staff at each destination assisted with identifying relevant, interesting roadblocks.

Figure 9: Roadblocks encountered in the Amazing Race

4.4.2.4 Clues

Similar to the television series, teams received their next clue after successful completion of the activity. The clues were designed to lead the team to their next destination and to sensitise them to their environment. For instance, students had to locate the "green route" on campus. The information is provided on noticeboards along the route that they had followed. In the final leg of the race,

> **Observation skills**
> Find the notice board with the information regarding the "Green routes" on Hatfield campus.
> Take note:
> - Purpose of the "Green route"
> - Significance of the stars on the "Green route" map?

the importance of this information (safe road to follow after the closure of the campus) is highlighted.

In the television series, teams encounter 12 legs of the race, and upon arrival at the final destination of each leg, the last team to arrive are usually eliminated (Cbs.com, 2019). This feature had to be changed due to the time that could be allocated to the activity. In the Amazing Race for Professional Orientation, the race consists of two legs. The first leg included visits to the different destinations where teams had to complete the creative tasks developed. The second leg consisted of a crossword puzzle in the next contact session. Teams are not eliminated from the race. If a team experienced any problems, be it with the clues, roadblocks or team-related issues, they could approach the lecturers or tutors who facilitated the race and are available at each destination. The race stimulates communication, and team members need to display a positive attitude towards their team to ensure effective participation in the race. In this way, the race environment adds value to the development of communication and collaboration among the team members.

4.4.2.5 The final leg of the race

All of the teams, unlike the scenario in the Amazing Race©, take part in the final leg of the race. The first team to arrive back is the winners of the first leg of the race. The final leg of the race was done in a formal class setting in the next contact session scheduled for Professional Orientation. For logistical reasons, students were sent on different routes on the campus. Students received one of three different coloured maps (of the campus) in the assignment. These colours marked the different routes. The clues provided at each destination were different for the different coloured maps and determined the route that the students would follow. Students from the three different coloured routes that arrived back in the same position (first, second, etc.) were grouped together. These new teams, consisting of six members, had to complete a crossword puzzle to win the grand prize: a hamburger at Steers, a local food vendor on the campus. In this way, students, already comfortable with at least their team member, were forced to collaborate with four new members and communicate effectively to find the answers to the crossword puzzle.

The clues provided to complete the puzzle are designed to highlight the most important information and to link the students' observations to the principles taught in the Professional Orientation lecture sessions. For instance, "life skill principle depicted by the instrument on the grass of the Aula facing Eng 1" refers to the sundial that they have encountered. They have to link this with the time management workshop that they have encountered in the lecture session that preceded the final leg of the race session. The reference to the CDIO principle followed in engineering practices provides another example of how the module content could be revisited in the context of the game. *Steers*, as the provider of the grand prize, was also promoted in the crossword puzzle by including the phrase "flame grilled, it just tastes better".

Listening skills are also evaluated by adding an instruction to the final question regarding the motto of UP. They had to provide the meaning of the motto as a team when they presented the completed assignment to the lecturers in the venue. The first team to hand in the crossword puzzle with correct answers, won this final leg of the race and each team member received a burger and Coke from a local food vendor situated on campus as their "grand prize".

4.4.3 The progress of the race

Students, in teams of two, received the instructions for the race and the clues to their first destinations in the formal classroom setting. The Amazing Race had to be completed within two lecture sessions (110 minutes in total). The handout included the instructions (Figure 10), a coloured map of the campus, information for navigation purposes and their first clue.

Instructions:

You will explore the Hatfield campus in the Amazing Race.

- Each team (2 members) will receive a map (green, blue or yellow) with their first clue at the beginning of the challenge. First orientate yourself (look at the section below). Then, follow the clue to your next destination, taking note of your surroundings as you will complete an activity at the end of the challenge.
- At each new destination you will receive a challenge that has to be completed before receiving your next clue. Proof of completion has to be handed to the relevant lecturer before receiving the next clue. The clues and answers to the challenges must be stapled to the handout.
- Use a coloured pen to plot the route that you are following.
- Both of the team members must take part in all the activities.
- You have to progress as a team (i.e. together) and are not allowed to run. A time penalty will be imposed upon teams caught running.
- At your final destination you will receive a number that indicates your place in the EC. Bring it, together with this handout (it will be assessed), to the follow up session on **Day 8**.
- In the next session you have to team up with the two other teams that have the same position that you have in the challenge (they will have maps in other colours). Your team will now consist of 6 members. You will receive a crossword puzzle to complete.
- Complete the crossword puzzle and hand it to the lecturer in the venue. The first correct entry will win the race!

Figure 10: Instructions provided for Amazing Race

The map of the campus, displayed in Figure 11, is similar to the one they received upon arrival as a new student. The cardinal direction and grid with the letters and numbers were indicated on the original map that the students received.

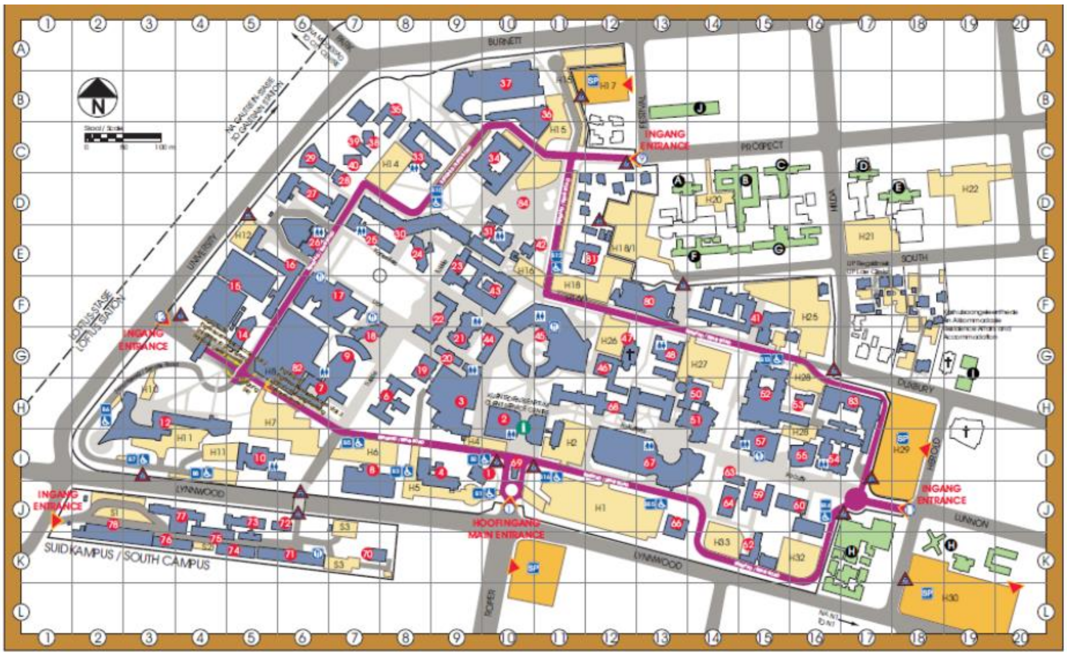

Figure 11: Map of campus (Wikimedia, n. d.)
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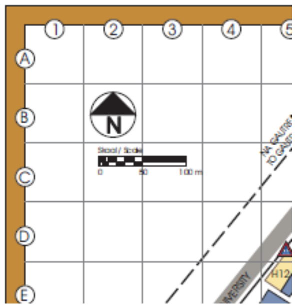
The clues pertaining to navigation to the different destinations, manifested in one of three fashions: using the cardinal direction indicated on the map, using the Cartesian plane or by using block referencing. The grid was turned into a Cartesian plane by providing the position of the origin (outside the venue where the race started) and the measure of a block. An instruction (seen in Figure 12) to enable effective use of the map was distributed to the students as part of the activity.

Cardinal direction on map



Before you depart:

Consider the map attached to the handout. The blocks formed by the grid on the map are vertically marked alphabetically (**A** to **L**) and horizontally marked numerically (**1** to **20**). A location on the map is indicated by first giving the vertical position and then the horizontal position of a block.

- The scale of the map attached is: length of the side of a grid block = 65m.
- The grid lines on the map represent a Cartesian co-ordinate system. Locate the origin of the system (marked with o) on the map. Use a ruler and a coloured pen to draw the horizontal and vertical axes so that they are clearly visible.
- Locate the **Natural Science 2** building (**NW2**) in blocks **D7**, **E7** and **E8**, which is where you currently are (building no. 25). Outline the building.
- Use another colour to mark the route you will follow, according to the clues received.

Figure 12: Information for navigation purposes

Students had to read the instructions carefully and before leaving the classroom provide proof that they had paid attention to the additional information provided for navigation purposes. The Amazing Race could be typified as action research; it constantly evolves to suit the needs of the students and eliminate pitfalls. Originally, students could only start the race, resulting in confusion with the clues to the destinations since they did not read all of the information provided. To avoid this confusion, lecturers check whether the students have found the origin indicated on the map and have drawn the x and y-axis, as depicted in Figure 13. Since this instruction aimed to develop the ability to read carefully and attentively, an activity, focussing on the abovementioned attribute, which would not jeopardise the success of the race, was added to the original instructions at one of the destinations.

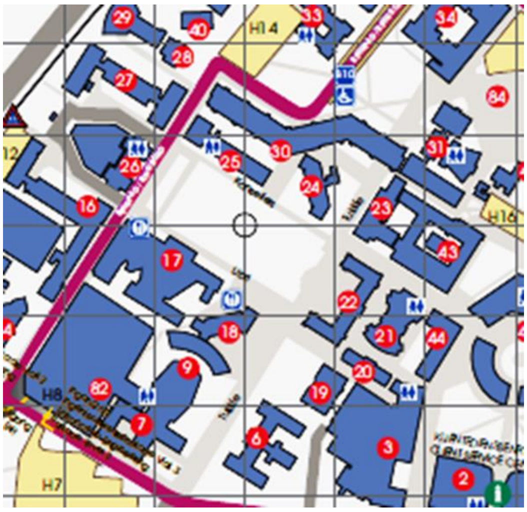


Figure 13: **Origin indicated on the map**

The first clue in the yellow version of Amazing Race led the students in a cardinal direction to a building indicated by block referencing. Students had to decipher the clue to be able to start the race. For the blue version, a co-ordinated pair (x,y) was used to indicate the location of the destination whereas, in the green version, students had to read to find one of the oldest buildings on campus. This building is visible from the starting position of the race. Examples of the clues provided to the students can be seen in Figure 14.

Clue no 1

- Follow the Ring road in a North-Eastern direction until you find the building in block B11. Go to the eastern corner to find the entrance to the building.
- Make sure that you receive the challenge to be completed upon entering the building. Complete the challenge using the resources in the building.
- Provide the necessary proof that you have completed the challenge.
- Receive the next clue.

Clue no 1

- Use the scale indicated on the map and go to (-65, 55).
- Make sure that you receive the challenge to be completed upon entering the building. Complete the challenge using the resources in the building.
- Provide the necessary proof that you have completed the challenge.
- Receive the next clue.

Clue no 1

- Continue to one of the oldest buildings on campus. It dates back to 1910 and faces the grass in front of the Aula.
- Your next challenge will be handed to you at the main entrance (north-western side of the building).
- Provide the necessary proof that you have completed the challenge.
- Receive the next clue.

Figure 14: First clues provided in AR

Upon arrival at each destination, teams received a roadblock to complete. They had to provide proof to the person that handed them the roadblock that they have completed it as instructed and had to reveal the correct answers before they received their next clue.

Examples of the roadblocks (printed on red to ensure seamless execution) received at the destinations are provided in Figure 15.

Sci-Enza no 1

Go through the mirror maze.

Suppose you have three mirrors and you want to create a maze. At which angles should the mirrors be positioned relative to each other to create an illusion that there are more than three mirrors?

Write the answer on the other side of the information and rules handout, show it to the person who handed you the challenge and collect your next clue.

Study Centre no 2

The study centrum has been nominated for a number of prizes. One of the prizes concerns the new engineering field: Blue and green engineering. Identify at least three methods implemented in the study centrum to save energy.

Show a photo of one of the energy saving devises as proof to the person who handed you the challenge and write the methods on the other side of the information and rules handout.

Sci-Enza no 3

Use a light beam and light a match.

Write an explanation of the scenario on the other side of the information and rules handout.

Show a photo of the burning match as proof to the person who handed you the challenge and provide your explanation of the scenario.

Figure 15: Typical roadblocks in the Amazing Race

Interesting phenomena that were added to stimulate the students' observation of their surroundings included typically the sundial where students had to determine the use of the "ancient device". The inscription "*Ek tel net die sonnige ure*" could serve as a hint although the majority of the students did not know the language of the inscription. The interaction between team members and between different teams was stimulated by including this stop, as the answer was not easily obtainable. The instruction and a picture of the students at the sundial are included in Figure 16.

Clue no 3

- There is a historical device that was used in ancient times to the south-south-east of your position (on the path between NW2 and the Aula). Have a good look at it - you will have to answer a question on the use of it in the contact session on Day 8.
- Continue to block H9.
- Make sure that you receive the challenge that needs to be completed at this point. Complete the challenge.
- Provide the necessary proof that you have completed the challenge.
- Receive the next clue.

Figure 16: Sundial

Students came across the fighter jet on their way to the Sci-Enza. They had to indicate the position of the jet (see Figure 17) on the map provided, guiding their orientation on the map. Activities in the other versions of the Amazing Race were designed to include the same kind of question to provide equal opportunities for the development of their skills. Different stimuli were used for logistical reasons and to prevent students from just copying other teams' information.

> **Orientation on map**
>
> Go to the Mathematics building (building 33) and locate the north sign (a letter N) on the paved floor of the courtyard in block C8.
>
> On the map indicate the position of this letter N. Write down the Cartesian co-ordinates of this position

Orientation on map

Follow the Ring Road and pass the Prospect street entrance. Write down the co-ordinates of the aeroplane and indicate the position on the map.

Figure 17: Fighter jet on UP campus (Wikimedia, n. d.)
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The Amazing Race was designed as an "ice-breaking" activity with the purpose of an introduction to the 4Cs while familiarising students with their environment. A fun element, typical from game-based learning, was added by including an activity to display the importance of reading carefully and comprehensively. The lecturer, observing the students, took pictures of the execution of the instructions (see Figure 18) that the students received at one of the destinations. This outcome was also tested in the final leg of the race.

Clue no 4

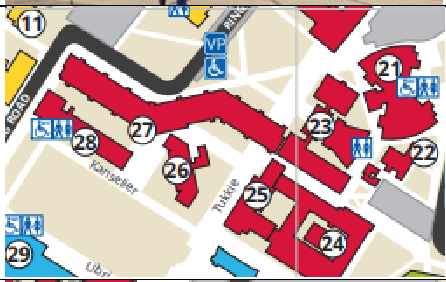
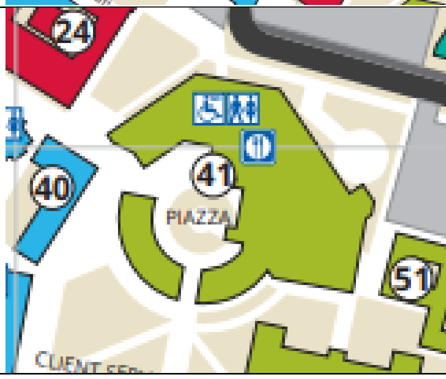
Read all of the instructions to this clue first, before executing them.

- Walk to the fountain.
- Take off your shoes.
- Put your right hand on your head and your left hand on your stomach.
- Make two turns in an anti-clockwise direction.
- Ignore the four previous instructions, go to Bookmark and present the map attached to the handout to the security guard stationed at the door.
- Then go to building 3. Pay attention to the markings on the pathway.
- Make sure that you receive the challenge that needs to be completed at this point. Complete the challenge.
- Provide the necessary proof that you have completed the challenge.
- Receive the next clue.

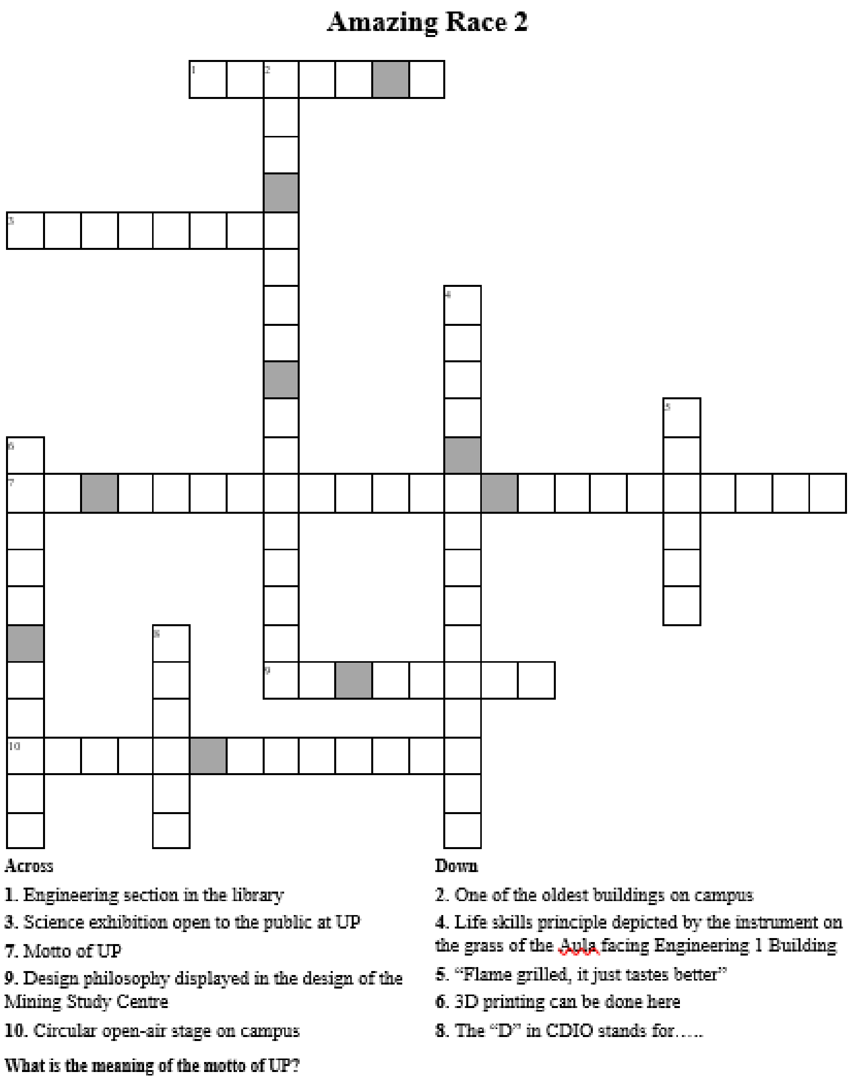
Figure 18: Reading hurdle

To contextualise the environment (Keller, 1987) even further for these engineering students, activities whereby teams had to calculate surface areas of specific buildings or circular platforms were included. They were prompted to calculate the circumference of the arc at the Musaion. Students had to think outside the box to provide answers to the problems. Proper instruments to aid in the calculations were not available. These activities, together with a picture of the information, are displayed in Table 5.

Table 5: Activities related to calculations

Estimate the area of the circular platform and explain how you arrived at your answer. Write your answer on the flipside of the Amazing Race handout.	
Estimate the floor area on the ground level of the building (27) and confirm your estimation by calculation. Use the flip side of the information and rules hand out to show your calculations.	
Leave the Aula building and follow the shortest route to block G7, where the Amphitheatre is situated. Indicate (in colour) on the map, the arc representing the seats nearest to the stage. Estimate the length of this arc. Give detail of the reasoning on which your estimate is based. Confirm your estimation with calculations. Use the flip side of the information and rules hand out to show your calculations.	

After the race, students were grouped in teams of six (three pairs were grouped together), based on the position they achieved in the race. The first teams to arrive with a blue map, green map and yellow map formed a new team and the second and subsequent ones were grouped together in a similar way. In their newly formed teams of six, students then had to reflect on their races after which they received a crossword puzzle to complete. The new teams received different versions of the crossword puzzle that is included in Figure 19.



Amazing Race 2

Across

1. Engineering section in the library

3. Science exhibition open to the public at UP

7. Motto of UP

9. Design philosophy displayed in the design of the Mining Study Centre

10. Circular open-air stage on campus

What is the meaning of the motto of UP?

Down

2. One of the oldest buildings on campus

4. Life skills principle depicted by the instrument on the grass of the Aula facing Engineering 1 Building

5. "Flame grilled, it just tastes better"

6. 3D printing can be done here

8. The "D" in CDIO stands for.....

Figure 19: Crossword puzzle

The first team to hand in the crossword puzzle with correct answers, won this final leg of the race and each team member received a burger and Coke from a local food vendor situated on campus as their "grand prize".

4.4.4 From "Campus Walk" to Amazing Race for Professional Orientation

The Amazing Race for Professional Orientation originated from a "Campus Walk" activity. The "Campus Walk" activity originated from 2009 and was developed to prepare students for the BuildUp project. The BuildUp project was designed to provide students with the opportunity to apply their trigonometry knowledge together with their practical skills to determine the height of a building on campus after which they had to compile their first academic report.

The “Campus Walk” activity also served as campus orientation in which students were guided to visit different destinations on campus. The assignment also instilled the notion of estimation as this concept was applied in the BuildUp project. The assignment was distributed to the students as an activity that had to be completed within the double lecture session.

After evaluating the activity and its outcomes, the potential of this activity for the development of the 4Cs, apart from orientating the students on the campus and preparing them for the BuildUp project, was realised. The activity’s impact on the students and student experiences was scrutinised, and the similarities with the television program were noted. By using the game scenario, it was expected that students would be more positive and driven by partaking in a competition. Since the students did not receive all of the information regarding the activity at the start of the race, their curiosity was evoked and their attention obtained. I applied the ARCS model of motivation (Keller, 1987) to ensure that the activities would motivate students to complete the race and that the experiences would be beneficial as the first introduction to the development of the 4Cs.

In the “Campus Walk” activity, students received all of the information to complete the activity as a handout at the beginning of the lecture session. The directions to the respective destinations and the questions that students had to answer regarding the facility were included. These destinations were also chosen based on their relevance to the students. The purpose of these destinations was to habituate the students in their new environment and, since the students came from previously disadvantaged backgrounds, provide them with information on resources available. The questions were aimed at the development of the students’ observation and estimation skills. A few of the destinations that were visited as part of the original “Campus Walk” activity together with the questions that students needed to answer and the purpose of inclusion in the activity are unpacked in Table 6.

Table 6: A few of the destinations visited in Campus Walk activity

Destination	Questions	Purpose
Roosmaryn	▪ Which student committee has its offices in Roosmaryn? ▪ What are the functions of this committee?	▪ Student governing information (professional development)
	▪ Enter the courtyard. See if you can find any strange looking 'instrument' that was used long ago. Describe it and suggest possible uses for it.	▪ Stimulate observation skills, curiosity, creativity
	▪ Inside the courtyard is a statue of a person. Who or what does this statue represent?	▪ History of UP
Monastery Hall	▪ Go to building 48, the Monastery Hall (Kloostersaal) in block G13. Find out what a breakfast will cost at the Monastery Hall. ▪ List the food items included in the breakfast in the previous question.	▪ Student environment and exploration of resources
	▪ What is the name of the building directly opposite the Monastery Hall?	▪ Student environment and exploration of resources
Student Health Services	▪ List the facilities that are offered at this building. ▪ Who may use these facilities and do you need to make an appointment? ▪ What costs are involved?	▪ Student environment and exploration of resources
Student Centre	▪ Walk to the Student Centre (building 45) in parts of blocks F11 and G11. Locate the ATMs in this centre. List the names of the financial institutions that support these ATMs.	▪ Student environment and exploration of resources
	▪ The student cafeteria is situated in the Student Centre. Estimate the number of hamburgers consumed each day by students at the University of Pretoria. ▪ If these hamburgers are kept warm in polystyrene containers, suggest a way to recycle these polystyrene containers. Explain in detail.	▪ Estimations

The questions that students had to answer were subject to the input from the staff members at each of the facilities visited. For instance, in one iteration, students had to collect an infographic with services available at student health services, apart from the information regarding appointments with the doctors and sisters and the cost implications for them as students. In that year, these infographics were available as part of student health services' campaign on the campus. This serves as one example of the constantly changing environment that has to be reckoned with in the design of the Amazing Race activity every year.

Originally, destinations where students had to walk further, were included. The time allocated to complete the race, unfortunately, limited the region that students could be exposed to. Since the sample of students changed and the orientation program for all first-year students at UP changed to include some of the destinations, the destinations visited needed to be constantly evaluated to determine the value of their inclusion in the race. The developments on campus also need consideration as can be seen from the example in the text box.

Developments on campus

Face the main entrance of the building in block **F7**, take the stairs to the upper ground level, turn right and walk to the back of the building so that you can have a view of blocks **H6**, **H7** and **I6**. On the map parts of blocks **H6**, **H7** and **I6** are indicated as a parking area. Is this still applicable?

The activities that students had to complete at the destinations were changed into roadblocks. Therefore, the questions had to change into activities that the students could complete quickly, but that would stimulate communication between team members, collaboration and critical and creative thinking. Since students experienced the Amazing Race as a competition, attention was given to the flow experience of the game (Csikszentmihalyi, 2016). The quest for instant access to the roadblocks gave rise to the creation of at least three different roadblocks at every destination. Immediate feedback was also given as the teams had to provide their answers before they could receive their next clue.

Some of the activities included in the "Campus Walk" orientation had to be excluded from the Amazing Race due to logistical reasons. An example of such an activity can be seen in the text box. The display of grain of wheat on the chessboard was situated in the Mathematics building and the corridor where students had to look at the information, was too small to host more than two teams. Furthermore, the

Activity excluded for logistical reasons

Pass through the entrance of building 33, located at co-ordinates (65,130) on the map. Find the display of grains of wheat on a chessboard near **room 1-18** (Ms L. Mostert's office). Consider the pattern in which the grains of wheat are distributed on the chessboard. If one continues to distribute the grains of wheat on the chessboard in this way, write down a formula to represent the number of grains on the last open block (block 64).

student movement in the corridor disturbed the students attending their lectures in the adjacent lecture venue.

Even the clues regarding interesting phenomena encountered during the race had to be changed to fit into the race scenario. An earlier version of one of the activities, as it was used before the implementation of the Amazing Race, is displayed in Figure 20.

1. Follow the path towards block F7. On the lawn on your left-hand side is an instrument.

2.1 What is the instrument called?

2.2 What type of animal appears at the bottom of this instrument? Do you think there is anything symbolic about this animal? Explain.

2.3 Why is the inscription: "Ek tel net die sonnige ure" significant?

Figure 20: Sundial activity before changes implemented for the Amazing Race

Since it was a race, students did not spend the time to answer these questions. Furthermore, since the purpose of the activity included the development of the 4Cs, this stop provided an opportunity to fuse the Amazing Race with the time management workshop presented to the students during contact sessions after the first leg of the race. Students had to make the connection between the sundial and the time management principle to be able to complete the crossword puzzle in the final leg of the race. It once again serves as a demonstration of the opportunities provided by the set-up, to help the students to integrate the learning content. The themes and destinations were constantly revisited to explore the scenario and refine the activity to provide the optimal learning environment to the students. By transforming the "Campus walk" orientation into an Amazing Race, the potential of game-based learning in the development of 21st century skills was recognised.

4.4.5 Logistical considerations

The Amazing Race activity can be implemented easily, but it needs proper planning and interaction with staff members at the destinations. The routes that students have to follow, need consideration, especially because of the time constraint. Since there are constantly new developments on campus, the routes and consequently the clues as well have to be revised every year. A summary of the routes followed by the students and the activities at each destination provides designers of the race with a visual map to aid in the planning. An example where the destinations are highlighted to establish the location of teams following their specific routes can be seen in Figure 21.

				Campus Walk 2014 - Amazing Race				
	Version 1			**Version 2**			**Version 3**	
1	Sun dial		1	Camera Obscura	View	1	Old Arts	History
2	Sci-enza		2	Old Agri	Animals	2	Library	
3	Study centre		3		Murial	3		
4			4			4		
5			5			5	Health	Services
6	Green route		6			6		Need
7	Library	Book	7	Old Arts	History	7		Cost
8	Piazza		8			8	Sci-enza	
9			9			9		
10			10	Study centre		10		
11	Aeroplane	Co-ordinates	11			11		
12	Old Arts	History	12	Fitness route		12		
13			13	Library	Reserve section	13	Study centre	
14	Route indicate		14			14	Musaion	
15	NW2		15	Sci-enza		15	Route indicate	
16			16			16	NW2	

Figure 21: Routes summarised

All of the teams visited the Old Arts, Library, Sci-Enza and the Mining Study Centre; the instructions signalled by the coloured maps with accompanying coloured clues sent them on different routes to ensure that students would not disrupt the other activities on campus. Support was obtained from the staff at each destination of the race during the development and execution of the Amazing Race to ensure that students would benefit optimally from their visit to the facility. The activities at each destination are revisited every year and new interesting features added. By including the staff at the different destinations, logistics such as increased traffic in certain areas can be discussed and the smooth running of the race due to positive participation is ensured. Students pass by the bookshop on campus to receive a gift with compliments of the shop as part of their marketing campaign. Multiple role players, not only academics and support staff, are involved in the iterative process of renewal and refinement, typical of action research.

The challenges posed along the way were designed to provide each team with similar difficulties and opportunities. Some of the activities were unique to certain versions with the intention that students would have to communicate in the new team of six people to be able to complete the final leg of the race. In this way, students could obtain more information on the environment that would not have been possible due to the time available in the contact session to complete the Amazing Race. The roadblocks were continuously reviewed based on the availability of services (as in the case of Camera Obscura), the history exhibitions available at the time of the race (at the Old Arts), new services offered by UP (3D printing at the MakerSpace), and the science phenomena displayed in Sci–Enza.

The majority of planning is done before the race takes place. Everybody involved on the day of the race needs to be reminded how the race works and need to have information regarding the routes followed by the teams. They have to be able to assist the students on the way. The lecturers/tutors stationed at each of the destinations need to have the roadblocks to hand out and the coloured clue to the next destinations for the different versions of the race. The different coloured clues correspond to the colour of the map, ensuring that the teams stay on track without complicated measures to ensure that they receive the correct clue. The staff at the facilities visited are reminded via e-mail since their assistance is needed with the roadblocks.

On the day, hopefully, a sunny day, lecturers have time to observe the interaction between students and provide assistance and in this way, get to know them. The first lecturer who established that all of the teams visited their facility, returns to the lecture venue. As the teams arrive back at the end of the race, the lecturer issues them with a number representative of their position in the race. This number determines the teams that will work together in the final leg of the race.

Planning for the final leg of the race is crucial. The teams have to find the other two teams that arrived in the same position and the crossword puzzles have to be handed out in the same order as that of their arrival back in the venue so that they can benefit from their position in the race. To effectively determine the winners of the race, the lecturers have to isolate the teams to prevent teams from overhearing the other teams' responses. The overall excitement calls for logistical perfection and smooth execution of the final phase of the race. The grand prize, negotiated as a marketing incentive for the food vendor on campus before the race, are distributed to the winners of the race.

4.4.6 Concluding remarks

By transforming the "Campus walk" orientation into an Amazing Race*,* the potential of game-based learning in the development of 21st century skills was recognised. This active learning approach was coupled with the basic components of problem-based learning, as proposed by (Barrows, 1996). An inquiry-based pedagogical approach was followed whereby the learning needs of the students and their exposure to the 4Cs in the race received top priority in the design of the activity. Students were encouraged to brainstorm in their teams and develop strategies to find solutions to the clues and roadblocks. The pedagogical design of the Amazing Race provided students with an opportunity to actively explore their environment, communicate and collaborate with their classmates and lecturers, use creative and critical thinking to solve the clues and roadblocks in a relaxed setting.

4.5 STUDENT EXPERIENCES PERTAINING TO THE AMAZING RACE LEARNING ENVIRONMENT

The Amazing Race activity was designed on the one hand for familiarising the students with the campus environment while on the other hand exposing them to an environment that could be beneficial in terms of the attainment of the much applauded 21st century skills. The statements “knowing depends on practice and participation” (Oblinger et al., 2005) and “learning is enhanced when it is collaborative and social” (Chickering & Ehrman, 1996) were used as guidelines in the design of the learning environment. However, I support the notion that no single experience will pioneer the desired changes in knowledge as stated by Kuh (1994). Students need to be subject to numerous opportunities to develop the desired graduate outcomes (Cranmer, 2006). It is evident from the literature that dropout rates could be reduced by well-designed student orientation on campus (Kuh et al., 2008). This activity could also influence the way that students experience their new environment.

In this section, information regarding the context of the Amazing Race is revealed after which the purpose of the learning environment is discussed from the lecturers’ and students’ perspectives. The learning environment is then discussed, using the words uttered by the students, in terms of the destinations visited, the clues and other activities encountered during the race.

4.5.1 The Amazing Race in context

The BuildUp project, the first project encountered in Professional Orientation, kicked off with the Amazing Race, an activity where students explored the campus environment in pairs. This activity was done in the first week of the semester when students were most likely to have paired up with a student sitting next to him/her that might be or not be familiar to him/her. Working in pairs created a safe environment where every student had to take responsibility for the tasks. Pairs could also interact with other teams that followed the same route around campus. The fact that they all had the same goal (finishing the race as soon as possible) provided students with the opportunity to mingle with others that were not yet familiar to them. Upon completion of the race, pairs were grouped with other teams to form new teams of six students each. Students were in this way challenged to move out of their newly developed comfort zone with only one familiar partner. Students did not necessarily know the other pairs of students and as such, had to decide on a common language to communicate in for one final activity after the race.

The Amazing Race activity had to be completed in a double contact session, i.e. 110 minutes in total. To complete the race within this period, students had to organise and manage themselves and their activities responsibly and effectively. It was necessary to apply time management measures to ensure the successful completion of each activity. They also had to manage their group interaction to be able to find possible solutions to the problems faced within the time constraints of each session. In the final reporting stage of the project, students had to organise and manage themselves to ensure that they completed a crossword puzzle related to the places they visited and the activities they completed during the Amazing Race, to win the race.

Student comments were used to investigate the value of the Amazing Race as a learning environment in which 21st century skills could be practised and honed. The destinations, clues and the roadblock activities were also under scrutiny, and the student comments are revealed in this section. The reflective essays were written only at the end of the semester. Interestingly enough, one of the students commented that if they had to write this essay immediately after the event, he would only have focussed on the fact that it was a very hot endeavour (referring to the weather on the day) and that they were physically tired. After some time passed he could actually reflect on the value of the activity without still being overwhelmed by the noise created by the environment.

The Amazing Race learning environment champions the notion of active participation in student-centred activities in a non-traditional educational setting. The traditional classroom setting does not always suit the learning styles of 21st century natives and as indicated by Duderstadt (2009) is not conducive to obtaining knowledge. It also does not warrant the motivation nor the skills for life-long learning. Especially when considering the dual purpose of the race (campus orientation, but more importantly, exposure to the 4Cs), the educational setting for optimal student engagement is important. Therefore, in this activity, students physically moved around on the campus while being subject to opportunities to provoke the development of the 4Cs. In the Amazing Race, I acted as a facilitator that provided guidance and motivation as proposed by Knowles (1984) to ensure that the intended learning outcomes were realised.

Interestingly enough, several students commented on the non-traditional educational setting, even though they were not prompted to do so. One student offered:

> *The navigation to the different places on campus was fun and was a good way to get out of the lecture halls for a while.* [RE_S69]

Another student commented that the fact that a non-traditional setting was used, added to the experience. They stated that

> *being outside and exploring campus was a lot more fun.* [RE_S10]

Students did not experience the activity as an academic learning event that formed part of the busy academic schedule as can be seen in the following student response.

> *The Amazing Race provided an opportunity for campus navigation without the hindrance of the busy academic schedule.* [RE_S21]

This could serve as motivation to transfer academic events into fun activities in a non-traditional setting where students experience it as a “breather” in their busy schedule where they can just relax without even realising the educational value of the activity.

However, one of the tutors mentioned student concerns that were voiced during the race: "*it is quite a physical activity so when it comes to the end they are tired and also some of them are worried that they need to go to another class or something afterward"* [FI_T5]. During the planning phase, extra care should be taken that the activity could easily be completed in the given timeframe. I also monitor the activity and make notes for future reference while helping students with hints along the way.

4.5.2 Elements of the Amazing Race

The concept of the game is known: teams receive clues to different destinations where, upon arrival, they have to complete roadblocks/tasks before they could continue in the game. The designers of the activity wanted to subject the students to different types of learning experiences. Therefore, apart from including destinations where they as engineering students would spend the majority of their time, destinations were also chosen that would showcase support services available to the students. Even destinations where students could experience the history of the institution, the Old Arts building, the library and the science exhibition, Sci-Enza, were places visited during the course of the race. The clues were given by using different navigational systems and the obstacles encountered stemmed from different fields.

4.5.2.1 Destinations

The designers of the Amazing Race activity aimed amongst others to give students a bird's eye view of the campus and facilities available. The campus environment offered many possible destinations, and as such, the destinations to be included needed careful consideration. Time constraints and other logistical considerations also limited the options regarding which destinations to include in the race. The process of designing the race started by identifying the stops that would potentially be most relevant for engineering students. The next kind of stops considered were those that offered services that students might need during the course of their studies, such as the student health centre and the library.

Students needed to be subjected to different categories of experiences to ensure that they could become well-rounded individuals that were aware of their society and its roots. For this reason, destinations that showcased the history of the university were also added. Places of special interest to engineering students, even though they would not need to know about it for the purpose of their studies such as the Sci-Enza, one of the first interactive science exhibitions in Africa, and the MakerSpace, a 3D printing service offered to students, were also included. The variety of destinations could also stimulate their interest and in this way, enhance their motivation (Keller, 1987) to complete the Amazing Race activity. Students commented that:

> *I enjoyed the race because it allowed me to know the university better. It really was a beautiful experience getting to explore different parts of the university, also acknowledging the various buildings. Many of the buildings that we went to, like the Old Arts building, the Merensky library which is one of the oldest buildings within the university, allowed me to get some knowledge about the history of the university. The university has got quite a lot to offer than I ever imagined. Places like the Scienza, where I acknowledged the real science in practice*. [RE_S97]

One of the students commented that this activity helped with navigating to their classes while another pointed out that apart from knowing where to go for classes, the activities during the race allowed a better understanding of the surroundings that benefited them in many ways.

> *It also helped us in knowing our way around campus better. I found this really helpful especially because my coordination around places is very bad. I was definitely one of the students who kept getting lost during the first few weeks, and this race really helped me with that.* [RE_S6]

> *All tasks during the race, provided me with a better understanding of all my surroundings which at the end of the day really benefited me in more ways than one and allowed me to know where I have to go for my classes.* [RE_S80]

As first-year students, they even remarked that this activity, apart from offering an opportunity to get acquainted with the major landmarks and buildings, relieved some of the stress associated with their new environment. One of the tutors indicated in the focus group interview that they have *"gained a lot of confidence on campus, because of it. Because kind of before it is very easy to get lost…So after the Amazing Race, I had a much better idea of where everything on campus was"* [FI_T6]. Since the students experienced that these destinations were relevant to their needs because of their usefulness in the future, student motivation to continue with the activity was enhanced (Keller, 1987).

> *Having specific destinations as part of the Amazing Race gave me and my team member the opportunity to explore the campus and get acquainted with the locations of major landmarks and crucial buildings. This made navigation of campus less stressful and more effective.* [RE_S19]

To keep students motivated throughout the activity, destinations of engineering interest were added as proposed by Cordova and Lepper (1993). The activities at these destinations were designed to trigger the students' curiosity and offer them an opportunity to see science in action. The engineering students were enticed by these two destinations included, especially to cater for their interests.

> *One of the most interesting destinations we reached was the Sci-Enza building. It just stunned both of us as we were exposed to all innovations of the Tuks students. I was inspired and I vowed to at least get one of my innovations in the building.* [RE_S109]

The Amazing Race served as marketing for these units and simultaneously rooted the activity in the science realm.

> *The places like the Maker Space and Sci-Enza were cool places to visit as they have a lot of things that we can do that I would not know about without having done the Amazing Race*. [RE_S45]

> *The race did a good job of showcasing the diversity of the buildings and their use. As a second-year student of the university, I did not expect to learn many new things from the race, however, it took me to places that I had not yet visited such as the Scienza building*. [RE_S8]

Even the other aspects, in this student's case, the snippets of history included, were experienced as being fun.

> *I especially liked seeing the Maker Space and Sci-enza. Also learning a bit about the university's history such as its oldest building and its architects, throughout the race was fun. Overall, the race was helpful to let me get acquainted with navigating through some parts of the campus.* [RE_S46]

All of the destinations were not exciting, but the designers had to consider the function of including the respective stops. Usually, students would not necessarily realise the relevance of visiting the library in such an activity. It thus came as a surprise that one student commented:

> *The Amazing Race also helped me most at the library. It gave me the necessary information needed when looking up books or in need of basic information.* [RE_S98]

There were numerous factors to take into account in the planning phase of the race. After mapping the chosen destinations, three different routes for the Amazing Race were planned to ensure logistical flow during the activity. This was done to ensure that the Amazing Race did not disturb other academic activities on campus by large numbers of students arriving at a destination simultaneously. In planning the routes, consideration was given to the location of notice boards with much-needed information and to interesting exhibitions available at the time of the race. Most importantly, the routes had to be short enough to complete in the limited time available without unnecessary to and fro walking while exposing the students to worthwhile campus views. Some of the students realised that the routes planned to the different destinations were intended to showcase the bigger campus area.

> *I think that the destinations that were given to find were well chosen because these* […] *are all destinations that are well scattered across the campus thus meaning we got a chance to know the campus better*. [RE_S64]

As could be expected, all of the comments regarding the choice of destinations were not positive. One of the students commented that visiting the student health centre was not relevant for engineering students enrolled for the module Professional Orientation. This is consistent with what Seemiller and Grace (2017) said when they discussed the characteristics of generation Z students – they want to apply everything that they encounter in their everyday settings.

Some of the destinations did not seem to be relevant to the course such as the student health center. Seeing as though it was for a professional orientation class for first-year engineering students this did not seem very relevant. [RE_S89]

As discussed previously, the designer of the race had to limit the number of stops due to the time constraints. The environment offered a variety of possibilities that forced the designer to carefully consider the destinations that were to be included in the race. It therefore came as no surprise that one student wanted to include more stops, especially those associated with his/her degree and even general campus life.

The race did fulfil its purpose on showing me essential locations on campus however it did not take me to all the buildings associated with my degree or general campus life. [RE_S42]

Similarly, students also wanted the race to include their hang-out places, "Aandklas" and also "Oom Gert" where students could socialise while eating and drinking something.

One thing I can recommend is that they can include places of campus like "aandklas". [RE_S69]

I think one of the ways in which the race can be improved is by making the route go a bit wider so that the students can have a quick stop at "Oom Gert" but that is just my personal opinion. [RE_S10]

The Amazing Race served as an introductory experience surrounding the navigation on campus. The idea of the race was only to provide information regarding the new environment in broad strokes and to scaffold the process of learning how to navigate to the different venues. Students had to use the campus maps that they received during the first week on campus.

> *The overall experience was a good one. I was able to learn a lot about the University and it certainly made it much easier to find my way around campus. During the race, I realised how big the campus is and learned how to make use of the campus maps.* [RE_S66]

Every year the destinations and activities included in the Amazing Race are revisited and new developments on campus are considered. Previously, the designer took informal student, tutor and colleague feedback and her own observations into account when planning the race for the next year. In the year under scrutiny, however, student reflections and information garnered by means of focus group interviews with the tutors revealed information that could be useful in future iterations of the race. Comments regarding specific venues to include in the future are valuable sources of information, and I will consider different methods to point to the location if deemed necessary. This can be done by either including it as a stop or prompting them with a question that relies on their observational skills.

> *Unfortunately, I felt that some buildings were unnecessary to visit. I would've preferred buildings that I use every day, such as the Chancellor's building.* [RE_S26]

In some cases, student comments will not be taken into account. Almost all of the students reacted overwhelmingly positive regarding their visit to the Sci-Enza. That served as an indication that the following student response should not influence the decision regarding the inclusion of this destination.

> *Then I also think the Amazing Race locations that we went to was not sufficient, like the Sci-Enza building after that day as an engineering student I have not visited that*

> *building again I think it would have been more sufficient if we went to more building that we will visit as engineering students.* [RE_S31]

As the Amazing Race idea is useful in many contexts, the designers have to keep track of similar activities offered by other groups on campus that also realised the potential of the game. Students might be demotivated if they encounter more than one Amazing Race, even though the format might be very different.

> *The reason for my low rating out the Amazing Race is because I had already gone on an Amazing Race with my residence during orientation week and found it very tedious to have to do again.* [RE_S76]

Each university offers its own orientation program that should also be taken into the account. The problem is that not all of the students have the same experiences and reside in residences offering the same activities. The decision surrounding the Amazing Race activity as a whole and the inclusion or exclusion of stops will, unfortunately, result in repetition for a few students. Boredom could be prevented by a different approach to the stops.

> *My partner and I then had to go to Bookmark and the Student health centre. Both of these were not useful at all for me since the information we had to gather was already given to us during the Orientation week at the beginning of the year. It seemed like a waste of time to give us something to do which we already know about.* [RE_S70]

Since more of the faculties started using the Amazing Race principle as part of their orientation programmes, the designer will have to revisit the activity and might have to change the format using a different name or change it to another reality game format such as *Survivor*. This implies an innovative revisiting of the outcomes of the activity in relation to the available resources offered on campus.

> *However, I do believe it was irrelevant at the time given that during Orientation week the faculty had arranged an Amazing Race for all first years. Irrespective of getting to see parts of campus that I would have otherwise never known was stimulating i.e. Scienza and Merensky library. …A recommendation I can suggest would be for JPO 110 to build on what takes place during Orientation week in order to save time.* [RE_S40] *(scored experience 7 out of 9)*

In conclusion, considering all of the different options, avoiding replication of experiences and considering the logistical aspects, the effort seems meaningful when students describe the journey as informative, enlightening and a pleasant introduction to the year.

> *In conclusion, the race was very informative and a pleasant introduction to the year*. [RE_S8]

> *With regards to the Amazing Race, the experience was enlightening as I became aware of how my campus is planned out.* [RE_S40]

The appreciation of the students for the effort that was needed to pull off a successful event is more than an educator could wish for and serves as motivation to include innovative methods in the normal educational sphere.

> *The Old Arts building was our last destination. I personally think this destination ended the race off on a high note because we had a chance to admire the beautiful view of the Aula lawn and also took a picture with our partners.* [RE_S44]

This activity is a great one especially for first-year students and I am grateful for the JPO 110 tutors who introduced this system to make life easier and fun for all of us. [RE_S82]

4.5.2.2 Clues

Before you depart:

Consider the map attached to the handout. The blocks formed by the grid on the map are vertically marked alphabetically (**A** to **L**) and horizontally marked numerically (**1** to **20**). A location on the map is indicated by first giving the vertical position and then the horizontal position of a block.

- The scale of the map attached is: length of the side of a grid block = 65m.
- The grid lines on the map represent a Cartesian co-ordinate system. Locate the origin of the system (marked with o) on the map. Use a ruler and a coloured pen to draw the horizontal and vertical axes so that they are clearly visible.
- Locate the **Natural Science 2** building (**NW2**) in blocks **D7**, **E7** and **E8**, which is where you currently are (building no. 25). Outline the building.
- Use another colour to mark the route you will follow, according to the clues received.

At the beginning of the race, students receive a handout with the general information regarding the process to be followed while competing in the race. This includes information regarding the rules of the game and also a campus map. Instructions on the interpretation of the map were given in written format. Students needed to read carefully to extract all of the information required for seamless navigation on campus. Two of the three different modes used for navigation are explained on the handout as can be seen in the textbox “Before you depart”. In previous iterations of the game, students did not read the instructions carefully; they were eager to start with the race without orientating themselves on the map. For this reason, the designer adapted the instructions to ensure that they have understood the information presented as guidance to the interpretation of the clues.

One student applauded the designer’s effort to include activities that would stimulate the students’ critical thinking capabilities.

> *The directions to these places cleverly worded and challenging for the most part.* [RE_S81]

Nonetheless, other students still felt that the directions were vague, the instructions difficult but manageable.

> *The directions were a bit vague and we did not always know where to go right off the bat.* [RE_S1]

> *I feel the instructions and map scale was difficult to interpret.* [RE_S65]

> *The Race was also confusing at first when we were trying to figure out all of the clues, but successfully we were able to solve the problems and came 1st in our group.* [RE_S101]

One of the challenges faced by engineering educators is to guide students to be inquisitive (Malone & Lepper, 1987) and resourceful as learners. Problems that they will encounter as professionals will not be clearly defined with all of the information readily available (Jonasson, Strobel, & Lee, 2006). It came as no surprise that students prefer to stay in their secondary school comfort zones where all of the information was readily provided.

> *One of the faults of this race, I found, was that the map was a bit difficult to understand in terms of the scales given. Also, more precise instructions should've been given.* [RE_S27]

> *I do think however that the scale used on the map should have been explained better.* [RE_S108]

The fact that students feel safe when information is used in recognisable domains is noticeable in the following comment.

> *It was not easy to get to the destinations because it was very tricky to get to them since we were using a rather unusual and tricky method of direction.* [RE_S84]

The balance in difficulty of the clues is important. Students should experience it as being challenging but achievable (Norman, 1993). Students tended to label their experiences of the race according to the level of difficulty that they have experienced. Sometimes student comments displayed mixed emotions as can be seen in the next comment.

> *Though the map was very confusing and did not clearly indicate the locations, this made it difficult for me to fully enjoy the Amazing Race. The coordinates were not easy to interpret because I was not used to going about directions in such a manner. The clues were fun and made it very motivational for us in a team to go and really find out and solve the clues. I feel like I could have done better if I was aware that the blocks which were labelled on the given map where not the labels to each individual building.* [RE_S54]

Some of the students felt discouraged because they could not dismantle a problem and find the correct destination. Even though there were numerous teams following the same route, it seems as if the problem at hand blinded them for obvious solutions such as to follow another team or to ask for help.

> *Having an average score means that not everything about the Amazing Race was amazing. We did not know how to use the map meaning that we got lost a couple of times. The last instruction was confusing and misleading. Due to this, we could not find the last destination for*

about an hour. We only found it when we had given up. [RE_S94]

The design of an activity such as the Amazing Race is always a balancing act. Even though some of the students commented that they eventually had given up since they could not find some of the destinations, other students felt that the race could have been more challenging. In the words of the students:

> *Navigating to both of them was fairly easy given that there are boards all over campus describing where you need to go, however, the challenge was the tasks that the gave forth as they just dragged out the whole experience.* [RE_S40] *(scored 7 out of 9)*

> *The navigation to different destinations in the Amazing Race was quite easy and I feel it could have been made more challenging* [RE_S89]

These comments underline the fact that all our students are different, they not only have different learning styles and interests but also a unique approach to the solving of problems. All of these will influence their successes and also contribute to their failures.

Students mostly commented on the challenging aspects in a positive way and commented that this experience was conducive to the development of effective teamwork between team members.

> *Navigating to the different landmarks was in my opinion, the greatest individual challenge but through the help of a teammate, this became a seamless exercise.* [RE_S78]

> *Working with my teammate was fun because we were able to cruise through the roadblocks and locating the*

destinations with my partner was a breeze because the clues that were given to us weren't that tricky and we were able to complete the challenge in minimum time. [RE_S105]

4.5.2.3 Activities in the Amazing Race

A variety of activities were incorporated in the design of the race. In this way, students stayed motivated, since they were intrigued by the combination of different experiences as mentioned by Palmer (2005). At each destination, a minimum of three activities, called roadblocks, were designed. These roadblocks enabled the students to explore each destination on different levels while at the same time limiting the influence of the students on the academic activities of other students. The roadblocks developed as part of the Amazing Race provided students with opportunities to interact with their environment and each other. By using active learning strategies, the success of any program can be increased according to Astin (1999).

> *The fact that the Amazing Race had destinations and challenges all around campus, and not just at the "engineering" section of UP, was extremely beneficial to my teammate and I. What I especially liked about these destinations, is that they engaged us in the activities that they offer, and gave us a real good opportunity to explore the university and its culture*. [RE_S22]

> *Each location we went to we learned what this location, or building, was all about and how it could help us on our journey through University. Because I was new and did not know anything this really helped me find my place in this new University world.* [RE_S24]

> *These roadblocks either gave us a better understanding of the destination or challenged our estimation abilities*. [RE_62]

The choice of destinations provided opportunities to design a diverse experience for the students that was further enhanced by the roadblocks. A wide variety of roadblocks were planned to cater for different interests while simultaneously exposing students to the multiple facets of life encountered on campus. The movement between different types of activities not only grabbed and maintained their attention (Keller, 1987), but also connected the needs of generation Y and Z students (Prensky, 2001b) with the goal of delivering well-rounded individuals.

> *I really enjoyed the Old Arts, Engineering 1 and SCI-ENZA road blocks, as they were really scientifically helpful at the SCI-ENZA and Engineering 1, whilst that of the Old Arts was hilarious and historically helpful.* [RE_S71]

> *The road blocks proved interesting and sometimes funny as we had to take a selfie in Sci-Enza on the most comfortable chair and find out what sources of energy the engineering study centre uses. The road block to the maker space in the Merensky Library was the most intriguing as we found out what type of material they use to print the 3-D models.* [RE_S85]

The race was designed to provide students with opportunities to interact with each other and also with the university environment and staff, which is an important factor to ensure student retention (Lau, 2003). Therefore, in the planning process, the designer consulted with staff at each of the facilities and specific activities that would best showcase the specific destination, and that would also serve the purpose of the race were identified.

The roadblocks presented at the Old Arts building talked to the history of the university. In 2018, one of the roadblocks instructed students to find the name of the architect of the building. Instructions to the name display were given by using cardinal directions provided on the map.

Old Arts no 1

Identify another building on campus that was built in the same year as this one. Who was the architect of the other building? What else is significant about this building and the year in which it was built? In the South-Eastern corridor of the building you will find clues that will help you to find the answers.

Write the surname of the architect/s on the flip side of your handout.

Another roadblock involved finding the building on campus that changed considerably over the years. They had to look at a photo exhibition to identify the building (formerly built over a road which was closed a few years ago to join the different parts of campus). The roadblocks changed from year to year depending on the exhibitions or services offered at the time of the race. In one of the years in what that has been described as part of the action research, students had to determine the direction from which an earlier photo of the Old Arts building was taken. This activity forced students to orientate themselves and buildings that were displayed at the time frame in which the photo was taken, on the map. The examples provided served as proof that the race provided an opportunity for the development of not only an awareness of their new environment but also their observational and creative thinking capabilities.

The activities mentioned were all planned after looking at the available resources at each destination at the time of the race and therefore would change from year to year. All of the roadblocks presented during the race were designed to stimulate communication among the students and facilitators and to foster the need for critical thinking. Students had to integrate different knowledge types to construct a new awareness of their environment that aided in the development of their cognitive abilities (Fisher, 1980). Not only engineering-specific content was included, and students commented that:

> *I enjoyed the roadblocks most that demanded us to get to know our University like the one where we had to get the name of the architects who designed the Old Arts building.* [RE_S82]

One student felt that including activities regarding the history of the university could be substituted with other information regarding opportunities at the university.

> *I think it would be better if the roadblocks included more information on the opportunities that the university has on offer instead of the history of the university.* [RE_S72]

Nevertheless, as an added bonus, through the exposure to the new setting and by including aspects regarding the history of the institution, students attained a feeling of respect and appreciation for the fact that they may be part of this environment.

> *My experience with the JPO Amazing race was basically the building blocks for my university life. Despite the fact that it was my first few weeks, it made me feel like a proud Tuks student*. [RE_S75]

> *We were given a clue that led us to a location where we had to answer a question about the university's history. This helped us understand where the university came from and made us fall even more in love with it.* [RE_S90]

Some even stated that they became a proud Tukkie after being exposed to this activity that implied that an activity such as this one could even create the much-needed sense of belonging that Tinto (2006-2007) identified as one of the key factors of student retention.

> *It taught me about the history of the University, in the process I became a proud Tukkie*. [RE_S109]

The Amazing Race activity changed every year depending on the campus resources available and based on the feedback received after the previous iterations of the activity. At the Old Arts building, for instance, the roadblocks went from using the first classroom on campus to looking at a video regarding the history over one year and exploring a photo exhibition of the history in another. The resources available at different destinations change. Unfortunately, all of the interesting exhibitions are not readily available and accessible to larger numbers of students to visit. One student that was aware of some of the exhibitions at the Old Arts commented:

> *The old arts building was a nice quick roadblock however that too can be more exhibit based, in think an essential part of that roadblock should be to show off what is inside the museum i.e. the Mapungubwe collection.* [RE_S42]

Apart from roadblocks aimed at creating an awareness of the history and knowledgeable landmarks, other roadblocks focussed on mathematical thinking processes. Students had to find an innovative method to calculate the circumference of a circular platform in the Piazza since they did not have any instruments to their exposure. It seemed as if the roadblock, even though it needed critical and creative thinking and forced sanctioning your solution as the most feasible in your team, which added fun to the experience.

> *I enjoyed trying to figure out the area of the pizza circle, at the student centre.* [RE_S57]

The intrinsic motivational appeal of the Amazing Race activity was increased by using contextualisation, one of the techniques proposed by Cordova and Lepper (1993). It became evident from student comments that the students needed challenges and even more so, engineering-specific ones to stay motivated to proceed in the race.

> *The least favourite was in the Engineering 1 Building, this wasn’t fun because the roadblock had no puzzle to actually solve* [RE_S83]

> *and I do wish they had more interesting challenges with specific engineering themes. All in all, it was a very good idea that can be very well received if a few tweaks are made to make it feel more like an “Engineering Amazing Race*”. [RE_S12]

In evaluating different options for the roadblocks, the engineering specific learning outcomes were also considered. One of the outcomes specified by ECSA explicitly stated that graduates should be aware of the influence of their activities on the environment (ECSA, 2017). The Amazing Race activity provided an opportunity to create an awareness of this much-needed engineering attribute while at the same time creating an awareness of the efforts and achievements of designers and engineers at the university in this respect. This experience was labelled as being enjoyable, remarkable and interesting as was evident from the comments of a few students. It served the purpose of creating an awareness of eco-friendly technology implemented on campus that could motivate them as the future generation to be sensitive to environmental issues and to employ similar efforts in their interaction with the environment.

> *I really enjoyed finding out all the technological aspects of the Engineering building, which make it advanced and eco-friendly*. [RE_S73]

> *The part that I enjoyed the most is to see the amount of renewable way of supplying the study centre of enough light and energy.* [RE_S67]

> *After figuring it out and reaching our final destination, we learned the most remarkable thing about the Engineering*

Building 1. We learned about how the building used Green engineering technology to decrease the amount of pollution and power generated by the building. [RE_S41]

Another roadblock that I found quite was how the Engineering 1 building's lights are designed in such a way that they are automatically turned on and off according to motion sensors, which saves a lot of energy. [RE_S50]

The value of using engineering-specific roadblocks that could also create awareness not only of the Going Green initiatives but also of the attributes of a well-educated engineer can be seen in the following comment:

My personal favourite destination was Sci-enza. To see all the fundamental physics laws in action was a very startling experience for an aspiring engineer like myself. My favourite roadblock was finding out how the Mining Industry study centre saves energy. It made me realise the lengths that engineers go just to try the world while making it better. [RE_S75]

The Sci-Enza contains numerous exhibitions of science phenomena. The students' curiosity was stimulated as they could see the science in action and had to provide explanations for these phenomena, often realising that they could not explain the scenario with the knowledge that they had. The resulting information gap (Loewenstein, 1994) triggered their curiosity and was conducive for stimulating their critical thinking capabilities. In one of these, the students had to light a match.

Our first destination was Sci-enza. I enjoyed this part of the race the most because the problem we had to solve was a scientific one, where we had to figure out how to burn a match using only a glass lens and photons that light *emitted. Since I find a great interest in science I enjoyed this problem the most*. [RE_S44]

By including these contextualised roadblocks, the intrinsic motivational appeal of the race was increased (Cordova & Lepper, 1993). It, therefore, came as no surprise that these roadblocks were rated positively by most the engineering students.

The race had certain roadblocks wherein each one we had to answer questions in order to move to the next and what I liked about the roadblock was that they each taught us interesting facts about the university. The roadblock which I enjoyed the most was the one at the Sci-enza where we had to find out which chair was the most uncomfortable, and unexpectedly the most comfortable one was the one with many iron nails. [RE_S66]

One of the students reacted to the fact that other students could not overcome the obstacle without hindrance. This students experienced the activity as being fun but might have missed the opportunity for the development of their critical and creative thinking abilities.

My favourite thing in the Sci-enza Building was the mirror maze by far, just because of how funny it is watching people walk into mirrors. [RE_S32]

What stood out from the students' experiences at the Sci-Enza is the fact that their curiosity was raised when they had to verify their assumptions and realised that there were gaps in their scientific knowledge (Garris et al., 2002). This student's effort is an example of one of the intended outcomes of this problem-based activity.

The roadblock I enjoyed was the one wherein we had to go to the sci-Enza and decide as to which chair was more

> *comfortable between the one with balls and the one with nails. I learned a lot that day because I did not know that a person could sit on nails and I also made research so that I know that how was it possible*. [RE_S33]

It becomes evident that all of the students do not have the same attitude concerning their lack of knowledge. Unlike the student mentioned above, one student just mentioned that he/she had no idea how to solve the problem and the comment does not provide clues as to which approach he/she intend to follow in the problem-solving process.

> *The roadblock presented to us was also quite interesting and complex, we had to use an instrument to draw onto a paper. Firstly we had no idea what the instrument was and how it was used. We did, however, manage to draw some shapes onto the paper but also had no idea how to explain how we got those shapes*. [RE_S41]

The designer had to carefully evaluate the different roadblocks not only in terms of the contextual relevance (Cordova & Lepper, 1993) but also in terms of the difficulty of these activities. Even though students will choose to partake in activities that do not appear too difficult or too easy (Rieber, Smith, & Noah, 1998), the balance between these two poles is crucial. It influences the level of enjoyment as can be seen in these student responses:

> *The clues and challenges that were presented to us were difficult enough to be challenging, but easy enough to be enjoyable.* [RE_S67]

> *The roadblocks were good but it could have been a bit more challenging as it was not that hard.* [RE_S59]

A next dimension to be considered in the design of the roadblocks is the time constraints of the race. As mentioned by one of the students, the time needed to solve the challenges could influence the successful timely completion of the Amazing Race.

> *The questions and riddles themselves could also have been a bit harder but I understand that there is a limited time span in which the race must be finished but for the brighter student the questions might have been too easy.* [RE_S10]

A number of the comments garnered in the year under scrutiny indicated that students needed more challenging roadblocks to stay motivated to continue with the game.

> *The rest of the roadblocks felt too easy, and I do wish they had with more interesting challenges with specific engineering themes. Perhaps if the challenge were smaller in quantity and greater in difficulty, the race would have been more memorable.* [RE_S12]

> *What would be a nice addition to the Amazing Race is if there were more challenging roadblocks*. [RE_S37]

These statements will be taken into account in the design of the activity for future groups of students. However, the opposite view could also be expected if one takes into account the diverse student group's level of preparedness for university studies.

> *The roadblocks we got was really challenging, it made you think out of the box.* [RE_S25]

Some students displayed a lack of self-directedness and initiative. Students were still operating as if all of the information will be readily provided before they would need to solve a problem.

> *What I did not like about the race was the fact that we were left to figure out everything on our own. With one of the clues, we could not find where we must go and eventually gave up*. [RE_S24]

In the future, the designer will still follow the same protocol but will include a time-out mechanism by which students can indicate that they need help to avoid the feeling of failure experienced.

All of the roadblocks were not perceived as being equally useful and interesting to the students. Differing interests and value systems of the participants combined with the educational intentions of the designer of the race are interwoven in the activities, and it can be understood that some of the students might react negatively. One of the roadblocks in the library, finding a book in the engineering section, might be redesigned to speak to the nature of the students as it received two of the negative comments.

> *some of the roadblocks were fun like the Sci-Enza roadblock, having to travel through the mirror maze but other roadblocks were tedious and unnecessary like finding the book in the library which caused havoc and disruption in the library while people were trying to study*. [RE_S73]

> *The roadblock I enjoyed was the one which made us complete an exhibit inside the Scienza building, as it was interactive and fun, while still learning something. The roadblock I did not particularly enjoy was the one in which we had to go into the library and find a book to move on to the next task.* [RE_S99]

Student responses mirrored the different interests and approaches to their studies. One student was definitely more inclined to physical activity.

> *Although I had wished that the roadblocks would have included more physical challenges and that the overall Race would have been longer, including more places and challenges*. [RE_S68]

Another student indicated the value of the race in finding study venues for group work.

> *Most of the roadblocks felt useless, however, I really enjoyed the roadblock at Scienza which was the mirror maze as I felt it was educative and fun. A roadblock I found very useful to everyday life at the University of Pretoria was the roadblock at the engineering study centre as we had to find out how to book a study room and how long you may book one for which will be helpful during semester tests for those who find it helpful to study in a group*. [RE_S76]

The designer of the race wanted to students to experiment with different sources of knowledge. Generation Z is very sophisticated and resourceful with regard to finding information digitally. They actually prefer to google it. This is demonstrated by these statements in a discussion concerning the use of maps as a navigational tool in the focus group interview: "*Google maps became a phone app this year"* [FI_T6], and "*You can go digital"* [FI_T3]. This tendency of the students was taken into account in the design of the race. At one of the destinations, students had to scan QR codes to obtain information. But at the Old Arts building, they were guided to find the answer to the roadblock displayed on the inauguration plate on the building. One of the students got frustrated when he/she had to look for information in "old fashioned" ways.

> *The Old Art building required us to find information on a set building on campus, I found this exercise futile because all the information could be found online and no meaning to me.* [RE_S30]

Once again, the challenge was to find a balance between the aim of the activity, stimulating their observational skills and their physical orientation abilities, and the net generation's quest for new pedagogies (Duderstadt, 2009).

In the end, students labelled the majority of the destinations and roadblocks as interesting and the race as being beneficial. One student summarised the experience as follows:

> *However destinations such as the Scienza where I saw the mirror maze and had to measure the angles the mirrors made, I also enjoyed the Makerspace and the Engineering 1 Study centre where I learned how they where I learned how they were using Green Engineering solutions to save energy I found that very interesting. I enjoyed working with my teammate and feel that I learned about the University during the Amazing Race.* [RE_S89]

Another responded that the roadblocks served as an opportunity to meet new people and discover his/her own strengths and weaknesses.

> *It was a great way to meet new people and it helped me to identify my own strengths and weaknesses when doing the roadblocks.* [RE_S63]

4.5.3 Concluding remarks

This section provided information regarding the different elements of the Amazing Race. The choice of destinations, the clues provided to each and the roadblocks that students had to complete, were discussed, and student comments shed light on their experiences of each of the above-mentioned elements. Other pitfalls were also highlighted with the relevant student comments. The designer used a game-based learning environment to, on the one hand, orientate students on the campus, but also to introduce the 4Cs.

4.6 SUMMARY

This chapter kicked off with a description of the background to the design of the enabling learning environment. Then, programs implemented at higher education institutions to accommodate ill-prepared students were discussed after which the focus fell on Professional Orientation, one of the modules presented to first-year engineering students in the ENGAGE program. The intervention, the Amazing Race, was unpacked by describing the elements of the race adapted from the television series Amazing Race*.* The description is fused with the transformation of an existing activity, the "Campus Walk" orientation to the Amazing Race for Professional Orientation. The logistical considerations are included to delineate possible pitfalls in the implementation of the Amazing Race in any context.

4.7 CONCLUSION

This chapter focussed on the first question that guided my inquiry: *How can a game such as The Amazing Race be adapted to suit an academic purpose in a higher educational environment?* I have described the process of transforming the game to suit the scenario on our campus and provided examples of the destinations, clues and roadblocks that the students encountered. The academic purpose of the activity was, apart from orientation on the campus, to provide a platform to expose students to the 4Cs (communication, creativity, collaboration and critical thinking). Student comments were used to provide insight into their experiences whilst partaking in the activity. Nearly all of the teams complete the Amazing Race in time every year, and students report that the Amazing Race was an enjoyable adventure.

I believe that with careful consideration of the educational arena in which you operate and taking the learning objectives as a guideline in the development of the learning environment, a suitable game that encapsulates these circumstances could be identified and thereafter transformed to suit an academic purpose in a higher educational environment.

The next chapter looks into the student experience of the activity as a game. The question is not whether the Amazing Race qualifies as a game but rather whether the students still experienced it as a game even though the setting was very different from that of the original scenario in the television series.

5. CHAPTER 5: AMAZING RACE AS A GAME

5.1 INTRODUCTION

Since the Amazing Race activity was imitating the Amazing Race game broadcast by CBN, the designer wanted to check whether the activity was still experienced as a game within the context of the module. This was done to shed light on the second research question: *Why can this learning environment still be categorised as a game-based learning environment?*

5.2 GAME CHARACTERISTICS

The benefits of game-based learning and the elements needed for effective games are frequently discussed in the literature (Vandercruysse, Vandewaetere, & Clarebout, 2012; van Eck, 2006). I wanted to focus on the gaming aspects and not as much on the learning and technical aspects as proposed by Sica et al (2012). Therefore, the 12 statements of Mark Prensky (2001b) about the elements of games and their respective functions were used to see if students were given the opportunity to develop the 4Cs in an environment that was experienced as a game. One student commented on the game-based teaching strategy as follows:

> *This experience was an ideal learning opportunity as students were free to experience new things and absorb new information in an abstract learning environment through abstract learning techniques. I would recommend that this exercise continues in future and be lengthened in duration as the impact it has is a beneficial one.* [RE_*S*78]

Not all of the students liked the idea of a race, and their comments reflected their feelings.

Next time the race shouldn't actually be made a race but rather an excursion where the participants take their time to get to know the university. [RE_S35]

5.2.1 Games are a form of fun. That gives us enjoyment and pleasure.

It was fun. [ES_S32].

This comment made by one of the students in response to a question in the ENGAGE survey resonated throughout most of the responses on the Amazing Race activity. Students were laughing, competing with other teams in a friendly manner, even collaborating with other teams when the challenges faced were perceived as too complicated to solve quickly. Statements of the students in their reflective essays confirmed these observations made during the activity.

I had an absolutely joyous experience and I learned so much. Ergo, I found it rather thrilling and unexpectedly fun. [RE_*S*52]

I think it was a worthwhile experience that has definitely given me a fun way to explore and discover the campus and shown me areas on campus that I have used daily to study and work. [RE_*S*98]

Students obviously experienced the Amazing Race in many different ways. If we consider the destinations, for instance, some of the students only saw the destinations and made a decision on the value of these for their own purposes, while others made connections with the environment via aesthetic appreciation. Some looked at Amazing Race from a perspective of meeting new people. The Amazing Race environment provided room for a wealth of different interpretations of the experiences offered through the design of the activity and, as such, can be seen as a source of fun according to Koster in his book *A theory of fun for game design* (Koster, 2014).

I really enjoyed the first four destinations because I learned a lot about the university and how things work around the campus. … Out of all destinations, the Sci-enza was the best because it included fun activities and an interesting experiment. [RE_S94]

They provided interesting facts about some aspects of the universities architecture, too. [RE_*S*53]

I like the whole idea of the Amazing race because it is a fun way to get to know the campus for the first years. Also, the fact that we had to team up was cool as it helped us to get to know a few people right in the beginning. [RE_S32]

Koster (2014) stated that students experience games as fun since they are cognitively challenged and they experience a sense of mastery. Students experience fun as the quest for stimulation of their brains and are satisfied when they have to solve the challenges posed by the game (Koster, 2014). Student comments confirmed that they experience the challenges posed during the activity as being the fun part.

This was the fun part, getting to tackle problems was exciting. Even though some of the roadblocks were tough and required a lot of thinking. [RE_*S*100]

*It was not very complicated to solve the roadblocks and they added a challenge to the race which was fun. [RE_S*53]
Out of all destinations the Sci-enza was the best because it included fun activities and an interesting experiment. The experiment was about how reflected light can be used to spark up a match stick. [RE_S94]

Even though educational strategies have developed immensely throughout the years, the needs of the Generation Z-student force educators to look at alternative teaching strategies. The tension between the world of work and the world of play complicates the task, especially when taken into account that games are actually supposed to be voluntary and non-productive (Garris et al., 2002). The words used by the students to describe their Amazing Race encounter may serve as evidence that they have experienced the game as being fun even though the game features were adapted to introduce students to the 4Cs. They confirmed that the game cycle aided in keeping their self-directed interest. Even the fact that they encountered tasks that did not necessarily fit their expertise or interests, did not lessen their experience of enjoyment and pleasure (Prensky, 2001b).

5.2.2 Games are a form of play. That gives us intense and passionate involvement.

Play has four distinctive qualities according to Rieber (1996): it is voluntary, intrinsically motivating, involves active engagement, and it has a make-believe quality. In the case of the Amazing Race, students enrolled in the module had to partake in the activity, it was not voluntary. However, observations by colleagues at the destinations confirmed my own as I was walking on the routes to check and assist students that were struggling to decipher the clues regarding the map, that the students did not perceive the activity as an academic task that was compulsory. One of the students, even though not prompted to comment on this aspect, stated that:

> *Most of the roadblocks were considerably fun and made it feel like the Amazing Race was not an assignment.* [RE_S22]

The second quality of play, according to Rieber (1996) is that it is intrinsically motivating. Students that are intrinsically motivated engage in activities that require higher-order thinking because of personal interest and enjoyment in the activity itself (Rieber et al., 1998). The activities that nurture intrinsic motivation usually display attributes of challenge, curiosity, fantasy and control (Malone & Lepper, 1987). One of the student's comments pictured all of these attributes.

> *The most challenging roadblock was solving or estimating the area and height of NW1 in order to figure out our next move, but we overcame it and this only built more excitement of what was to come next.* [RE_*S*43]

Keller (1987) mentioned that persistence, the intensity of effort, emotion and attitude may serve as a direct measure to judge the level of motivation that the students experience. The following comment portrays one of the students' levels of motivation to partake in the activity.

> *I really enjoy scavenger hunt type games so from the start I was excited and itching to get out and start the race.* [RE_*S*24]

All of the students were actively involved in the scenario, the third quality of play consistent with what Rieber (1996) suggested. Students had to complete the activity in 110 minutes, and the last clue led them back to the lecturing hall where they received a number displaying their place in the race. Students valued the teaching approach followed as can be seen in this comment.

> *The roadblock added a more engaged approach to finding out what is offered on the campus, for example I didn't know about the free health services offered there and about all the cool stuff you can build at the Maker Space.* [RE_*S*86]

The last quality of play stipulated by Rieber is the make-believe quality. Play as such provides an opportunity to escape from reality and experience an environment where the consequences of bad decisions are evident, but not serious or lasting (Teed, 2018). The outcome of the decisions that the students made based on the information provided did not have detrimental consequences and could be corrected through consultation with other groups, or with one of my colleagues. Students were serious to complete the race, as can be seen in the following excerpts. I thought that the students were passionately and intensely involved as confirmed by the following statements.

> *The part I enjoyed most was when we had to figure out where the clues were directing us and at the meantime we were in a race, not only against each other but also a race against time, so we had to think of our toes.* [RE_*S*51]
> *The fact that it was a race was a factor that made the whole activity more enjoyable because I am a very competitive person.* [RE_*S*1]

However, in the focus group interview conducted after the race, one of the assistant lecturers commented that "*there was a mixed response towards that"* [FI_AL1]. Students that were doing well in the race "*rushed there. They were eager to participate, and they fulfil the task properly"* [FI_AL1] and then she continued that students "*at sort of the backend they didn't want to do it, they wanted me to give them the answers and then they just kind of wandered off"* [FI_AL1]. Yet another tutor commented that the students "*just didn't really care"* [FI_T3] and continued that "*you get people that are willing to try and willing to do it and make the best of it and then people that don't really want to do it and just mope around"* [FI_T3].

5.2.3 Games have rules. That gives us structure.

Unstructured play is changed into playing a game by adding rules and limits that force the players to stay in the same bounds while participating in the game (Prensky, 2001b). There are three types of rules that govern the game world: system rules, procedural rules and imported rules (Pivec, Dziabenko, & Schinnerl, 2003). These rules separate the real world from the game, the "magic circle" (Huizinga, 1949) and the player's behaviour is limited to be able to participate and receive the rewards offered by the game environment (Bartle, 2004). The rules, therefore, govern the actions of the players (Bartle, 2004) and set the stage whereby the game could be won or not (Mallory & Guadagno, 2016).

In the case of the Amazing Race*,* the students knew the structure of the game as many of them have seen the television series beforehand (system rules). The procedural rules were provided on the handout that the students received at the beginning of the activity. They had to read through the assignment provided, to realise that they had to operate in teams of two at all times, that they had to follow the instructions sequentially, provide proof of the execution of the roadblocks before they receive the clue to their next destination and that they may not run during the course of the race. Students realised that they had to take other students on campus into account as they proceeded in the race. For instance, they had to be quiet upon entering the library, imported rules from the real world.

During the activity, it became evident that the students were abiding by the rules. Even though they did not necessarily like the fact that they had to follow rules.

> *I liked almost everything that we did in the Amazing Race except for the fact that we had to walk because we weren't allowed to run to the destinations.* [RE_*S*64]

Students were actually very upset when their teammates did not abide by the rules. One student's partner did not want to enter the library and left, leaving the other student stranded. The unfortunate event resulted in this comment:

> *I would recommend that students should do the Amazing Race on their own. In this way when you don't want to take part you can say so at the beginning of the race and when you want to leave the race along the way it would only affect one person unlike having to be in a team, then you are forced to quit due to unforeseen circumstances.* [RE_*S*39]

The structure provided by the rules proved in this case not to benefit the student. This incident actually developed a negative attitude towards teamwork, whereas the student who left was observed by my teaching colleagues to have a bad attitude and left the university after the first semester.

The rules actually sparked enthusiasm and creativity by the students. One of the tutors commented in the focus group interview on their experiences in the first year of their studies that "*we were all trying to do it fast because we know that one of the rules was that you can't run, so we were trying to do it as fast as possible*" [FI_T4].

5.2.4 Games have goals. That gives us motivation.

The goal of the Amazing Race in the CBS television series was to win a 1 million dollar prize by completing each leg of the race successfully in minimum time (Cbs.com, 2019). This entailed furthermore that teams adhere to the rules of the game as set out before the race and that they complete the activities added to the race such as the roadblocks and detours.

Much is said in the literature regarding goals. Palmer (2005) described three types of achievement goals: social goals, an individual's need for recognition; mastery goals, the need to master the work; and performance goals, the need to perform better than your peers. Sailer, Hense, Mandl and Klevers (2013) refined the different types of driving forces further by stating that individuals with strong affiliation motives will prefer scenarios that emphasise membership; success and progress. Achievement will motivate individuals with a strong achievement motive, whereas individuals with a power motive crave status, control and competition. The Amazing Race game can be seen as an environment wherein most human beings will experience satisfaction, all of the above-mentioned traits that motivate individuals appear in the scenario.

Malone and Lepper (1987) stated that the motivation of students depends on clearly defined goals and achievable, but not too easy, challenges. According to Baron (2012), the act of the achievement of smaller goals that link to larger goals gives rise to a feeling of accomplishment that serves as motivation to continue with the game. The Amazing Race activity consisted of different legs that had to be completed, each leg containing different activities that could add to the feeling of achievement. The following statement suggested that the students did understand the goal of the race in terms of the game in which they were participating.

> *Winning was in our minds from the beginning and we have achieved our goal.* [RE_S49]

Students reacted positively to the challenges posed by the game and stated that even though it was not always easy to decipher the clues, the end goal motivated them to move forward.

> *Although it was quite difficult to navigate these buildings, I never gave up, motivated myself and kept on moving.* [RE_S20]

One of the students remarked that the difficulty of roadblocks added to the fun in striving to reach the goal of the activity.

> *I enjoyed the old arts roadblock the most as it presented the most difficult challenge in terms of finding our goal.* [RE_S98]

As expected, some of the students inferred the goal of the activity to what they thought the real goal was and tried to summarise it.

> *This task taught us how to work under pressure, work in teams, estimate and work towards a goal.* [RE_S62]

Nonetheless, it seemed as if students were motivated to complete the activity regardless of their interpretation of the real goal of the game.

5.2.5 Games are interactive. That gives us doing.

To ensure that students are interactive within the learning environment, special attention to the design of the learning environment is needed. John Keller (1987) proposed the Motivational Design Theory, the ARCS Model. The ARCS Model builds on the fact that individuals are willing to engage in activities when they expect that involvement would result in the satisfaction of their personal needs and also when they expect that they would be successful in their execution of the activity (Keller, 1987). He stated that the following factors need special attention if you want to intrigue students: the environment should grab the students' attention, it should be relevant, students should expect that they could be successful and they should have positive feelings about their accomplishments. Prensky (2001b) said that games are interactive when your actions while playing the game change something in the game that you are playing. The Amazing Race environment was designed keeping these factors in mind. The students reacted as follows:

> *I got to see things I have never seen before in my life. It was very interesting and we got to do exciting activities.* [RE_S84]

There were mixed reactions regarding the relevance of the destinations visited during the activity, as demonstrated by the following comments:

> *Some of the destinations did not seem to be relevant to the course such as the student health centre seeing as though it was for a professional orientation class for first year engineering students this did not seem very relevant. However destinations such as the Scienza where I saw the mirror maze and had to measure the angles the mirrors made, I also enjoyed the makerspace and the Engineering 1 Study centre where I learnt how they where I learnt how they were using Green Engineering solutions to save energy. I found that very interesting.* [RE_S89]

But mostly, student reactions were positive.

> *The locations we were sent to were very informative, they were relevant to what we are studying and where we would want to go to make the most of university. The roadblocks were good as they allowed us to find out more information*

> *about the university itself, things that you didn't know before.* [RE_S35]

During the activity, I saw students clogging together to find the answers to the clues, excited and determined to finish the race. It seemed as if they did not experience the activity as being too difficult for them to master. One of the students commented on his/her initial feeling of incompetence as follows:

> *I had an absolutely joyous experience and I learned so much. And the fact that I was afraid and in some way nervous about the whole challenge. I actually thought I was almost incompetent of doing this challenge because it was new to me and I lacked confidence in my teamwork skills. But I proved myself wrong because I discovered my communication skills and teamwork skills were really good.* [RE_S52]

The choices that students made during the race, be it with regard to their interpretation of the clues provided or the instructions to complete the roadblocks, did influence the outcome of their game in terms of the final position in the race based on the time that they arrived back in the lecture venue.

> *We did not know how to use the map meaning that we got lost a couple of times. The last instruction was confusing and misleading. Due this we could not find the last destination for about an hour. We only found it when we had given up.* [RE_S94]

Students were offered an opportunity to do something. The following student comment confirms that they were interactive, that the activity was experienced as being attention-grabbing, relevant, students felt confident in their own abilities and experienced the satisfaction of being purposefully engaged.

> *The roadblocks were for the most part enjoyable. Some even had a sense of humour, for example, the roadblock we got at the Old Arts Building's first instructions jokingly wanted us to walk into the pond.* [RE_S81]

5.2.6 Games are adaptive. That gives us flow.

The Amazing Race television series had been adapted to fit the scenario on the campus. It was integrated into the curriculum to fit the purpose of the module by creating opportunities for the development of the 21st century skills needed to be successful in the workplace. These opportunities were developed taking the level of competency of the students into account, they were a diverse group of first-year students with little or no experience of the campus environment, but most of them knew the concept of the Amazing Race game. Furthermore, the activity was restricted to a certain part of the campus for logistical reasons, and there was also a time constraint to take into consideration in the design of the learning environment. The game was therefore adapted to fit the circumstances of the learning environment.

During the activity, I have sensed that the students lost track of time, I had to urge them to move faster since they did not have enough time to finish the activity. Csikszentmihalyi (2008) defined this state of involvement in a task to a level where nothing else matters, as experiencing flow. A student even commented that:

> *My personal favourite roadblock was the Sci-Enza. Here I saw numerous science projects and for the most part forgot about the task at hand.* [RE_S81]

Garris et al. (2002) further stated that flow is encountered when students experience a balance between the difficulty of the task and their own capabilities; when goals are clearly defined; regular feedback is provided and they feel that they could control the situation. They conclude by saying that the enjoyment and engagement that participants in games experience can be explained by examining the concept of flow. A comment such as this one gives the impression that the students were experiencing flow.

> *What I can say I enjoyed about the whole experience was the roadblocks which really allowed us to explore and perceive various vicinities around the campus and I found beauty and majesty. I was intrigued and my curiosity about everything we did is even now sky high. I frankly feel like challenges like this are very beneficial for us students because we get to learn, discover, explore, adventure and so much more.* [RE_S52]

5.2.7 Games have outcomes and feedback. That gives us learning.

Marc Prensky (2001) typified the process of playing games as payoff vs patience. He stated that people playing games know that if you put in the effort to master a game, you will be rewarded (be it with a next level, or even a place on the scoreboard). Students want to see results now, not in the long run (Prensky, 2001b). Sailer et al. (2013) also linked motivation to play a game to immediate positive or negative feedback. A gamer wants to know how their actions influenced their performance in the game (Baron, 2012). Different mediums of feedback can be employed: a numerical score, a graphic representation, an oral response or a physical result (Wilson et al., 2009). In the Amazing Race activity, the feedback was provided by presenting the next clue after the successful completion of a leg of the race. A student commented that the:

> *…road blocks were little bit complicated because they wanted us to know the necessary things in order to move on to the next one.* [RE_S95]

Students complained when an activity in the game did not have immediate consequences on the outcome of the race:

> *However I found the road block of examining the Sundial to be totally useless, as no questions were asked on it as the clue had implied.* [RE_S68]

When students misinterpreted the clue provided to the next destination, the result was that they could not reach the specific stop. "*When I was sitting outside the mining study centre, I saw students suddenly wandering off down the side that had absolutely nothing to do with the task. They were completely off track. The way they worked it out, that is the way they were going…*" [FI_AL1]. Feedback, in this case, is a physical result; they have to re-evaluate the information to be able to continue with the race. At most of the destinations, students had to give oral feedback regarding the roadblock that they received. The tutors or colleagues stationed at each destination were well informed "*so if the student comes back and you know that they didn't really focus on anything, they just grabbed the pen and wrote something down"* [FI_T6], they could send these students back to find the correct answers. Should their answers be correct, they received their next clue, the action then functions as a form of feedback (Pivec et al., 2003).

> *We were presented challenges through the form of roadblocks. The roadblocks were considered challenges because we could not move to the next destination if we didn't solve the challenges.* [RE_S37]

Some of the activities included in the race involved the calculation of the circumference of a circular platform or the floor area of a building. These answers were not used to progress in the race. Students complained about the inclusion of these as can be seen in the following excerpts.

> *My least favourite road block was the one was my team mate and I had to calculate the Natural Sciences Building 2 and it was not even necessary for the next road blocks.* [RE_S81]

The process of debriefing, according to Garris et al. (2002), is crucial to link the learning that took place in the fantasy world to real-world experiences. Students expected to receive feedback on the accuracy of their calculations. They would be able to connect the knowledge that they have gained from being involved in the game to real-life situations through the debriefing process (Hromek & Roffey, 2009).

> *The Natural science one especially since that one was just estimate the area that the building takes up. This was really boring to do and the estimation wasn't even checked to see if it was accurate.* [RE_S74]

Based on this feedback from the students, the activity, being a design experiment, was changed to include detailed feedback on these activities in the following year.

5.2.8 Games have win states. That gives us ego gratification.

Everybody likes to win. A feeling of competence lead to motivated individuals (Sailer et al., 2013). The winners of the race commented as follows:

> *Overall I enjoyed the Amazing Race, and coming in first place definitely added to the fun.* [RE_S67]
>
> *The highlight of this part of the Amazing Race was that my team won and this gave me a proud feeling and free food from Steers, a good combination.* [RE_S85]

Since the Amazing Race environment consisted of several activities, each activity that has been successfully completed could add to the experience as being a competent contender. The feeling of accomplishment experienced by the students after successfully completing a leg of the race was evident from the following comment.

> *I rate it 9 out of 9 because it was the best event that improved my social and life skills. The destination that we had to reach was quite tough to reach at the start but later the keys that were given to us made me understand how to track my destination at a faster rate. It was very nice to reach my destination since reaching my destination made me understand different buildings. [RE_S*92]

The fact that it was a race influenced the students in different ways. One student commented that it influenced the functioning of their team.

> *Teamwork between me and my partner was not always smooth because we did not trust one another with the map and the instructions. Winning was in our minds from the beginning and we have achieved our goal. The Amazing Race competition helped me to find a place in the social structure of the University of Pretoria.* [RE_S49]

Others did not consider the winning stance as being the notable factor in the activity.

> *My partner and I came 2nd place in the group we were assigned, we were quite surprised seeing that we never took this task as a race, but to learn more about Tuks.* [RE_S65]

The important factor for the students was that the outcome of the race would be fair and that the rules be applied consistently. Colluding and the breaking of rules in a game are inevitable. It should not only be seen in a negative light but could also positively influence the design of the game since it leads to the modification of the game mechanics to ensure a better game experience (Robson, Plangger, Kietzmann, & McCarthy, 2015). In the following iteration of the experiment, the issue raised by the student was addressed.

The actual racing portion which included the roadblocks was well administrated which led to it being rather informative. Something that did bother about the roadblocks was that many teams did not complete them properly and were just given the green light to continue as all they cared about was winning. This diminished the point of the race slightly for me. [RE_S8]

But in retrospect, most of the students enjoy winning even if the prize for completing the activity is only a water bottle.

I really did enjoy The Amazing Race and receiving a free water bottle for completing the race. [RE_S110]

We did well since we managed to get the bookmark bottles which was the price. [RE_*S*60]

5.2.9 Games have conflict/competition/challenge/opposition. That gives us adrenaline.

Most people enjoy a challenge, especially if they sense that they can win (Prensky, 2001b). It is these challenges, the conflict, competition and the opposition that trigger an individual's creativity and excitement and keep him/her glued to the game (Prensky, 2001b). The excitement caused by the successful completion of the challenges can be detected in the following student comments.

Another thing was the roadblocks, getting there and waiting to hear if you qualify for the next clues and planning your next destination, this kept us on the tips of our toes, I'm sure the tutors at the roadblocks could even see the excitement on our faces. [RE_S6]

Most challenging roadblock was solving or estimating the area and height of NW1 in order to figure out our next move, but we overcame it and this only built more excitement of what was to come next. [RE_S43]

I enjoyed the Amazing Race as it was a big challenge in finding the buildings, figuring out what to do and what the answers were of the road blocks as well as the teamwork. [RE_S47]

The importance of balance in the level of difficulty posed by the challenges can be seen in the next student comments. If the challenges are too easy, the game could be seen as pointless, and students will be bored and lose their motivation to continue, while challenges that are too hard will discourage students from continuing in the game (Sweetser & Wyeth, 2005). Two different perceptions regarding the difficulty of the activities of the Amazing Race are voiced below.

The challenges were disappointingly easy to solve and served no real purpose other than sending you to as different place on campus. While taking part in the race it felt like there was no reason for the activity, and most people simply wanted to finish it as fast as possible, not for a reward or as a race, but to leave earlier. [RE_S87]

What I did not like about the race was the fact that we were left to figure out everything on our own. With one of the clues we could not find where we must go and eventually gave up. [RE_S24]

It seems as if this student craves competition in a thought-provoking environment.

The road blocks were fairly well done except the roadblocks for Natural Sciences one and the Old Arts building…. I single these two out because their roadblocks felt a little

> *derivative and pretty pointless. I would improve it by reworking the two mentioned road blocks and then making the race more competitive. Many students had more motivation to go home than to rather compete in finishing everything first. It could be a very fun activity and I think the premise behind the Amazing Race is fantastic.* [RE_S74]

Deci and Ryan (2002), on the other hand, warned that competition, rewards and deadlines were found to diminish self-determination and autonomy. The competition activates performance goals and this type of learning environment does not necessarily enhance learning and intrinsic motivation (Sailer et al., 2013). However, if students have mastery goals together with performance goals, the effect of competitive activities will not be unfavourable for learning to take place (Pintrich, 2000). These views are illustrated by the following comment made in the reflective essays.

> *The purpose of the Amazing Race was to ensure that the learners familiarize themselves with the buildings around the Hatfield campus. So that during the very first round of lectures they will know where their respective classes are located. The problem arises when it is turned into a competition. Learners focus more on winning than actually getting to know their surroundings. The locations we were sent to were very informative, they were relevant to what we are studying and where we would want to go to make the most of university. The road blocks were good as they allowed us to find out more information about the university itself, things that you didn't know before. As a result it did promote teamwork, as two brains are better than one when it comes to solving puzzles. Next time the race shouldn't actually be made a race but rather an excursion where the participants take their time to get to know the university.* [RE_S35]

The student just looked at the activity at face value and did not realise that the environment was aimed at the development of their communication skills, providing an opportunity to collaborate in a competitive setting while applying their creative and critical thinking abilities. The competition scenario concealed the real purpose of the educational environment.

5.2.10 Games have problem-solving. That sparks our creativity.

Students had to unravel a range of navigational instructions during the race. It was evident that they found this activity challenging considering the questions that they asked during the activity. I was on numerous occasions surprised by the fact that they were not able to analyse the instructions critically and by their quest to have all of the information readily available to react on. This observation was confirmed by the comments made during the focus group interview. Four of the seven participants mentioned that the students did not read. One of the tutors said that a lot of people asked questions and his reply was: "*It's right there, it's even in bold, it's right there, you just need to read"* [FI_T3]. The students were actually quite frustrated when being told to read properly to find the answer. The assistant lecturer commented that: "*They almost get like: it is not there, I am telling you it is not here"* [FI_AL1]. It could be said that students were forced to think critically and creatively, out of the box, they were operating in unfamiliar territory.

Most of the students enjoyed the challenges posed to them during the race.

> *I enjoyed all the roadblocks we were given but my favourite was when we had to find a means of getting the area of this circular path at the Piazza.* [RE_S37]

A number of students linked the level of difficulty with their positive or negative experience of the Amazing Race activity. Some of them found the difficulty entertaining while others commented that it was hindering their enjoyment of the race.

> *We were assigned to go to certain destinations and at every destination we had to do a quiz or measure and figure a few things out. It was very difficult to find the buildings on campus because we were first years and we didn't know where everything is. Some of the quiz questions were very difficult but were very entertaining.* [RE_S47]

> *Though the map was very confusing and did not clearly indicate the locations, this made it difficult for me to fully enjoy the Amazing Race.* [RE_S54]

> *I did not enjoy the old arts building destinations because we had to read on the things we don't know and it was written in Afrikaans which was a bit tricky to understand.* [RE_S84]

Sometimes students revealed mixed feelings with regard to the balance in difficulty. The following student comment shows the incongruity between "instructions being vague" and the feeling of accomplishment after solving challenges successfully.

> *However, I did feel like some of the challenges' instructions were not clear enough and did not say what we should have done exactly. Other than that, I enjoyed being mentally challenged and feeling satisfied when we got it right. [RE_S*22]

Csikszentmihalyi (2008) highlighted that flow will only be experienced when feelings of boredom and anxiety during the same activity are avoided. As such, the balance between "too easy" and "too difficult" activities need continuous attention. Numerous students, however, concluded that the Amazing Race

> *..helped the students with problem solving and communication.* [RE_S25]

> *All the roadblocks (puzzles) given was enjoyed as it tested our problem-solving skills and teamwork capabilities. Teamwork played a vital role in solving the Amazing Race as both members had to think very hard to complete the roadblocks, both members relied on each other for support and problem-solving.* [RE_S36]

5.2.11 Games have interaction. That gives us social groups.

The Amazing Race activity was scheduled for the first week after lectures started. As such, the students were not yet familiar with the campus environment and also not with their classmates. It was planned to serve as an ice-breaking activity where students would have an opportunity to develop the 4Cs while being orientated in the new environment, especially in the light of the fact that the Generation Z students are known to prefer texting to talk, even though they seem to be very social (Igel & Urquhart, 2012).

> *We worked in teams and socialized with other people and this made the whole experience great.* [RE_S66]

During the Amazing Race activity, casual observations made by the assistant lecturers, lecturers and colleagues stationed at the destinations revealed favourable signs of student interaction. Most of the students commented that the activity enabled them to meet new people and that they managed to build lasting relationships with fellow students.

> *The Amazing Race as a whole was enjoyable and succeeded in introducing students to each other.* [RE_S87]

> *Working in a team to solve those kinds of problems was also a great experience because I got to meet new people through it as well* [RE_S82]

Since the students had fun together, they experienced a sense of belonging (Ayers, et al., 2005) and the group could interact in a relatively safe environment.

> *The way the race was in parts of teams made it better because we had a laugh with each other and get to know other people around you.* [RE_S67]

> *The teamwork was absolutely fantastic, although my teammate and I were always lost but we persevered though it with wide smiles on our face and tears dripping down our faces.* [RE_S71]

Not all of the students felt comfortable to work in teams. The game scenario created a make-believe environment (Prensky, 2001c) where these students could be eased into working together, a quality that is imperative for a successful employee in the 21st century. One student said that:

> *When it comes to teamwork, I'm not much of a team player or team person in general, I prefer to work alone but I enjoyed working in a team for the first time.* [RE_S102]

One of the six elements that make a good game according to the New York Film Academy (2015) is that the winning team should be the team that managed to work effectively as a team together. Students commented that they needed to work in their team to be able to solve the challenges and that this collaboration helped them to form relationships with their fellow students.

> *It helped for new bonds with your partner because you had to work with your partner to solve problems.* [RE_S86]

> *Working in teams we could easily solve the questions and finished in second place. This helps learn new people and build bonds with new friends.* [RE_S90]

5.2.12 Games have representation and story. That gives us emotion.

"Any narrative or story elements in the game" form part of the representation, be it abstract, concrete, direct or indirect (Prensky, 2001b, p. 15). The Amazing Race, adapted for our educational purposes, is a game about a journey through the campus where students have to overcome specific obstacles to be able to complete the race in minimum time. It served the purpose of orientation in a new environment but was mainly aimed at the development of 21st century skills that students need to be successful. Students perceived the activity as a nice introduction to the campus.

> *The race was very informative and a pleasant introduction to the year.* [RE_S8]

> *But all in all the Amazing Race ultimately a nice lesson about the University and the people you are probably going to work with for the next five years.* [RE_S56]

> *The Amazing Race served as an induction to our very first task in JPO 110. The task as a whole gave me certain insight as to what I can expect from the module a whole. The task showed me that the module would put me in situations that would make me practically apply all the tools that were provided to me by all my respective courses.* [RE_S80]

Students labelled the activity as a great experience, "above par one" and the amazement in the game shows in these student comments.

> *That was one of my greatest experiences, where we lit up a match without any physical interaction.* [RE_S97]

My experience during the Amazing Race was an above par one. The race itself was interesting in the sense that I got to make new friends and I also learned more about the campus. [RE_S5]

In the process I learn a lot about the campus and if we didn't do the race I don't think I would have discovered the scienza and all the cool science things there. [RE_S10]

Different emotions were highlighted, one student said that it was entertaining and challenging.

I found it difficult to navigate to the different destinations using the map provided. It resulted in a tremendous amount of unnecessary walking, because we often got lost. Along the way we encountered different road blocks that I found very entertaining and challenging, without it being impossible to complete. [RE_S26]

Another student pointed out that it was especially beneficial in limiting stress factors associated with the new environment.

I think the Amazing Race is a great idea for first year *students as they learn the situation of campus and therefore they don't feel overwhelmed.* [RE_S50]

The experience was enjoyable and stressful at the same time.

Overall the Amazing Race was enjoyable and stressful at the same time because it was different having to use the map and understand which of the given information was relevant. [RE_S62]

It was cumbersome.

Navigation was mostly achievable except the journey to the Engineering 1 building which my partner and I found cumbersome because it took a big chunk of our time because we both misinterpreted the instructions. The road block I least enjoyed was where we had to answer a question regarding why the mining study centre won an environmental award because it took us a long time to figure it out. [RE_S3]

Interestingly, one of the students commented that the activity tested his/her patience. Duderstadt (2009, p. 47) mentioned in his description of Generation Z that these students have the ability to "navigate through complex arrays of information, acquiring the knowledge resources they seek and building sophisticated networks of learning resources". He continued that some observers suggested that qualities such as patience and tranquillity, might be sacrificed as a result. "But, of course, patience and tranquillity have never been characteristics of the young" (Duderstadt, 2009, p. 47).

My experience during the Amazing Race was good. It tested my patience more than anything else. [RE_S2]

The motivation of students to continue with that game depends on the feelings that they experience during the game (Sailer et al., 2013). Negative feelings such as fear and anger are not promoting engagement whereas positive feelings such as sympathy, emotion and pleasure endorse student commitment to the educational environment (Sailer et al., 2013).

It had a thrilling twist in finding the locations due to the cryptic wording used in the clues. Another thing that intrigued me about the *Amazing Race was the idea of roadblocks.* [RE_S102]

The Amazing Race environment draws forth different student emotions, not all of which was conducive in terms of motivation to continue with the game. The comments of the students will be used as guidance in future iterations of the activity.

5.3 SUMMARY

The Amazing Race was developed as an enabling learning environment to expose students to the development of the 4Cs. The research question that structured the discussion in this chapter was: *Why can this learning environment still be categorised as a game-based learning environment?* I have used the 12 elements of games and their respective functions as proposed by Prensky (2001b) to analyse the student comments. The focus was on the student experience of the activity and whether they still experienced it as a game even though the game was changed to fit an educational purpose. For this purpose, the students' voices, blended by phrases from literature, were presented to enable the evaluation of the scenario as a game-based learning environment. This comment says it all:

> *I am grateful for this Amazing Race, because the students didn't realise that they are learning while having fun.* [RE_S25]

5.4 CLOSING COMMENTS

The Amazing Race learning environment posed opportunities to develop far more than only the intended 4Cs. The student comments opened new horizons in terms of possible outcomes for the activity. Although student comments were categorised using the 12 elements of games and their respective functions, most of the students' comments could easily be used to provide substantiation for other categories. I have tried to, as far as possible, be unbiased in my analysis and provide the data as objectively as possible.

The opportunity to develop the 4Cs by participating in the Amazing Race will be explored in the next chapter by referring to student, tutor and lecturer comments and observations on the value of the learning environment as an opportunity to introduce students to the 4Cs and to provide them with the opportunity to practice these 21st century skills. The dual goal of the Amazing Race was to serve as orientation on the campus and as the first introduction to the most applauded communication, collaboration, creativity and critical thinking skills. Since the students did not receive any information regarding the educational purpose of the activity, the reflections that they have written on their experiences, provided a wide variety of information that could inform educational practices.

6. CHAPTER 6: AMAZING RACE AS PLATFORM TO DEVELOP THE 4Cs

6.1 INTRODUCTION

The research questions were divided into key concepts to address the intended research. Higher education institutions have to prepare students to be “job-ready” employees in a demanding 21st century environment. The 4Cs, communication, collaboration, critical and creative thinking were identified as skills imperative in the industry. Students attending the extended program complicate the educational playing field; lower grades and differing backgrounds emphasise the urgency of activities that would strengthen the student’s academic position. The quest for delivering graduates that display not only content knowledge but also 21st century skills led to the question of whether it is possible to create a learning environment that would be beneficial for the development of 21st century skills and to identify design principles that could be applied in the design of any game-based environment.

A game-based learning environment was designed with the aim to provide the underprepared students with an opportunity to develop these most applauded 21st century skills. Rieber et al. (1998) noted that games provide a socially acceptable platform to practise the skills needed in real life. Furthermore, these teaching approaches are appealing to 21st century learners, and apart from transferring knowledge, the game based environment serves as a motivating factor to engage in the extension of problem-solving, collaboration, and communication skills (Figueroa-Flores, 2016). Social and emotional skills are practised in a safe environment without the agony that arises from failure in real-life situations (Figueroa-Flores, 2016). Strategies to engage the students in activities where they could practise these skills include discussion, role-play and problem solving (Hromek & Roffey, 2009).

The previous chapters shed light on the environment in terms of the elements of the game. Student comments were used to elaborate on their experiences of the scenario. This chapter aims to look into the learning environment as an opportunity to practise 21st century skills. Once again, student voices are used to paint the picture. The chapter concludes with design principles that could be considered in the design of similar learning environments.

6.2 PURPOSE OF THE AMAZING RACE LEARNING ENVIRONMENT

Self-reflection on experiences (specifically sculptured to develop skills) is one of the three principles on which skill development modules are based (Berdrow & Evers, 2011). By reflecting on their experiences, learners internalise new knowledge to supplement and extend their existing knowledge (Desjarlais & Smith, 2011). Since the learning objectives of the activity included the exposure and development of 21st century skills, I wanted students to reflect on their experiences during the Amazing Race activity. On the one hand, I wanted them to internalise what they have gained from the experience, but I also needed their reflections to guide my enquiry into the effect of a game-based learning environment on the attainment of these skills.

Students had to write a reflective essay on their experiences of the Amazing Race activity two months after it had taken place. They were instructed to reflect on their experiences by mentioning the destinations, clues and roadblocks that they have encountered. No mention was made of the real purpose of the activity, namely, the enhancing of communication, collaboration, critical and creative thinking skills. Interestingly enough, though, numerous students tried to define the purpose of the activity and did it very successfully. Students' perceptions regarding the purpose of the race provided valuable insights for further development.

The Amazing Race activity had a dual purpose. It was meant as an ice-breaking activity where students could familiarise them with the new environment and their peers with whom they share this new life experience. However, mostly, it served as the first introduction to the 21st century skills needed to be successful as a student and in the 21st century workplace.

Whilst the purpose of an instructional activity might be clear to the designers of an event, the student experience does not always reflect the same level of clarity regarding the value or purpose of the event. When the Amazing Race was presented in the year under scrutiny, the purpose of the activity was not communicated explicitly to the students. I did not want to hinder the students' spontaneous contribution by pointing towards the introduction of 21st century skills that they believe that they have already attained at the school level. Students participated in the game for the sake of the game. One student commented and said that they were:

> *…somewhat [ ] confused as to why we were doing the Amazing Race.* [RE_S101]

Another student revealed the expectation that all of the activities encountered in their lecture halls should have a strong connection to their academic careers at the university. No wonder that they could not see any value in doing the Amazing Race.

> *It was a good experience, but did not add to my academics*. [RE_S90]

Numerous students tried to define the purpose of the Amazing Race and the difference in their opinions can be seen in the student comments below. Some of them thought that the activity was beneficial in terms of their orientation on campus as can be seen from the following comments.

> *I actually found that most of the race was rather meaningful and interesting as it gave us more knowledge about the university.* [RE_S44]

> *The Amazing Race was a clue based treasure hunt that allowed us, the JPO 110 students, to orientate ourselves on campus. I believe it was incredibly helpful, as I was new to the campus grounds and was unfamiliar with the university, so I got lost quite often.* [RE_S53]

One student was so convinced that the purpose was solely to orientate students to the campus that they wrote:

> *I also then think the roadblock was fun but the last one was quite hard for most of the people. I know a lot of teams that could not finish the last one and the goal of the race was not to struggle but to learn your way around campus*. [RE_S31]

And as many students considered an orientation to the campus to be the goal, it could be understood that one student commented:

> *I would have liked to have a bit more stops along the way to even get a better picture of what the university is about. Lastly, it would be fun to also get a little more background of the university.* [RE_*S*34]

Interestingly enough, a number of students intuitively understood that this activity benefitted them in more ways than only being an orientation on campus. This one seemed to notice the intrinsic value of the activity in that it got students engaged with others on a social level.

> *I thought the Amazing Race was a great activity to participate in because we got to meet new people and make friends while working on the Amazing Race. Aside from meeting new people and making new friends, it also gave me an opportunity to get to know the campus a little better as I was still new to the university and did not know where all the buildings are. The destinations helped me familiarise myself with the campus and how to get around it. [RE_S*59]

Similarly, another student recognised the fact that the activity allowed students to meet and connect with people that are different from them.

> *The race allowed me to interact with other groups and meet new people, while exploring the campus and learning where*

buildings and important destinations are on campus. I thought making us do certain tasks in the campus, forcing us to learn about places in the campus, was a good idea. [RE_S99]

Some students recognised and coined the purpose of the Amazing Race as an opportunity

to improve mainly teamwork skills, navigation skills, communication skills and estimation skills. [RE_S52]

Others identified a number of “purposes”, as the quotes below will highlight:

…thus this project taught me many things which include reading, teamwork and thinking through. [RE_S64]

*The Amazing Race tested our understanding, map work and communication skills. [RE_S*37]

I learnt a lot from the experience and obtained a number of new skills and properties such as teamwork and communication. [RE_S51]

These statements serve as an indication that the activity was spot-on as an opportunity to introduce the 4Cs as they relate to 21st century skills, namely communication, creativity, critical thinking and collaboration. Duderstadt (2009) acknowledged that our students outsmart us as lecturers with regard to their navigational capabilities regarding knowledge about things, they have an urge to learn how to be, and they need experiences that will enable them to be successful in the workplace. The opportunities developed for the purpose of the Amazing Race were not necessarily perceived as being directly associated with the engineering profession but as an added bonus one student commented.

> *As future "engineers" it is essential that we learn […] how to work in teams, to solve problems and to explore our surroundings*. [RE_S83]

The race scenario allowed for the inclusion of activities that could address student impediments identified in previous years. These impediments, in this case their inability to read properly, was used to add additional fun elements to the game. Opportunities to experience amusement, surprise, excitement and wonder add to the emotional experience of the participants that could further the influence of the game (Robson et al., 2015). Students commented on one of the activities developed to sensitise them to the importance of reading.

> *I also enjoyed our last stop. The instruction on the paper we were given said we should go to the fountain and take off our shoes, and put one of our hands on our head and turn around. As I was about to take my shoes off my partner saw one of the lectures taking a video and when we read down the instructions we saw that we did not have to do it*. [RE_S107]

One would expect that not all of the students would be able to identify the educational value of the activity. They experienced certain activities as being part of the fun that participating in gameplay usually provide and did not realise the value of the first-hand experience of not reading carefully and following the instructions given to them.

> *The road blocks were for the most part enjoyable. Some even had a sense of humour for example the road block we got at the Old Arts Building's first instructions jokingly wanted us to walk into the pond*. [RE_S81]

> *…which was hilarious because the JPO 110 lecturer almost made my teammate dive in the pond. This was quite fun for*

> *me as I learnt some amazing history stories about the University of Pretoria.* [RE_S71]

Student reaction to this activity ranged from disregarding the activity since it did not have anything to do with the race, to realising the academic value of impounding the information provided. Hopefully, the exposure to the activity would have an effect on the way that they approach certain tasks, and remind them to read before they do. The following comment serves as motivation since it seems as if the intended message was delivered.

> *The roadblock that we received was well thought out because they taught us that we need to read before we do.* [RE_S64]

Students commented that they have obtained the ability to use the campus map and that they were exposed to interesting buildings and high tech services on campus that they would not necessarily have encountered.

> *Places like the Old Arts building, this is a good example of a building that I now only know more about because of JPO 110. The map also help a lot because campus is a maze when you first see it in January.* [RE_S4]

> *Were it not for the race, I would not – by now – have known about the MakerSpace and I would crown that destination as my preferred favourite. Knowing of such savvy tech gadgets ready at my disposal is a useful tool for the future.* [RE_*S*21]

The Amazing Race activity ensured that students were actively engaged, exploring the campus environment together with the new community in which they had to function. This kind of engagement could have an influence on their perseverance as a student (Bottrell, 2009). Particularly in terms of a sense of belonging in the new society as a student retention strategy (Tinto, 2006-2007), students acknowledged the influence of the race.

> *The friends I made helped me to feel more at home when coming to campus*. [RE_S27]

> *The pairing with random class mates is a good idea, it allows you in your first week to get to know at least one person so you don't feel so isolated in a new place*. [RE_S42]

Finally, students reacted mostly positive when prompted about their Amazing Race experience. They labelled the race as being an extraordinary event to familiarise students with the campus environment, an enriching opportunity for interaction with the milieu and a chance to make life-long friends.

> *My experience of the Amazing Race was a remarkable event for me, due to [the fact that the] event created some familiarity of the campus for me and enabled me to visit buildings and place I would never think of going to. The Amazing Race also made me acquire some history of the University of Pretoria when the race directed me to the Merensky library. I gained some background in how most of the building on the Main campus was built and what changes they went through till the present day.* [RE_S71]

> *Overall, I would deem the Amazing Race Exercise as beneficial and stimulating as it offered us, the JPO 110 students, an enriching opportunity to interact with our campus and get to know the university's facilities and all that Tuks has to offer. During the exercise, we went across the main campus and visited the major landmarks such as the Merensky Library, The Piazza, Scienza and various others at which we were tasked with simple challenges that*

encouraged us to learn a thing or two about our new school. [RE_S78]

The Amazing Race was really fun and exciting as [we were] coming into the University of Pretoria, not knowing anything. It helped a lot to get familiar [with] all the different buildings and places on the main campus. I also got to know a lot of new people and made some long-life friends during this Amazing Race. [RE_*S*61]

The comments of the students that were involved in the Amazing Race learning environment underlined the fact that there are multiple versions of the reality as proposed being typical of qualitative research (Creswell, 2013; Denzin & Lincoln, 2000). While some of the students found the Amazing Race activity enlightening, other students commented that they could not see the value of the activity in relation to their studies. Whether the environment was conducive to fulfil the real purpose, will be investigated in the next section.

6.3 THE 4Cs, communication, collaboration, creativity and critical thinking

I wanted to establish the value of the activity in terms of the attainment of communication, collaboration, critical and creative thinking skills. For this purpose, I have used student comments regarding these aspects to evaluate their exposure to an environment wherein these attributes could be fostered. Although not explicitly asked to comment on the attainment of these skills, numerous students mentioned the opportunity in terms of the exposure to the development of skills.

I honestly enjoyed this module because I am learning a lot of new skills and actually getting experience on how to actually become a professional engineer. [ES_S10]

> *It was an enjoyable challenge and it taught us valuable skills.* [RE_S62]

Most of the student comments referred to not only one skill but mentioned an array of different things that they found beneficial.

> *This task taught us how to work under pressure, work in teams, estimate and work towards a goal. This task ignited our map skills and connection skills because we have to find the best way to communicate with our team members. Thus this is the reason why I rated it a 6 because it was an enjoyable challenge and it taught us valuable skills.* [RE_S62]

> *The exercise was meant to help us hone our communication, cooperation and problem-solving skills. We were paired with people we did not know in order to truly test out communication skills and were given a set of instructions and tasks to complete.* [RE_S93]

The skills needed to complete the Amazing Race activity were closely blended. If the students did not articulate their thoughts and ideas clearly, try to decipher the meaning of the instructions and listen to each other, they risked not being able to complete the race. At the onset of the race, only two students, not necessarily acquainted with each other, worked together. They had to take the initiative, be self-driven, and they needed to be able to reason and persuade their respective team members of their standpoints. In the final leg of the race, six students worked together based on the position in which they had completed the first leg of the race. In this scenario, the multi-language, multi-cultural setting provided the setting for exercising their collaboration and communication and their critical and creative thinking skills.

Practicing engineers rarely recommend more engineering content in the curricula but rather that more attention should be given to skills that would enable engineers to make professional oral presentations, write good reports, skills to interact and collaborate with each other and clients, and the ability to deal with ambiguity and complexity (Jonasson et al., 2006). The Amazing Race learning environment was designed to serve only as an introduction to these skills. These skills are closely knitted together but are nonetheless described under separate headers.

6.3.1 Communication

According to Darling and Dannels:

> *Engineers communicate interpersonally, in small groups, and on teams almost daily. The most important communication skills to develop are those related to oral performances. For the most part, though, the oral performances that are central in daily practices are conversational and informal. Skills in listening, negotiation and questioning that allow small groups of individuals to function effectively on teams and in meetings are the types of communication skills that engineers need and use on a regular basis.* (Darling & Dannels, 2003, p. 13)

The ability to communicate effectively is of extreme importance to be successful academically, professionally and personally, especially in the 21st century (Morreale & Pearson, 2008). New technological developments changed the modes of communication and reshaped the methods used to communicate, play and work. Vest, Long and Anderson (1996) found in a national survey that engineers spend more than four of the eight working hours per day communicating with other employees or individuals from other organisations with whom they collaborate on projects.

Knowledge is of no value if it is not shared, and especially in the workplace where teams of people with different expertise work together, the ability to communicate is imperative to demonstrate cognition (Jonasson et al., 2006). Communication skills are critical to be successful as a professional engineer, especially since engineers need different ways to explain their ideas to their co-workers (Darling & Dannels, 2003).

The Amazing Race learning environment was developed to stimulate communication between team members and between the students and the lecturers and tutors at the destinations. Even though the students enrolled in Professional Orientation reflected the ethnical diversity of South Africa, they had to communicate effectively with each other to be successful in the Amazing Race. Miller (1996) noted that an increase in diversity and change could cause difficulty in communication between individuals. The fact that South Africa has 11 official languages gives rise to the fact that students could face challenges in their interaction in the teams with communication. However, most of the students used English in their communication with each other. It seemed as if they intuitively switched to the language that was presented as a compulsory subject for everybody, regardless of the type of school attended. As could be expected, not all of the students were comfortable with communicating in their second language. Although nothing was mentioned in the reflective essays about the fact that they had to use a common language, one student commented that the fact that they spoke the same language was beneficial for their team's effective functioning.

> *We worked very well together because both of us spoke the same language and we both had previously been on campus.* [RE_S9]

Upon receiving the instructions for the activity, they needed to comprehend the instructions provided in written format and communicate orally using visual, mathematical and language skills to be able to unravel the first clue in the race. Luhmann (1992) identified three stages in the communication process. The message or information is selected, and then it is articulated and lastly interpreted, either in the correct way or by forming the wrong idea. In previous iterations of the race, students did not read the instruction sheet handed out in the lecture venue properly, and it caused a lot of confusion during the activity.

After much deliberation, I have changed the instructions and students had to, before leaving on their journey, show the map with the X and Y axes indicated on it, to show that they comprehended the instructions. Still, numerous teams struggled to find the solution. One of the tutors said that "*It was not that difficult. It really was not especially since they found the origin themselves, so they had to just go from that"* [FI_T4]. In the Amazing Race activity, the misconception of instructions did not lead to detrimental outcomes and as such, students had the opportunity to revise their thinking patterns and realise that effective communication skills could eliminate problems or help in providing possible solutions to challenges encountered.

The instructions that the students received in preparation for the reflective essays focussed on the activity in terms of the destinations, clues and roadblocks. Interestingly enough, even though not prompted to elaborate on the influence of the Amazing Race on the exposure or development of the much-applauded 4Cs, numerous students commented on their exposure to the different 4Cs. Most of the students commented that the activity forced them to communicate mainly because they had to work in pairs.

> *The race showed me the value of teamwork and good communication.* [RE_S5]
>
> *It also taught me how to communicate effectively in a team, as we were assigned team members to work with.* [RE_S11]
>
> *The race also allowed me to interact with other students in the class that I did not know at the time, and really boosted my communication in class.* [RE_S97]

The students associated the development of their communication skills with the fact that they were meeting new people. Some of the students wanted to meet even more people as they thought it would be even more beneficial for the development of their communication skills.

> *I think that the teams should consist of more people so that it will enable us to meet even more people. This will help us develop our communication skills and social skills which will help us work more effectively when working in future projects.* [RE_S108]

Students rarely realise that communication skills entail more than just talking to each other. Morreale and Pearson (2008) documented five different communication skills: listening, questioning, information giving, observing body language, and describing. One student acknowledged that they did not only communicate verbally.

> *My team partner and I navigated through the Amazing Race very quick but we were not hasty. We communicated with each other not only verbally but also body language, environmental sensing and mathematically.* [RE_S104]

Communication skills also entail unidirectional and bidirectional forms (Moreau, 2003). Students need to be offered the opportunity to question but also to respond by revealing information (Morreale & Pearson, 2008). Students were offered the opportunity to practise different forms of communication, sometimes in the role of the person taking the lead and asking the questions and vice versa.

> *Working in a team was also a very rewarding experience. It improved my comprehension and communication skills. Giving instructions is always easy but receiving them is not always as easy. However, this task helped me manage in terms of that.* [RE_S91]

Students had to be able to convince their team members of their standpoints and needed an ability to listen to each other to find solutions to the challenges posed during the race. The importance of keeping an open mind when communicating and also to be able to see the other person’s point of view is one of the ten most important communication skills stressed by Doyle (2019). After the Amazing Race experience, one student realised that the problem of miscommunication in their team was that they were not open to each other's ideas. Unfortunately, they posited that the solution to the problem is a bigger team and not that they should practise effective communication skills.

> *… it took time because of some of the miscommunication we had. We both believed in our own knowledge and we did not come together in the* beginning and infuse *our knowledge to complete the race in the first place. The Amazing Race could have got a better score from myself if we were in a group of four*. [RE_S109]

Levin-Goldberg (2012) said that if individuals do not possess befitting communication skills, a collaboration between them cannot realise. Many of the students linked the successful completion of the race to their teamwork and communication capabilities and even extrapolated the scenario to their future careers as professional engineers.

> *Teamwork is one of the most significant points for both this Amazing Race, as well as the life as a qualified engineer, because you need a team to communicate with effectively in the field of work.* [RE_S20]

There are numerous ways to stimulate the need for communication between students. Especially in this group of engineering students, they need to be forced to communicate. As noted by one of the tutors during the focus group interviews:

> *I think also think the biggest issue is that the general stereotype of an engineering student, especially around campus, is that you know you're very introverted. You stay up all night working and like you know there's a whole lot of stereotypes, like don't approach from behind and you know stuff like that. So I think a lot of people though are introverted and I think that also helps them to get through that, because you know you have to speak to someone if*

you're lost and you don't know what to do and you have to go and speak to someone and you think that helps them, you know to cope with it. [FI_T3]

One student agreed that the fact that they worked in teams, forced them to communicate with each other.

The teamwork factor worked well because it helps with communication skills. [RE_S34]

The design of the activity also stimulated communication between the students, the team members had to stay together throughout the race and had to complete the activities together. They had to decipher the clues provided to proceed to the next destination or receive their next clue. One of the tutors reflected on their first encounter with the Amazing Race activity as first-year engineering students by saying: "*We were trying to do it as quick as possible, solve all the problems, get all your minds together and because of that with people that we didn't know in our groups, we got to communicate more on that basis"* [FI_T4]. One student commented that although the race did not challenge them enough to feel the need for teamwork, they needed

some discussion about where to go next based on the clue. [RE_S12]

The challenges had to stimulate communication in the team but also between different teams in the race. One student commented that they did not need help to complete the race. And this might be the case in a real-life working relationship where you might be the strongest person in a team and as such prefer to work alone. The important factor, however, is that the team need to perform and that everybody needs to work together to accomplish the goals. In this activity, we have seen that many others did not even manage to complete the race because they found it so difficult. Is it then not important in a 21st century environment that those who know share what they know with those who do not?

> *Although we had to complete the race in teams of two people, it wasn't necessary. The tasks were simple enough to do without the help of someone else.* [RE_S70]

Since the students were sent on three different routes for logistical reasons, the final activity, the completion of a crossword puzzle, forced communication between three teams that were grouped together based on their position in the race. The problem surrounding logistical factors was used to create yet another opportunity where the students could practise their communication skills.

> *After the Amazing Race we came back to class where we were divided into groups of six and made to solve a puzzle which didn't take us long because everyone in my team could communicate effectively and that lead to us working better together as a team.* [RE_S51]

The views of the students regarding the need for more complex problems to stimulate the need for communication in the teams will be taken into account in future iterations, and the level of difficulty will be increased. Students pointed out that aside from enhancing their communication skills the environment also helped

> *with problem solving and communication.* [RE_S25]

In the student survey, one student added that:

> *JPO was by the far most helpful module for me. It helped improve both my computer and communication skills.* [ES_S87]

The Amazing Race learning environment was designed to provide students with an opportunity to, among other things, practise their communication skills. All of the student comments, lecturer observations and the remarks of the tutors serve as confirmation that the Amazing Race learning environment did stimulate communication between the different team members, between students and lecturers and even between different teams competing with each other. Since there is a vast amount of 21st century communication tools available, the Amazing Race activity could be further enhanced by using electronic media to teach students befitting ways to communicate effectively.

6.3.2 Collaboration

Thomas Friedman used a title, *The world is flat,* to illustrate the global change in communication and collaboration brought by advances in technology (Friedman, 2006). Diverse people from different sectors of life all over the world are in touch and to be successful in the 21st century.

> *You need to like people. You need to be good at managing or interacting with other people. Although having good people skills has always been an asset in the working world, it will be even more so in a flat world.* (Friedman, 2006, p. 106).

The Amazing Race learning environment was designed amongst others to serve as an ice-breaking activity where students were not only introduced to their new environment but also to their peers. The students, new to the environment, were forced to interact with each other, which could be a positive factor not only for the development of communication and collaboration skills but also with regard to student retention as indicated by Kuh et al., (2008). A large number of the students echoed the following statements in their reflective essays.

> *Before the Amazing Race I was lonely, I had no friends.* [RE_S107]

> *The teamwork idea was also nice. We got an opportunity to meet new people and since we were new on campus we didn't have any friends.* [RE_S47]

> *It was very nice to meet and work with another person and get to know them so early in the year and try to solve these clues with this person.* [RE_S73]

Students have a desire to connect with people (Oblinger et al., 2005). One tutor described it as a clubbing feeling: "*That was my favourite part of the race when I was a student, because you got to group together, someone to look after you as well as you did in the race and it has this like instantly like this clubbing feeling. Like comradery of your equals in this race"* [FI_T6]. One student voiced the need to interact with even more people, even those that they would normally not interact with.

> *I would recommend having bigger groups to allow more students whom would normally not socialize to interact.* [RE_S 19]

The students did not only meet new people, but they also started building relationships that have grown into friendships.

> *The teamwork aspect I enjoyed as it gave me the opportunity to get to know my fellow students. This allowed me to start building relationships at the university that has since grown into friendships. [RE_S19]*

> *The race also gave me an opportunity to meet new class members and build a relationship with them.* [RE_S98]
> *My team mate and I worked well in a group so much so that we are now friends.* [RE_S81]

> *With regards to the teamwork aspect my partner and I worked well together and there was no conflict and being partners in the race helped us to become better friends.* [RE_S76]

The Amazing Race activity was designed to stimulate interaction between the students, either only in their respective teams or even between different teams. The emphasis of the activity was on student interactions, the core element of collaborative learning rather than on learning as a solitary activity (Prince, 2004).

> *One of the things I really enjoyed was the teamwork we had, because even though we were only in teams of two allot of the teams came together and helped each other. The symbolised for me something that my res always try to teach us and that is Tirisano that means "working together".* [RE_S69]

A number of students indicated that the Amazing Race activity provided an opportunity to not only meet new people, especially given the fact that they were new to the environment but also to develop a learning community.

> *Because the same for me that was beneficial is communication and getting to know and getting more friends in your group, because it was just me and my friend and then we joined another two girls for the Amazing Race and they had a group of friends that was in another group, so when we got stuck on something, we asked that group for help and the two girls introduced us to their friends and therefore we all became friends in the end. At the end of that week we were getting each other's numbers and talking, so that was very nice*. [FI_T4]

Students are frequently encouraged to form learning communities. Some of the students actually recognised that the Amazing Race activity provided them with an opportunity to meet their peers in a relaxed setting. One of the tutors stated that "*I know that it's very, very beneficial in terms of meeting new people and getting comfortable with the people around you, because you're going to be with that same group of people most likely for the rest of your degree"* [FI_T2]. Yet another tutor said that "*you force them to work in groups of people you don't know and from my* *experience last year I didn't know one of the people in my group that was studying the same degree as me, but I've never met them before. You know, so it does help you to interact and work on social skills*" [FI_T3].

The comments of a large number of students showed that they actually valued the fact that they could meet people "in the same boat", people that they are studying with and specifically people in the same engineering study field.

> *I enjoyed the teamwork part of the race as I got to meet new people that I would be studying with.* [RE_S72]

> *I teamed up with a friend from my civil engineering class, Lebo, and we set out to start our journey. For myself and Lebo, it was a learning experience for us to work together even though we barely knew each other, and I think that cemented our friendship.* [RE_S77]

The Amazing Race learning environment was developed to provide students not only with experiences that would advance their collaborative skills but an opportunity to practice these skills. Rotherham and Willingham (2009) delineated the difference between experience (an opportunity to use a skill) and practice (an opportunity to see what you are doing wrong and improving on it). By competing in the Amazing Race activity, the students received constant feedback on their progress in the race, albeit from the fact that they have reached a new destination or from the staff at the destinations or even their peers. In this way, they could try to improve their approach to the scenario and devise more effective ways to collaborate in their team.

> *JPO110 increased my ability to work with other people. It is my passion to assist others and to come up with a solution when working with others in a team. This event brought me closer through working with other people, and, trying by all means to cooperate with my mates in our group, I was able to do a puzzle that we were grouped in a team of 6. And I was able to finish the puzzle in a record time. I even learnt*

> *that through socializing and listening to others you can easily finish your task in a short period of time so group work was the best things that taught me how to cooperate as an engineer with others. The Amazing Race event improved my thinking capacity together with my socializing skills.* [RE_S92]

The nature of working collaboratively in the 21st century had changed from being face-to-face around a conference table to collaborating with peers that you have never met in person halfway across the world (Dede, 2010). The skillset needed to work collaboratively in the 21st century is more sophisticated since employees have to accomplish tasks through mediated interactions (Dede, 2010). The American Management Association, a world leader in professional development, indicated that since employees have to collaborate effectively from afar, they need to also have self-direction apart from good team-building skills. (American Management Association, 2019). Since the 21st century workplace places a high value on the ability to collaborate with co-workers and with clients, students need to develop their interpersonal skills. A tutor mentioned in the focus group interviews that "*doing group work you know, I made friends because you're forced inside of people that you wouldn't normally socialize with and I think that is quite beneficial to both work and emotionally"* [FI_T5].

Students had to adapt to different approaches and learn to compromise to be able to collaborate effectively. They had to be flexible and adaptable, they had to be willing to compromise and be able to work with different kinds of people to be able to complete the race successfully. Even though not prompted to elaborate on these elements of teamwork, students frequently commented on the fact that they worked together in teams.

> *Working in a team is a good thing because you then learn different ways of doing things. Whenever I did not understand what I had to do my partner would explain. Alone I would not do the Amazing Race because I did not really know how to use the map.* [RE_S33]

> *Working in a group of two was a different experience as you don't really know the person that you have just met on campus, but it teaches you to adopt new ways of working in a team and you can learn how to compromise and work together as a team.* [RE_S57]

They even commented that they felt the need to adjust their communication styles to ensure that their teams could function optimally and to guarantee friendship outside of the activity.

> *During this assignment I also got a chance to meet a girl that's really interesting and also got to know my teammate whom is now my good friend. I am really grateful to be a part of the Amazing Race because it improved my ability to work as a team and learn how to say things appropriately without offending my team mate.* [RE_S94]

> *This task ignited our map skills and connection skills because we have to find the best way to communicate with our team members.* [RE_S62]

> *I was really happy to have her as a partner, because she was very open-minded and easy to speak to. It is only easy to speak to someone when they are interested in you as well, which was the case because we had just met each other then.* [RE_S96]

Furthermore, the experience of peer communication could be beneficial for the development of social processes such as participation and argumentation. The Amazing Race learning environment forced the students to participate with each other and provided an opportunity to bounce their ideas off other team members.

> *[Name} and I disagreed a lot. As much as I did not know how to use a map I still questioned [Nname] because of my*

> *so-called stubborn personality…..Teams of two was a struggle but we eventually set our differences aside and worked very well together. We started working together from then onwards.* [RE_S110]

Hromek and Roffey (2009) argued that games are especially useful to develop social and emotional learning amongst people. And given the fact that games usually contain elements of conflict, competition and cooperation, participants could learn effective group dynamics through their participation in the game (Bodnar et al., 2016). The competition and goal characteristics of game playing provide a forum for the development of collaboration and as such, the social skills of the participants (Romero et al., 2015).

Even though the two students that were grouped together did not necessarily know each other and most likely, being aspiring engineers, both being people with strong ideas, they had to resolve conflict in the team to be able to complete the activity successfully. Students have to employ basic conflict resolution skills to enhance their teamwork while simultaneously engaging with the content (Hromek & Roffey, 2009). The following comment shows the conflict that arose in the teams because they had to solve problems together. In this case, the student did not elaborate on how they managed to resolve their problems.

> *Now that I reflect on the experience, I can see that my partner and I disagreed on a lot of the directions as she struggled to understand the map and was doubtful of my directions.* [RE_S53]

This particular student acknowledged that they experienced some difficulties in working together as a team. It seems as if they have learned how to work effectively as a team as they said that they had learned a lot of things through the Amazing Race experience.

> *The Amazing Race also taught me of teamwork. My partner and I had some disagreements and conflicts, we had to*

> *resolve our problems and get on the same boat. This was not easy to do, we both wanted our opinions to be taken. The Amazing Race taught me a lot of things, working with someone I did not know was an awesome experience.* [RE_S100]

When you are collaborating in a team, your actions may endorse the success of others, it may barricade the other participant's success or may have no influence on the success or failure whatsoever (Laal, Laal, & Kermanshahi, 2012). Students had the first-hand experience of the actions of their teammates in the activity and its influence on the outcome of the race. The assistant lecturer indicated in the focus group interview that

> *they'd probably like it's the first week and yes, I noticed that was a good thing for some teams, like they just met someone and they click and it sort of worked well and there's also the alternative where there were just absolutely no dynamic for the team and they didn't work together at all. They fell behind. Therefore, I think that someone who might get enthusiastic if they are lumped with someone who is not at all in it could possibly be negatively affected. [FI_AL1]*

The comments of the students indicated that they realised the possible effect of a team member on the outcome of the activity, albeit positive, negative or no influence at all. One student actually stated that they preferred working in a team and continued that they made good progress during the race as a result of certain character traits of the two team members that complemented each other.

> *Being in a team has always been my preferred approach to completing tasks and I enjoyed the company of my team member. I appreciated our alliance as he is not as lazy as I know my peers to be. His quiet nature allowed my charisma the light it needed to bloom and we made good progress in the race as a result.* [RE_S21]

Many of the students attributed the successful completion of the activity to the team dynamics. The scenario pointed them to the importance of collaboration in the 21st century workplace.

> *The race also allowed me to interact with other students in the class that I did not know at the time, and really boosted my communication in class. My team member and I were working together in this race which helped us to successfully reach the final point*. [RE_S97]
>
> *The Amazing Race helped me to know the university and made some friends during that time because almost everybody did not know the university pretty well so we helped each other out.* [RE_S95]

Students were also experiencing a feeling of despair either since they could not contribute to the successful completion of the race or because they had to do all of the work because the other team member could not pull their weight. Once again, the learning environment proved to host valuable lessons in terms of collaboration for 21st century employees.

> *The teamwork was of a learning experience for me as I have stated on the first paragraph, but I was really gutted, because I had no input on the race, I could not contribute anything because there was nothing I could contribute due to my poor direction skills using a map. We at least managed to reach bookmark, all thanks to my partner*. [RE_S29]
>
> *It also taught me how to work with people that I don't know since we are randomly grouped in teams. What I didn't like is that my partner was dependent on me, he could not interpret the map. After all the activities we did we were put in groups of six to apply our knowledge that we gained from*

> *the race and I loved it because no one was shy we were all participating.* [RE_S60]

A problem arose when one of the students arrived back in the lecture venue stating that they lost their team members. I asked how that was possible since they were supposed to stay together and do all of the activities together. The truth however surfaced in the comment of a student in the self-reflection essays. In this case, the actions of the team member had a negative influence on the outcome of the race for both team members since they had to be disqualified for not adhering to the rules of the game.

> *I actually enjoyed the destinations, road blocks and any other aspect of it except the teamwork which consequently ruined the other experiences. My teammate was reluctant to embrace the race and constantly complained about participating. To be honest he became annoying. He even refused to enter the Merensky library which we needed to do at one point, then left to continuing the race without me while having the gall to claim that I left him. Besides that, everything was cool.* [RE_S46]

One student commented on the fact that one of them was motivated and the other not. This was an unfortunate real-life situation, and the student had the first-hand experience of the problems faced in the workplace. Now, they could try to resolve this issue without permanent damage to working relationships.

> *As a team we did not work very well, one of us was motivated to finish the race while the other not. This brought us down as a team.* [RE_S54]

Students need to learn how to regulate their negative emotions, they need to be just, fair and respectful to be able to succeed at work and in adult life (Hromek & Roffey, 2009). De Graaff and Kolmos (2003) also draw attention to the need to show understanding and respect in the workplace. Students experienced more than what the activity was designed for. Unfortunately, one of the students was subject to the aggressive behaviour of their team member. Since the incident was not reported, and I only learned about the negative behaviour of the student a month later, the matter could not be addressed appropriately. Additional measures or even rules need to be in place to limit the type of negative behaviour and also to be in a position to use it to mentor the students.

> *Unfortunately, I and my teammate did not finish the race. This is because he lost his temper, as he was frustrated with the fact that we kept on going to the wrong places. So we decided to forfeit the race as he seemed to be losing his patience and showing signs of being violent. I was scared that he might do something that would harm me*. [RE_S39]

Even though the students had a common goal, they had to manage themselves and their emotions to be able to reach their final goal. The fact that they all had the same goal, finishing the race as soon as possible, provided students with the opportunity to mingle with others that were not yet familiar to them. Hromek and Roffey (2009) highlighted that collaborative and co-operative play depend on the ability of players to manage their feelings of frustration and delaying gratification. The students were not asked to comment on the effect of the Amazing Race activity on their feelings of discouragement in the face of challenges that seemed too difficult to overcome and nonetheless, one of the students commented as follows:

> *We almost gave up but somehow managed to work through it; I used my positive thinking to persuade us.* [RE_S96]

Trust, leading with influence, the ability to work fluidly across boundaries and global awareness are crucial elements upon which an employee’s collaborative success rest (American Management Association, 2019). Trust and respect were two emotions that featured prominently in student comments. One student mentioned that the activity taught them to trust and respect others, while another commented that their team could not function effectively since they did not trust each other.

> *I ended up picking a partner who I did not know at all which made the race interesting as we got to know each other and become friends. The fact that the race induces teamwork was interesting since I am not used to working in teams, however it teaches one to trust and respect others.* [RE_S8]

> *Teamwork between me and my partner was not always smooth because we did not trust one another with the map and the instructions.* [RE_S49]

The setting was beneficial especially for the "weaker" students since the relationship building between the students was mediated by the intervention of the lecturer (Mittelmeier, Rienties, Tempela, & Whitelock, 2018) albeit by providing clues to the destinations and roadblocks to complete before they could continue with the race. These activities forced them to interact with each other, and since they had to find solutions to the problems posed as roadblocks, they had to discuss possible answers to the scenarios. Damon (1984) pointed to the fact that through mitigating with their peers, students are motivated to discard fallacies and search for better solutions. The understanding of particular issues or phenomena can be enriched and expanded by questioning your own understanding and scrutinising the understanding of other people (Savery & Duffy, 2001). Many of the students commented that the fact that they were working as a team was beneficial in terms of solving the problems posed to them.

> *The roadblocks were good as they allowed us to find out more information about the university itself, things that you didn't know before. As a result, it did promote teamwork, as two brains is better than one when it comes to solving puzzles.* [RE_S35]

> *Due to our teamwork, we managed to figure out where we should go after a long walk and a lot of wrong turns.* [RE_S96]

Teamwork was quite essential in the race. It helped us to put our intelligence together and come up with a solution. We were almost forced not in a bad way to get to know our fellow students and get over being shy. I did make some new friends and we were each given an opportunity to express ourselves in terms of opinions and reasoning. [RE_S22]

I found some of the instructions tricky but luckily my partner was there to assist me. The teamwork assisted me to find destinations, the clues I couldn't figure out my teammate figured out. [RE_S15]

Some of them actually stated that the roadblocks could be more challenging and added that it would promote teamwork.

The teamwork factor worked well because it helps with communication skills. I would recommend keeping the Amazing Race with teams of two, but to make the roadblocks a bit more challenging in order to improve teamwork even more. [RE_S34]

All in all, it seems as if the Amazing Race learning environment was successful in creating an environment in which students could not only experience the influence of effective team dynamics but also practice this important 21st century skill.

The Amazing Race was a developed with the intentions of educating the learners in a lot of different ways. It helped the learners with navigations around the Campus and also played a big role in improving the ability of an individual to work in a team. That is, of course, one of the most important aspect of an engineer. [RE_S91]

6.3.3 Critical thinking

> *"Growing proportions of the nation's labour force are engaged in jobs that emphasize expert thinking or complex communication—tasks that computers cannot do" (Dede, 2010, pp. 53-54).*

Expert thinking or complex communication, the tasks that computers cannot do, can be translated to the ability to think critically. The concept of critical thinking as one of the goals of education is widely accepted. A variety of definitions of the concept "critical thinking" can be found in the literature.

> *"Critical thinking refers to the use of cognitive skills or strategies that increase the probability of a desirable outcome. Critical thinking is purposeful, reasoned, and goal-directed. It is the kind of thinking involved in solving problems, formulating inferences, calculating likelihoods, and making decisions". (Halpern, 1999, p. 70).*

Hitchcock (2018) offered an overarching definition by stating that critical thinking is "careful thinking directed to a goal" (para. 1). He affords the difference in the meaning that researchers assign to "critical thinking" to the scope of such thinking, to the type of outcome that the action of "thinking critically" presupposes, the standards and rules set for thinking carefully, and the focus on the differing thinking components.

Ennis (1987) gives yet another definition by stating that critical thinking is a practical activity that results in a decision regarding what to accept as being truthful or not, and how to react to the information or which action to take based on the information. It entails an ability to elucidate, to make inferences, establishing a sound basis for inference and solving problems in an orderly and useful way.

Funke, Fisher and Holt (2018) state that "problem-solving is a goal-oriented and high-level cognitive process" (p. 46). Jonasson (1997), again, describes well-structured problem-solving in terms of information processing theory. He proposes that the problem presented constructs a space in which a student needs to decompose the problem by mapping the problem statement on their prior knowledge. The problem is, thereafter, reconciled with potential solutions in an interactive means-end analysis (Jonassen, 1997). Jonasson stresses the fact that problem-solving is a higher-order skill activity in which the student not only has to ascertain the nature of the problem but also propose a feasible solution and describe the process followed to arrive at the answer. The point is, students need to be trained to solve problems that have not yet even be voiced or might not be a reality for years to come (Bakhshi et al., 2017).

Another take on problem-solving is that the problem analysis is both a process (during which the ability to think critically is developed) and a product (that demonstrates the students' competency to think critically by evaluating the solution that the student offer to the problem) (Throndahl, Velmurugan, & Stentoft, 2018). To this end, special care should be taken in compiling the question: the solutions to the problems should not be stated in the question and should especially not be readily apparent (Jonassen, 1997).

In a normal transmission classroom, engineering students often encounter word problems where the parameters of the problem can be found in the problem statement (Jonasson et al., 2006). Jonasson et al. (2006) note that this linear process of problem-solving is not necessarily applicable to the solving of problems in the workplace, since the latter is usually ill-structured, vaguely defined with constraints that are not explicitly outlined. Multiple solution paths could be followed and students need to decide on appropriate, justifiable actions in their approach to these problems. They continue by stating that engineers do not engage in solitary problem-solving, they have to, apart from using their own abilities and skills, also call on the expertise of a variety of other personnel and solve the problem while collaborating with the others extensively.

The quest for employees that are 21st century adept, being excellent communicators that are able to function well in a team-driven environment (Gee, 2003), might not necessarily be developed in a traditional lecture class (Bodnar et al., 2016). Bodnar et al. (2016) pointed out that many of the student outcomes of ABET (similar to ECSA in South-Africa) i.e. the ability to communicate effectively while collaborating in multidisciplinary teams to formulate and solve problems, can be fostered in a game-based classroom.

The Amazing Race learning environment was developed to expose students to opportunities in which the 4Cs could be attained. Teams of two were sent on a race through the campus, a multiplayer game environment as proposed by Shaffer, Squire, Halverson and Gee (2005), that poses opportunities to experiment and think creatively, whilst solving problems. One of the students that participated in the activity responded as follows in the survey that they had to complete.

> *Recently I had to participate in a JPO 110 activity that required my team mate and I to use our logic and reasoning skills to solve problems. The activity was useful in making me realise the higher cognitive functions my brain had in solving problems and coordinating with other people.* [ITS_S32]

Damon (1984) applauds the potential of peer education and states that the skills needed to solve problems, to abandon misconceptions and find even better solutions could be fostered through mutual feedback and debate. He, furthermore, stresses that social processes (participation and argumentation) and cognitive processes (verification and criticism) could be mastered based on experiences of peer communication. Students commented that the Amazing Race activity provided them with opportunities to express their opinions and reason with their team members to find a solution.

> *It helped us to put our intelligence together and come up with a solution. We were almost forced (not in a bad way) to get to know our fellow students and get over being shy. I did make some new friends and we were each given an opportunity to express ourselves in terms of opinions and reasoning.* [RE_S22]

When students are working together to find solutions to problems, cognitive conflicts will arise, since the students will question the reasoning process of their peers, and because of the resulting disequilibrium, students will revise their thinking processes and arrive at a higher-quality understanding regarding the problem (Slavin, 1996). Johnson and Johnson (1979) point out that to really engage in critical thinking, students have to experience the dissonance of contradictory ideas. Students worked together to solve problems in the Amazing Race, as such, the learning environment posed opportunities for critical thinking, as the solutions posed by the different team members might be different. Interestingly, one of the students commented that it was a fulfilling experience and that they had to put their minds together to find solutions.

> *Not to mention the fact that there were times when we went on conflicts with our team members. On the other hand, it was a fulfilling experience in a manner that we knew it was somehow of a mind game. As a result, we had to work collaboratively and put our minds together, figure things out*. [RE_S18]

> *All the roadblock puzzles…was enjoyed as it tested our problem-solving skills and teamwork capabilities. Teamwork played a vital role in solving the Amazing Race, as both members had to think very hard to complete the roadblocks. Both members relied on each other for support and problem-solving*. [RE_S36]

Students did experience conflict with their team members, albeit because of a difference in opinion with regard to the solution to the problems, or as another student put it, because of their stubborn personalities.

> *I can see that my partner and I disagreed on a lot of the directions as she struggled to understand the map and was doubtful of my directions.* [RE_S53]

I personally struggle with geography so using a map didn't go very well. [Name] and I disagreed a lot. As much as I did not know how to use a map, I still questioned [Name] because of my so-called stubborn personality. [RE_S110]

The Amazing Race activity had to be completed in a double contact session, 110 minutes. To complete the race within this period, students had to organise and manage themselves and their activities responsibly and effectively. Not only was it necessary to apply time management to ensure the successful completion of each activity, but they also had to manage the group interaction to be able to find possible solutions to the problems faced within the time constraints of each session. In the final reporting stage of the project, students had to organise and manage themselves to ensure that they complete the crossword puzzle to win the race.

Students were forced to make choices during the Amazing Race activity. Choices foreground decision-making skills and as such, could further learning (De Freitas, 2006b). Every action that the students took during the Amazing Race had a direct influence on the successful completion of the game. Since the relationship between the actions and the outcomes of the game were noticeable and the actions influenced the larger scheme of things, meaningful learning could take place (Tekinbas & Zimmerman, 2003).

We got roadblocks on our way before our final destination which needed to be critically interpreted and analysed. This led to effective communication. [RE_S11]

During the Amazing Race activity, students had to follow clues to the different destinations, and at each destination, they had to complete a roadblock before they could receive the next clue. These activities were specifically designed to present opportunities to develop critical thinking. Special care was given to the fact that the students had to experience positive emotions during the race to increase their capacity to learn (Fredrickson & Joiner, 2002). Positive emotions boost buoyant thinking that in turn inspires a creative approach to the solving of problems (Hromek & Roffey, 2009). The words "thrilling twist" and also "intrigued" served amongst others as an indication that the students did experience positive emotions that might encourage critical thinking during the activity.

> *It had a thrilling twist in finding the lo*cations *due to the cryptic wording used in the clues. Another thing that intrigued me about* the *Amazing Race was the idea of roadblocks.* [RE_S102]

The activity was specifically scheduled to take place in the first week after the students arrived on campus. New to the environment, they had to put the knowledge gained during the sequential tasks to navigate between the different destinations together to construct a mental map of their new environment (Levine, Jankovic, & Pali, 1982). Numerous students commented that the activity was especially helpful in terms of their navigation on the campus. One of the tutors mentioned that they felt totally lost *because "… before it was very easy to get lost. I had no idea where classes were, I couldn't tell the difference between tutor and chemistry*" [FI_T6]. They concluded by saying that: *"They've gained a lot of confidence on campus, because of it"* [FI_T6].

When students have to navigate on the campus to different destinations by using a map, they have to solve spatial problems where their vision is restricted by the size and clutter of the environment (Levine et al., 1982). The students were only able to see the immediate environment of the starting point. Some of them found the surroundings beneficial, possibly in terms of the fact that it helped them to orientate themselves:

> *To find the destinations on the map was a very challenging experience, which I found very enjoyable. Some destinations were easier to find than others because they were surrounded by many landmarks.* [RE_S7]

Students had to collect, analyse, organise and critically evaluate information to find the next destination, a few of the characteristics of critical thinking that Fisher (2011) highlights in his discussion of Glaser's list of skills needed to be able to think critically. Dede (2010) also states that students have to develop an ability to assess which part of the flood of data is applicable to their problem, and after they have evaluated the data, have to be able to manage and integrate it into their existing databases. Since the navigation was done in three different ways, students had to realise that there are different approaches to problem-solving and that the context needed to be considered. By having to decipher the various ways in which the clues were structured, students had to solve a simple problem in a safe environment, one of the characteristics of games (Squire, 2011). Problems could be attempted in more than one way since the students received rapid feedback on their attempts, learning from the first-hand experience of the decisions that they have made based on their interpretation of the information provided (Bodnar et al., 2016).

Since all of the above-mentioned materialised in a game setting as opposed to a formal setting, students had the opportunity to revise their thinking patterns critically and creatively to double-check the answers that they generated (Facione, 2011). Students handled the challenges differently, as some of them tried to solve it for themselves, while others asked for help or just stated that they did not understand the instructions.

> *What made the race a bit more challenging was the fact that we had to use a grid as a map to find our way around the campus. None the less, we used our coordination skills optimally, and through efficient reasoning found our way around the campus.* [RE_S44]

Since the students were interested in the game, they continued seeking a resolution. In this way, they have the opportunity to develop their critical thinking abilities and also their problem-solving skills (Rieber et al., 1998; Barab & Dede, 2007). All of the students did not readily find their destinations.

> *After about 20 minutes of asking around, we finally reached our first* ….[RE_S77]

> *… of which we did not understand the given instructions on how to navigate there.* [RE_S96]

Sometimes students were given the cardinal direction as a clue to the next destination. Since the students had a map with the north indicated on the map, they had to turn the map so that it matches the environment and then orientate the map so that the direction in which they needed to go, is forward. Now the students only had to take the scale indicated on the map into account; no other computations were needed. Levine et al. (1982) point out that you have to orientate maps to ensure better map use. Although none of the students commented on orientating the map to match the environment, they said that they have learned how to use a map for navigational purposes:

> *The navigation to these buildings was somewhat challenging. It challenged our map reading and interpretation skills.* [RE_S9]

> *This particular activity helped a lot on how to use coordinates from the map and use them to reach a specific destination.* [RE_S11]

Students were subject to a number of learning experiences while using the map for orientation. They had to locate themselves on the map and align the map with their current bearing. They had to mentally simulate the route to be followed to the next destination and perform informal algebra. Students also obtained procedural knowledge of the route that might have included more detailed information regarding the route travelled, for example, distances, angles between turns, and terrain features. This information is usually sequentially organised (Levine et al., 1982). All in all, apart from an opportunity to develop critical thinking capabilities, the students found the activity helpful in terms of their introduction to their new environment.

> *The Amazing Race was really fun and exciting as coming into the University of Pretoria, I did not know anything. It*

> *helped a lot to get familiar all the different buildings and places on main campus*. [RE_S61]

> *The Amazing Race had different levels of difficulty… this forced the students to work together and show knowledge and experience to fellow students, and to learn new things for example how to read a map. … this was the biggest highlight of the race which I enjoyed most.* [RE_S111]

Apart from deciphering the clues to the destinations, students also had to complete a roadblock at each destination before they could proceed. The roadblocks were designed to create an awareness of its relevance, or reveal interesting facts regarding the destination. The nature of the problems that they had to solve at each destination differed extensively. The students were prompted to find answers on the history of the university, they had to do calculations and had to explain science phenomena, to only name a few. All of the roadblocks were designed to provide opportunities, as suggested by Halpern (1999), where students could enhance their critical thinking abilities. Learning is also enhanced by an element of uncertainty, students are eager to solve the roadblocks, and they strive to be more accurate during the problem-solving process, in part because of the uncertainty of the influence of their actions toward the outcome of the game (Ozcelik, Cagiltay, & Ozcelik, 2013). The students reacted overwhelmingly positive to these opportunities. One student commented that the

> *Roadblocks were my favourite part of the Amazing Race. Each roadblock we had to solve puzzles to get to the next clue, to progress in the Amazing Race. I found that very enjoyable, as I am someone who likes to solve problems.* [RE_S7]

Rieber et al. (1998) highlighted that to play a game successfully, students have to solve problems with no obvious solutions. The problems that students had to overcome during the Amazing Race activity were unlike those that they would face in a traditional lecture hall setting. One of the tutors stated that "*It cannot be like by* *the book I have to do this, it's going to get you nowhere…what I mean, they need solutions that they never had to think of before"* [FI_T5].

In one of the roadblocks, some of the students had to calculate the surface area of a specific building on the campus, while others had to calculate the circumference of a circular platform, without instruments to measure the dimensions needed. The milieu of the Amazing Race environment demonstrated to the students that the context of a problem is a factor to be considered. As one of the tutors pointed out: "*Critical thinking involves using your resources to surround you".* [FI_T4].

In these activities, the students had to, in the first place, draw on their existing knowledge regarding areas, in the one case, and circumferences in the other. To be able to find the circumference of the piazza and the area of Natural Sciences 1, they had to take the area in which the building is situated into account. They had to look at the surroundings to find a frame of reference to use. They had to consider different possibilities in the problem-solving process. They had to move between their prior trigonometry knowledge and the scenario at hand. They also had to realise that to be able to report on the process, they had to present the scenario to the reader and explain their reasoning in the problem-solving process.

Students need to be exposed to situations where no standard approach seem to be applicable to develop expert decision making and metacognitive strategies (Dede, 2010). By using these roadblocks, students were encouraged to use science and technology effectively and critically. The students enjoyed being challenged, as they indicated in the next responses.

> *We also calculated the size of the circle in the Piazza. We enjoyed this, because it was an activity that involved our logic and mathematics skills.* [RE_S68]

> *I enjoyed the challenges we got as roadblocks because we had to think and use mathematics to work out some of the problems.* [RE_S1]

> *The destinations that followed included the Piazza which was my second favourite "roadblock", because we put mathematical principles to use to solve the problem.* [RE_S44]

And it seems as if they are disappointed when the challenges were not at a high level of difficulty, although some of them considered that the time allocated to the activity limited the extent of the challenges. One of the tutors addressed the fact that a balance was needed when evaluating the level of difficulty of the challenges: "*The difficulty of it, but then on the other side to make it too difficult, too many people are going to be that it's too difficult*" [FI_T3].

> *I think that the roadblocks were quite fun, however I also think there should be more challenging events.* [RE_S108]

> *… but to be honest, the roadblocks were not as challenging as I was expected and was a huge let-down, that is why the score dropped from a 9 to 7. The puzzles were easy to solve and did not challenge the mind. I expected more due to the fact that the clues were mildly challenging.* [RE_S102]

> *The questions and riddles themselves could also have been a bit harder but I understand that there is a limited time span in which the race must be finished. But for the brighter student, the questions might have been too easy.* [RE_S10]

The roadblocks were specifically designed to evoke the students' curiosity and provided an opportunity to explore different scenarios in which they could solve the problems and test their own hypotheses (Kiili, 2005). Students had to go through a mirror maze, and after this experience they were prompted to find the angle at which the mirrors should be positioned relative to each other, to create a mirror maze. The students reacted as follows:

> *The road blocks that I enjoyed the most was the one in which we had to find the angle of a triangle in Sci-Enza building, entering in the room of mirrors was an amazing experience for me, because what I saw in movies, I experienced it*. [RE_S29]

> *The next destination was the Scienza, which was were things got a little interesting. We had to go through the mirror room, which is something that is really cool in my eyes. The way it was designed and the way it works is simple, yet amazing.* [RE_S70]

Apart from commenting on the fact that the challenges were science-related, students also valued the fact that these roadblocks were inventive and challenging, activating their critical and creative thinking processes.

> *The roadblocks that was set up for us was inventive and challenging. The best roadblock was the challenge at the scienza where I had to go through the mirror maze.* [RE_S69]

Students could see science in action, they could learn the science phenomena by actually doing something and by the resulting quest to know why it happened (Moye, Dugger Jr, & Starkweather, 2018). One student commented that they were fascinated by the science behind the lighting of a match, while another learned about the distribution of weight by experimenting with different chairs.

> *I must say that my favourite destination was the Scienza building, where I found myself during my free time. Coincidentally, the Scienza also happened to be my favourite roadblock, as I was tasked to light up a match with a beam of light. The science behind why the match lit up fascinated me.* [RE_S50]

> *I remember at one of our stops we were supposed to sit on chairs, one with needles and the other with balls and write down on a piece of paper we were given, which one was comfortable. None of us wanted to sit on the chair with needles because we thought it painful and it turned out to be more comfortable*. [RE_S107]

The Amazing Race activity was designed to create opportunities for the development of the 4Cs. In the case of critical thinking, the clues to the different destinations and the execution of the roadblocks at each of the destinations proved to provide numerous opportunities, as one student summarised:

> *The Amazing Race event improved my thinking capacity together with my socializing skills.* [RE_S92]

6.3.4 Creativity

> *At its heart, creativity is simply the production of novel, appropriate ideas in any realm of human activity, from science, to the arts, to education, to business, to everyday life. The ideas must be novel - different from what's been done before - but they can't be simply bizarre; they must be appropriate to the problem or opportunity presented. (Amabile, 1997, p. 40)*

Sir Ken Robinson, in an interview with Azzam, defined creativity as a process of looking for new ways of doing your everyday tasks, it is a function of everything we do albeit as a chef, teacher or engineer (Azzam, 2009). In the 21st century especially, the new generation will have to draw on their creativity to solve the numerous problems of this era. Martin (2007) delineates 17 great challenges of the 21st century, and according to Sir Robinson, the challenges are without precedent, and we will need our imagination, ingenuity and creativity in a highly unpredictable environment (Azzam, 2009). He continues that the creative process leans on co-operation, diversity, the exchange of ideas and building on other people's accomplishments.

The students that took part in the Amazing Race activity relied on each other to complete the race successfully. They had to co-operate in their teams to decipher the clues to the different destinations, and upon arrival, had to complete the roadblocks. To this end, they had to exchange ideas and build on each other's contributions. All of the above mentioned align with what is needed to stimulate creativity as specified by Sir Robinson.

> *Teamwork played a vital role in solving the Amazing Race as both members had to think very hard to complete the roadblocks; both members relied on each other for support and problem-solving.* [RE_S36]

At one of the roadblocks, students had to find the energy-saving devices in the building. As these were not clearly indicated in the building, students had to move through the facility to find these devices. Damon (1984) highlighted that teamwork could provide a forum for learning by discovery and as such, be a platform for creativity as students generate new ideas collaboratively. The students had to posit solutions to the question, discuss it with their team member, confirm the presence of such devices in the facility and test their answers by discussing it with the lecturer before they could receive their next clue.

> *…we learned about how the Mining Centre conserves energy and saves money in the process.* [RE_S105]

Students were not always willing to solve problems by experimentation, as can be seen in the following student comment.

> *I remember at one of our stops we were supposed to sit on chairs, one with needles and the other with balls and write down on a piece of paper we were given which one was*

> *comfortable. None of us wanted to sit on the chair with needles because we thought it painful but it turned out to be more comfortable*. [RE_S107]

However, students need to be encouraged to experiment, to be innovative, to explore new paths while solving problems, since it will enhance their creativity (Nisula & Kianto, 2016). To stimulate creative thinking, students need to be equipped with the tools to find correct answers; this entails not giving them the answers per se (Azzam, 2009). Some of the students wanted more guidance, whereas others commented that there was no obvious solution to the problem.

> *What I did not like about the race was the fact that we were left to figure out everything on our own.* [RE_S24]

> *Some of the roadblocks were interesting and made you think, such as the one about the energy conservation methods used in the engineering study centre, but some of the others were confusing, such as the one asking for the building that was built at the same time as the Old Arts building, as there was no clear way of getting the answer.* [RE_S45]

> *Finding the buildings was quite fun as we had to use clues and hints to figure out which building had the next clue, but the scale of the map should have been explained a bit better.* [RE_S59]

Highly creative scientists are impelled by curiosity; they cannot wait to find the answer to a problem (Amabile, 1997). Schawlow, the winner of the Nobel Prize in physics in 1981, used these words to explain his drive to pursue answers to phenomena (Amabile, 1997). Students experienced the same curiosity during the Amazing Race.

> *This was the fun part, getting to tackle problems was exciting. Even though some of the roadblocks were tough and required a lot of thinking.* [RE_S100]

> *Another thing was the roadblocks, getting there and waiting to hear if you qualify for the next clues and planning your next destination. This kept us on the tips of our toes. I'm sure the tutors at the roadblocks could even see the excitement on our faces.* [RE_S6]

The roadblocks that the students had to complete demanded a variety of approaches to problem-solving. In one of these, students had to find the arc length of the first row of seats. They had to take a new perspective and explore new pathways by applying techniques differently to be able to solve this problem, forcing them to be truly creative (Amabile, 1997).

In a question of whether the Amazing Race learning environment enhanced the creativity of the students, the assistant lecturer answered: "*Yes, I would not say it has an avert creativity, but you have to think outside the box somewhat because it is not laid out for you necessarily. You have to make those sorts of connections and that requires a little bit of broad thinking*" [FI_AL1].

Nisula and Kianto (2016) say that "creativity and innovation benefit from experimentation and creative play with new ideas and ways of working" (p. 159). A student confirmed that this specific activity sparked their creativity by saying that

> *The roadblock (task) I enjoyed the most was the auditorium calculations because it required a creative approach to the problem.* [RE_S93]

Some of the important personality characteristics needed for creative thinking are motivation to engage in a task and perseverance in the face of frustration (Amabile, 1997). The game-based learning environment was designed to enhance the extent to which the student engages their expertise and creative thinking skills and also their perseverance to complete the task at hand. Some of the students did mention that they were frustrated and lost, but they persevered. As such, the Amazing Race activity could be seen as an opportunity to practise these important skills as a preface to creativity.

> *…even though it was frustrating circling the university a lot of times, it was very interesting getting to know more about the university in terms of where the buildings are and its history.* [RE_S56]

> *…although my teammate and I were always lost but we persevered through it with wide smiles on our face and tears dripping down our faces.* [RE_S71]

According to Amabile (1997), a student's creativity skills can be enhanced by learning and practising methods that could help to improve their ability to focus on more than one facet of thought at the same time and the ability to think for yourself (intellectual independence). The Amazing Race activity forced students to take numerous inputs into account while they were competing to the finish line. They also had to find answers to the clues and roadblocks and had to consider the viewpoints of others before they could reach a final answer, showcasing intellectual independence. One tutor commented that "*everyone came up with a different solution, so it is each person's creativity coming through and how they would solve that problem*" [FI_T3]. One student mentioned that the clues forced them to think outside the box combining their forces as a team:

> *The destinations were exciting and educational because we had to use various ways of navigation to get around campus and to reach the destination that was on the clue. The different ways of navigations thought to think outside the box and making it an interactive race, involving us to work as a team.* [RE_S57]

To be able to solve the roadblocks or clues posed during the Amazing Race, the students had to first understand the problem first, then solve it and implement the solution (Basadur, Graen, & Green, 1982). During each of these stages of the creative thinking process, they have to develop an idea and evaluate it before they could proceed (Sowden, Pringle, & Gabora, 2015). One of the tutors said that they have analysed the scenario and implemented this strategy in their approach to the problems in their first year:

> *We made the whole activity competitive. We were all like trying to do it fast because we know that one of the rules was that you can't run, so we were trying to do it as quickly as possible, solve all the problems, get all your minds together and because of that with people that we didn't know in our groups, we got to communicate more on that basis*. [FI_T4]

One of the teams followed another innovative strategy to overcome their challenges.

> *At first, my partner and I had difficulties reading the map and whenever we got lost we would follow people who had the same flag as us and they would lead us to our destination.* [RE_S107]

One of the students commented that it was important to read between the lines to be able to solve the problems. Another said that you need to think in an abstract way while yet another said that you need to think out of the box. All of these descriptions of the thinking processes needed to solve the problems could indicate that they felt a need for creativity in their problem-solving process.

> *The Amazing Race taught* me *how to work as a team and how to read between the lines. It was a nice experience.* [RE_S14]

Some of the roadblocks were fun and pushed you to think about things in an abstract way to solve problems, but some roadblocks did not offer much in terms of fun or did not offer much in terms of learning. The Sci-Enza building was really interesting and it was really cool to see the different scientific discoveries explained and demonstrated. [RE_S72]

Some of the roadblocks were intellectually challenging because one had to think outside the box to solve the given problems which were good and developed some thinking skills along the way. [RE_S82]

Fun and humour craft a relaxed environment in which creativity is stimulated as the brain no longer functions in a cognitive rule-bound state (Hromek & Roffey, 2009). One of the roadblocks was specifically designed to demonstrate the importance of following instructions, as students had to read all of the instructions before executing it. Needless to say, the last line instructed them to ignore the previous lines and proceed to the next destination. Students reacted positively to this tongue in the cheek attempt to create a relaxed environment to further creativity.

…which was hilarious because the JPO 110 lecturer almost made my teammate dive in the pond. [RE_S7]

I also enjoyed our last stop. The instruction on the paper we were given said we should go to the fountain and take off our shoes, and put one of our hands on our head and turn around. As I was about to take my shoes off my partner saw one of the lectures taking a video and we read down the instructions we saw that we did not have to do it. [RE_S107]

Creativity and innovation are enabled by highlighting the importance of synthesising and the integration of knowledge (Duderstadt , 2009). One of the tutors mentioned that to be able to take part in the activity, the students had to first shift gears:

> *I think in order to actually go with the flow of the actual Amazing Race, they needed to be creative, because it's very analytical parts of something that is essential to a scavenger hunt. Therefore, unless they actually sat there and decided we are now changing from class scenario to scavenger scenario, that is quite a big league in mentality, and I think that it's necessary for creativeness to make, because if they're very analytical, they're going to be stuck on it in the wrong way*. [FI_T6]

Another tutor pointed to the fact that the students "*have never been exposed to like different environmental things that can be used in a building and for that you have to be, you need to think creatively, but still be analytical logical about it…..they have to start thinking* in *that manner and then use their intuition as well which is very important" [FI_T5].*

It shows that the learning environment posed opportunities for the students to integrate different aspects of their knowledge.

Students need to be inquisitive. The changes in the ever-evolving workplace require employees that are continuously "updating" their knowledge and building new expertise (Thijssen, Van der Heijden, & Rocco, 2008). They also need to be self-directed learners that grab opportunities provided by organisations to increase their knowledge (O'Toole & Essex, 2012). Therefore, a desire to know more than only the bare essentials need to be fostered in the students. The roadblocks were designed to evoke curiosity. Students were prompted to provide possible reasons for the phenomena that they have explored.

> *The science behind why the match lit up fascinated me*. [RE_S5]

The students labelled the Amazing Race activity as being fun and said that it challenged their creative abilities.

> *The roadblocks challenged us in a fun and creative way. It forced us to think outside of the box to solve the problems that we were faced with and interact with people around us.* [RE_S19]

> *The Amazing Race allowed for a good team working opportunity and helped in improving our communication and thinking skills. Overall I feel that the Amazing Race was a fun and creative activity.* [RE_S59]

One student described the science projects as being creative and they were inspired by these projects to continue with engineering, confirming that the activity was useful in terms of introducing students to creativity as one of the 21st century skills.

> *After the engineering building, we went to a roadblock at SCI-ENZA building where we were tasked with drawing a picture using a "something pendulum" which was one of my favourite tasks or activities because I got to perceive some cool inventions and fooled around with the instruments there. This showed me how creative people can get and how that creativity is used in innovation to improve life, which inspired me to continue with engineering to improve people's lives.* [RE_S79

6.3.5 Summary

The 21st century skills are intertwined as can be seen from the following student comment:

> *The teamwork factor worked well because* it helps with *communication skills. I would recommend keeping the Amazing Race with teams of two, but to make the roadblocks a bit more challenging in order to improve teamwork even more.* [RE_S34]

Participation in the race provided the students with the opportunity to practice leadership and responsibility. They had to organise themselves and their activities effectively and responsibly to complete the race. They had opportunities to apply critical thinking and problem solving and had to be productive and accountable. The designers of this activity can in no way claim that students would have obtained the 21st century skills, but it has served as an introduction that could be reinforced in more challenging learning environments. Another advantage of the environment was that it was conducive to a wide variety of students in terms of their proficiency, the ill-prepared students benefitted from the module, and at the same time, the well-prepared students stayed engaged and interested as can be seen from their performance.

The game-based environment provides students with an opportunity to develop social and collaborative skills (Romero et al., 2015). They emerge in activities that force them to make decisions by using critical and creative thinking while considering a variety of inputs from different knowledge fields (Pivec et al., 2004). Therefore it can be concluded that a game-based environment, in this case the Amazing Race, is beneficial for the development of 21st century skills (Romero et al., 2015).

6.4 **DESIGN PRINCIPLES**

Educators are continuously searching for strategies to increase student engagement and to enhance learning in their teaching environments (Ozcelik et al., 2013). Especially in skills development modules, the search for effective “mediums” that would engage the students in meaningful learning continues. In participating in a game, students are offered the opportunity to be part of an imaginary world where people experience fun while they are intensely concentrating to solve problems (Prensky, 2001b). While students are immersed in a game designed for multiple players, they are communicating in their respective teams, solving problems by being creative and using their critical thinking capabilities. It could thus be said that games provide an excellent opportunity to develop 21st century skills.

After a search through literature, evaluating the process involved in designing the Amazing Race learning environment and analysing the research data, a number of design principles that could be beneficial in the design of any game-based learning environment, crystallised.

6.4.1 Take stock of the unique characteristics of your student body

In designing a learning environment, I always have to take stock of the characteristics and pre-knowledge of my students. I also have to consider the implicated proficiencies that the learning environment might compel students to have. It is therefore important to list the things that students need to have and also what they need to know to be able to take part in the learning events. In the Amazing Race activity, I have included engineering-specific challenges that leaned on the students' knowledge of mathematics. To strike the delicate balance between too easy and too complicated challenges, I need to know my student body.

6.4.2 Consider the hardware and software requirement to take part in the game

Successful and meaningful participation also depends on the availability of the devices or instruments needed. These could entail having access to a smartphone, having airtime on the devices or access to wireless internet services to search for answers online, and the knowledge of the technology and search engines available. We often forget to consider the necessities that speak for themselves, and although these might seem to be trivial, it could have a big influence on the successful execution of your learning event. It is therefore important to be explicit when you state hardware and software requirements.

6.4.3 Fit the characteristics of the learning environment to a relevant game

The learning outcomes and the educational context at hand play a detrimental role in the pedagogical approach to a specific scenario. Factors such as the facilities available, time constraints of the activity, the characteristics of the students for whom the activities have been developed all need consideration in the planning phase of an educational event (Arnold, 1991). After all of these factors were considered, look at the possibilities to adapt an existing game, or create a customised game, that could optimise the learning experience.

The milieu faced in this study called for a game that would orientate the students, not all of them adequately prepared for a higher education environment, on the physical campus, while simultaneously exposing them to opportunities to develop the 4Cs. The campus environment opened up certain prospects but posed other challenges as well. Furthermore, the time constraint, 110 minutes, had to be taken into account. I was looking for an activity that could encapsulate the learning outcomes while considering constraints with regard to the students, time available and the facilities/opportunities available. The Amazing Race scenario was found to fit the learning environment, but I could have implemented another game as well.

I wanted a learning environment that would fit not only the educational objectives of the module but also the students' need for a non-traditional educational setting (Duderstadt, 2009). A game-based learning environment seemed a perfect fit for the scenario. Furthermore, I specifically wanted the students to play the game outside of the traditional lecture halls on the campus. The game could easily have been adapted to be played indoors, or even by using a virtual platform if the circumstances did not allow for an out-of-class experience. With careful planning, the students could be exposed to different learning outcomes introduced as activities that need to be completed during the game. And as a bonus, since the actions influence their progress in the game and they are motivated to complete the game successfully, learning takes place effortlessly (Prensky, 2006).

After critically evaluating the learning outcomes of a module, an educator has to evaluate which of the outcomes could be realistically addressed in a once-off event such as a game. Educators could consider using an existing game, such as the *Amazing Race*, *Survivor*, *Who wants to be a millionaire,* or other commonly played games such as *Scavenger Hunt*. Any of these could be adapted to address the specific learning outcomes as well as suiting the conditions under which the learning has to take place. Alternatively, a custom-made game could be developed for the same purpose. The latter, however, demands considerable energy and creativity, but it remains a possibility that could be investigated even though it may not always be a feasible solution. It is normally much easier to simply alter an existing game. The challenge, however, is to find a game that would lend itself to be adapted so that students would be able to reach the learning outcomes by playing the game.

The choice of a gaming environment is not limited to the development of skills, content-rich modules could also benefit from the application of gaming principles (gamification) or learning that is based on playing a specific game (game-based learning). The learning outcomes of the module and the educational milieu are used as the basis in all of the decisions with regards to the suitability of the game.

6.4.4 Contextualise the game environment

After I have chosen the Amazing Race as the theme of the learning event, I had to contextualise the game so that the learning objectives could be reached in an environment that would appeal to the student cohort. I had to narrate the context to ensure situated learning that "involves adapting knowledge and thinking skills to solve unique problems…and is based upon the concept that knowledge is contextually situated and is fundamentally influenced by the activity, context, and culture in which it is used" (McLellan, 1996, p. 9). The activities, developed in the context of the game chosen to drive student learning, could be customised to encapsulate the learning outcomes. These learning outcomes could either be reached explicitly as in a module where students have to learn facts, or implicitly where students need to analyse and synthesise information to obtain the outcomes (National Research Council, 2002). These activities could be introduced as obstacles, as this is one of the major elements of the Amazing Race. The successful completion of these activities could be translated to “extra lives” that could be used at later stages in the games.

Since I was working with engineering students, the context of the game needed to be authentic and the clues and the roadblocks had to be specifically engineered to fit their repertoire. The clues were relating to the world of engineering students, where they had to use different navigational systems. The roadblocks included activities where they had to explain certain scientific phenomena such as the chair on which they had to sit in Sci-Enza. They even had to apply trigonometric principles in their calculations to overcome some of the obstacles in the race. I could even have considered the use of GPS navigation, cell or WLAN positioning since I am working with engineering students. With creative thinking, a variety of activities could be designed that could fit into the repertoire of the students partaking in the learning environment.

There is a complex interplay between the learning objectives, the choices regarding the context of the game and the design of the activities that the participants have to complete during the game. The uniqueness of the location-based game is the environment itself, and as such, it is no wonder that Montola (2011) suggests that the cultural value of the environment should be used to engage the students. The three major principles linked to authenticity according to Yuan, Fu, Venter and Hainey (2019) is that the game as such should showcase the real world, the logic of real events should be followed and that students should be offered an opportunity to reach certain levels of cognisance. Situated learning could be ensured by connecting the learning environment to the context of the students for which the gaming environment is designed.

6.4.5 Develop the whole experience by keeping the mechanics of the game, the dynamic interplay of the elements and the emotional experience of the players in mind

In the case of the Amazing Race, I have chosen the destinations based on their relevance to the student cohort. The elements of the game, the clues and roadblocks, were designed to bring their creativity and critical thinking abilities (the learning objectives) to the table. The level of difficulty of the activities that were included influenced not only the student experience of the game but also the extent to which they had to communicate and collaborate in their teams. In essence, every element of the game was designed to speak to the learning environment in its totality. Activities that are included to realise learning outcomes have to be inherently part of the game.

The mechanics of the game include the key role players in the game, how the players interact in the game, and how they win (Hunicke, LeBlanc, & Zubek, 2004, July). All of these aspects need attention before any game could be staged. In the Amazing Race, I had to look at the student cohort and I had to consider their specific characteristics and abilities. The colleagues that formed part of the teaching team and other staff members at the different destinations visited during the race also needed consideration as key role players in the event.

Decisions regarding the destinations visited, the clues to these destinations and the roadblocks to be executed at each of these destinations were also considered as part of the mechanics of the game that need attention before the game could be initiated. Furthermore, the types of interactions between the students and their environment, their teams and the lecturing staff, the rules of engagement, how the students' progress through the race and how they win, played a crucial part in the planning phase of a game such as the Amazing Race.

The motivational theory of Keller (1987) proved to be extremely informative during the planning phase of the event. Specific activities were developed to awaken student interest, to establish relevance, to amplify the students' expectancy of success and to enhance a sense of satisfaction through intrinsic and extrinsic rewards. The mechanics of the game influenced the student experience of the event (Hunicke et al., 2004, July). For instance, the decisions regarding the activities included in the race could influence the pressure that students experience with regard to the time afforded to complete the race. This could again shape the emotions experienced as a result of the game environment. It is evident that there is a serious interplay of the mechanics, dynamics and emotions that influence the outcome of a game (Hunicke et al, 2004, July). As such, special consideration should be given to these aspects involved in the design of a gaming environment.

6.4.6 Retain the gaming elements of passion and engagement

The game needs to feel like a game from the perspective of the designer and, most importantly, from the perspective of the player. Hunicke et al. (2004, July) use words such as sensation, fantasy, fellowship, discovery, expression, challenge and drama in their description of the emotions encountered when playing games.

All of the game elements as specified by Prensky (2001b) that were discussed in detail in Chapter 5, played a role in the redesign of the Amazing Race. I had to make sure that none of the elements that could give students enjoyment and pleasure, and that ensured intense passion and involvement (Prensky, 2001b), were removed due to the changes that I have made. I had to consciously add activities that I knew would intrigue the students (Arnold, 1991). In one instance, I wanted to address the fact that students do not read instructions in a fun way. I wanted to illustrate to them the effect of not focussing on detail, in a non-threatening humorous event. This activity was not based on the learning outcomes, but the opportunity to include it came as an added bonus.

Fun is only one of the twelve characteristics of effective gameplay (Prensky, 2001b) that I have singled out with an example of how I tried to add to the experiences of the students. To create a fulfilling gaming experience, it is imperative to look at all the characteristics of games and incorporate activities that conscientiously add pleasant emotions during the learning event by adhering to these principles in game design.

6.4.7 Strike a balance between the level of difficulty of challenges and the sense of success by the students

I had to find a balance between activities that seemed to be too easy or too difficult to complete. On the one hand, it could discourage students to take part in the game and influence the outcome in terms of the time needed to complete the game (Cornelisz & Van Klaveren, 2018; Sweetser & Wyeth, 2005). On the other hand, students could lose interest in the game since it was not challenging enough and it did not spark a need for creative thinking (Funke et al., 2018).

The difficulty of the challenges also influenced the extent to which the students were forced to communicate with each other while they were participating in their teams. Students commented that they did not need the help of others to complete some of the challenges. It seems as if collaboration and communication depended on the difficulty of the challenges that they needed to overcome. “Bonus” tasks with appropriate rewards could be considered for those teams who felt it was too easy, there are numerous options for creative educators. The important factor though is to strike a balance between student competency and level of difficulty of the challenges.

6.4.8 Provide opportunities to learn individually and incidentally by student choice

As kick-off of the Amazing Race, I provided students with a hand-out that contained a description of the event, the rules of engagement, a map of the campus and their first clue. Students had to organise themselves in teams of two and read through the instructions before they could start. Since they had to interpret the clues, they could make mistakes and end up at the wrong location. These mistakes were not detrimental to the game, and no player was excluded based on their wrong choices during the experience. They could also learn through their mistakes and adjust their thinking patterns.

Since the game-based learning environment is planned as an educational event, it is important to ensure that all of the students could partake fully and complete the whole activity. To this effect, special measures need to be taken to monitor student progress and to intervene where and if necessary.

6.4.9 Define rules, set clear success criteria (learning aims) and provide rewards

The Amazing Race broadcast on the television already had rules to which the contestants had to adhere. I had to adapt the rules of the game so that it could still provide structure, but that it was fitting for the circumstances in the new environment. The rules and the goals of the game had to be redefined. This was presented to the students as part of the introduction that painted the scenario. Clear, specific objectives for the activity were presented, and in this way, students were motivated to partake in the game (Sweetser & Wyeth, 2005). Special attention was given to the interplay of the different game elements to ensure that the game was still interactive (Prensky, 2001b) and experienced as being adaptive to ensure the experience of flow (Csikszentmihalyi, 2008).

Even though I was working with first-year university students, the concept of winning and receiving a prize intrigued most of the students and served as motivation to complete the activity successfully (Prensky, 2001b). Vendors on campus are more than willing to provide promotional items such as water bottles, pens, rulers or even food vouchers. Even intangible prizes such as badges seem to heighten the student experience of the game. The prizes could be small, but the prospect of winning something seems to enthral almost every human being.

Apart from the importance of feedback on all of the activities, a mechanism to reward good performance and penalise students that do not adhere to the rules need to be in place. I have created a final event to wrap up the Amazing Race and to endorse collaboration in bigger teams. The crossword puzzle was completed in teams of six and although the teams were awarded for the position in which they have completed the first leg of the race by receiving the crossword puzzle ahead of the other teams, all of the teams still had a fair chance of winning the grand prize.

6.4.10 Provide clear instructions and communication with regard to rules and code of conduct

All of the instructions that guide the students through the process should be carefully considered and voiced in such a manner that students clearly understand what is expected of them. I most certainly know what I want to say, but the students might misinterpret the instructions, and that could lead to chaos. It is therefore commendable to run the instructions to the event by your colleagues or the tutors before the activity to be able to refine instructions that could possibly be misunderstood.

At the onset of the event, the students need to receive clear instructions as to what is expected of them, the rules need to be spelled out and they also need to know the rules of engagement and where they could find help. During this face-to-face session, chaos and confusion amongst students could be prevented by walking the students through the process and addressing problems that might arise.

6.4.11 Offer elaborate feedback on every element of the game

Even though this is a game, feedback is important. Students want to know whether their answers were correct or not, even though it did not influence the outcome of the race. Opportunities to provide feedback proved to be very important (Prensky, 2001b). Students not only need feedback on their progress in the game, but also detailed feedback on each activity that they have encountered during the game. I realised that I had to give “model answers” and perhaps even recommended methods to achieve success at each of the roadblocks at the end of the game, to ensure that the weaker students also benefited from that aspect of the game. But more than that, it became evident that students all wanted feedback (Sailer et al., 2013). The stronger students wanted to know where they went wrong, whereas the weaker students needed guidance (Baron, 2012). It seems as if the students wanted a sense of closure after the completion of the activity, and the feedback session completed the circle of events.

6.4.12 Create a safe environment

One of the biggest advantages of a gaming environment is the fact that students can learn by making mistakes and relearn without any detrimental influence on their studies (McGonical, 2011). Students need to feel safe to be able to fully engage in any learning environment. Since none of the students' choices resulted in them being excluded from the activity and the fact that personalised feedback was available at each of the stops during the race, students could experience the safety offered by a gaming environment. Special attention should be given to measures to ensure safety in the gaming environment.

6.4.13 Ensure seamless logistical execution of the activity

Planning is essential for the successful execution of the game. Arnold (1991) described planning as being positioned to act, to do whatever you are able to do beforehand than to face the challenges as they surface. Logistical issues such as the compilation of the teams, the set-up of the clues and roadblocks, administrative issues and staff support requirements all need a hands-on approach to ensure the seamless execution of the activity (Arnold, 1991).

Even when one has taken all of the design principles discussed in this section into consideration, the logistics surrounding the event can still counter all of your efforts. Firstly, during the initial planning phase, there were numerous decisions to be made. I had to look critically at all of the destinations and decide on the feasibility of their inclusion in the race. I had described this process in Chapter 4.

The clues, the navigational information to each of the destinations, were then configured. Since I had a large number of students (about 100) partaking simultaneously, I had to send them on different routes to lessen the impact on the campus environment. For this purpose, I had to plot the routes on the map to ensure that each route flows logically. At each of the destinations, specific activities needed to be considered to serve as roadblocks.

Since the destinations offered a wide variety of services, creative thinking comes into play to design activities (as roadblocks) that would showcase the facility while at the same time would be interesting to the students and stimulate the exposure to the 4Cs. I also had to design at least three activities at each of the facilities to spread the students evenly. This meant that I had to find activities that were positioned at different corners or at least so far apart that two or three teams would be able to do the activity without hindering the teams at the other roadblock. The colleagues at each of the destinations chosen had to buy into the concept as well.

After all of these decisions had been made, the administrative tasks awaited. The map and instructions, clues and roadblocks need to be prepared. Every destination's roadblocks and the clues for three different groups of students needed to be prepared. To avoid confusion that would result in chaos, three different colours were used to distinguish between the different versions' clues. Students received the same coloured clue as the map that they received at the onset of the race.

There are, as can be seen in the description above, numerous factors that come into play during the planning phase of an event such as the Amazing Race. Many of the factors that could derail the event could be eliminated, or their effect could be lessened by careful consideration of the potential problems during the planning phase.

Before the Amazing Race activity, I walked every route as a student to ensure that the routes were accessible and that the journey could be completed within the time allocated. I visited all of the destinations, discussed the clues with other stakeholders to eliminate possible dual meanings and used colour codes to eliminate mistakes in the distribution of the clues at the different destinations during the race. I executed every roadblock as if I was a student to ensure that everything is in place and in working condition.

Since I did not have control over the facilities, I had to communicate clearly and remind all of the stakeholders of the important details concerning the event. I had to ensure that each station had the relevant paperwork needed by the students. This included the roadblocks at the specific destination and the correct answers (there were more than one for logistical reasons) and the clues for each version of the race (three different ones to ensure that we did not disturb other academic activities on campus by arriving in numbers at a destination). Furthermore, every staff member involved needed to know which routes students had to follow, they needed to be able to help the students to figure the clues out themselves and not simply provide them with the answers. All of the people involved in the execution of the activity were reminded of their respective roles one day in advance, and all of them received contact details and information regarding the total process so that they could help students that did not know where to go.

From the above description, it surfaced that the design of a gaming environment requires a hands-on approach where the designer thinks of different situations and problems that could surface and take measures to minimise the probability of such occurrences. Without careful planning and reconsidering every little detail, even the best-designed event could go south.

I have found that by checking and re-checking the details of the activity, problems could be ironed out before the day of the event, and in this way, the disappointment of realising that something did not work as anticipated could be avoided. Everybody needs to be on board to ensure that the process runs smoothly.

6.4.14 Ensure that prior knowledge about the nature of the game is not a prerequisite for playing

Since student engagement is crucial in the design of any educational event, any factors that could impede on their participation needed to be considered. Even though all of our knowledge and understanding are connected to prior experiences, the capability to arrive at a new understanding is more important than knowledge already attained (Cronje, 2018). The problem is that our students do not arrive equally prepared for their studies. By using a game-based scenario, the educational playfield was levelled since even students originating from remote areas, and who had no prior exposure to the game, could play it with success. The input of every student was important (only two students per team) to proceed in the race. By using small teams, every student had equal opportunities, and since no one had more experience than another, they had to rely on each other, and in this way, both team members had opportunities to develop the 4Cs.

6.4.15 Support better transferability of skills by introducing an interleaved practice of reflection on the learning environment

The value of reflection after any activity should not be underestimated. The influence of metacognition, the buzz word of modern pedagogy, cannot be neglected (Bruner, 1996). When students have to reflect on what they have been doing and how they can improve on it, full mastery is possible (Rotherham & Willingham, 2009). I found that students did not realise the value of the activities immediately after they have completed the activity. As one of the students said:

> *In the first week of university, our JPO 110 lecturers tasked us with various challenges and objectives in the form of the show, The Amazing Race. We were told that the purpose of this activity would be to help us familiarise ourselves with the University of Pretoria campus. Personally, I was not really keen and excited by the prospect of having to walk around campus completing objectives. During the activity all I remember my partner and I doing was complaining. We were complaining because of how far we had to walk, we were complaining about how irrelevant this activity was and on top of all of that, it started to rain. Once we finished the activity, we were over the moon that we were done. We were tired, wet and irritated and to be honest [my partner] and I absolutely hated the Amazing Race because we*

> *found no relevance to it. However, fast forward 2 months and now that I reflect on the Amazing Race and everywhere, I went and everything I learnt, I realised why the lecturers made us do this. If it wasn't for the Amazing Race I wouldn't know where the library is, I wouldn't know where Make a Space is and I wouldn't know what and where Scienza is. Now that I have been at Tuks for the past 2 and a bit months, I've realised how beneficial the* Amazing Race *actually was and I am really thankful and grateful that I was able to do it. Before I actually reflected on what I had just done for the Amazing Race I would've rated it a 2 out of 9 just because of how much I hated it, but now that I have reflected on it, I would rate it an 8 out of 9.* [RE_S48]

Reflection is useful and should be intertwined in the whole game experience. Questions such as "why do you think that the mirrors are positioned at 60 degrees?" force students to think about their thinking and in this way further the learning process. Therefore, reflective moments should be built in the process but also as a final activity to conclude the learning experience.

I believe that many existing games could be changed into educational experiences reaching the learning objectives as defined in any module. These activities need not be out-of-class experiences, virtual reality is also an option, and we have seen that students value any non-traditional experiences.

6.5 CLOSING COMMENTS

The Amazing Race game was introduced in which students explored the campus environment navigated by the clues provided at each destination. Students had to interact with each other to be able to complete the race successfully. They had to solve problems and use critical thinking to complete the roadblocks. Creativity and innovative thinking were needed to be successful in the activity. Numerous life and career skills as stipulated by the P21 movement, have been in play.

Qualitative evidence shows that it is possible to create a learning environment that is conducive not only for the transfer of 21st century skills but also for other educational purposes such as for instance student retention. The researcher stresses however that students will develop these skills as far as their own capacity allows them, only if they are subjected consistently to environments where these skills are typically addressed (Fisher, 1980).

7. CHAPTER 7: FINDINGS AND RECOMMENDATIONS

7.1 INTRODUCTION

Chapter 7 will bring this thesis to a close by first describing the background and the rationale for the study that resulted in the research questions and summarising the literature review and the methodology followed in this study. It will also include a brief description of the intervention and the findings. Three reflective sections will also be included: a methodological, a substantive and a study-specific reflection. The chapter will conclude with the design principles and some recommendations for policy and practice, for further research and further development work.

7.2 SUMMARY

The overarching aim of the study was to ascertain specific design principles that influence the successful implementation of a game-based learning environment. For this purpose, I first wanted to establish the suitability of a game-based environment in an academic higher education scenario. Second, I wanted to know if a game can be modified to serve an educational purpose, while at the same time still have the benefits of student engagement posed by a game environment. And finally, I wanted to investigate the influence of the game-based learning environment on the exposure and attainment of the 4Cs, namely communication, collaboration, critical thinking, and creativity. The game-based activity adapted from the television series the Amazing Race, was at first described as action research since it was focussed on the improvement of the learning environment. After I have realised that the educational scenario could be replicated by adapting other existing games and learning content, the study changed to a design experiment that kicked off with a cross-sectional case study. This approach to the study allowed establishing game principles that could be applied in other scenarios, and it also shed light on the exposure to and attainment of the much applauded 21st century skills, communication, collaboration, critical thinking, and creativity.

The quest for employees that are apart from being experts in their fields also individuals that are 21st century attuned guided the investigation into learning environments that are conducive to the attainment of these skills. The main research question that guided the study was:

> *Which design principles can be used to create a game-based learning environment in higher education that promotes the development of communication, collaboration, creativity and critical thinking skills in ill-prepared students?*

Three sub-questions were employed to shed light on this question:

1. *How can an existing game be adapted to suit an academic purpose in a higher educational environment?*
2. *To what extent are the characteristics of games still present, once an existing game has been adapted to serve an academic purpose?*
3. *To what extent does a game-based learning environment provide the opportunity for the development of the 4Cs (21st century skills)?*

The learning environment was designed as a result of the quest for employability by industry. Numerous institutions define sets of attributes needed to be successful, and frameworks, whereby these skills are categorised, have been developed (DEST, 2002; NCREL, 2003; OECD, 2005; SAQA, 2000). Even the professional bodies that regulate the professional attributes needed in the engineering workplace (ABET in the USA (ABET, 2003) and ECSA in South Africa, specify learning outcomes expected of newly graduates (ECSA, 2017). After analysing the frameworks and taking the 11 outcomes for engineering students in the South African context into consideration, the 4Cs, communication, collaboration, creativity and critical thinking of 21st century skills were identified as skills that encapsulate most of the skills delineated by the different frameworks.

Higher education institutions, being “in the business of developing the whole person, including all facets of their lives” (van Breda, 2018, p. 1121) are compelled to deliver employees that could meet the challenges of the fast ever-evolving 21st century workplace (Murali & Rajaram, 2015; Pegg et al., 2012). In South Africa, where the school system is failing the majority of learners (Spaull, 2013), the obstacles faced by higher education institutes call for special measures. Students arrive ill-prepared; as indicated by statistics showing that South Africa is rated 146th out of 148 countries in term of the educational system's quality (DHET, 2013). Socio-economic and historical factors (Kraak, et al., 2013) further convolute the educational setup. Therefore, the dropout rates are high, and the skilled people emerging from these institutes are not found to be job-fit by employees (Kraak, et al., 2013). Apart from challenges with regard to the level of preparedness of our students, the demographic cohort, Generation Z, further complicates the educational playfield. The typical Generation Z-student poses new challenges with regard to engaging in learning environments. As stated by Duderstadt (2009), these students challenge the traditional style of knowledge delivery and demand a new, innovative approach to learning.

All of these discussions built up to a discussion of learning environments that would engage students actively (Astin, 1999) and motivational factors and measures to ensure engagement were discussed (Deci & Ryan, 1985; Keller, 1987; Lepper & Cordova, 1992). Environments in which students are actively engaged and in which effective learning takes place have the following common denominators: challenge, fantasy, curiosity and control (Malone & Lepper, 1987). These environments also seem to be able to grab the students' attention, is relevant to the student's milieu, promotes student confidence and provides satisfaction (Keller, 1987). During the discussion of the different elements in play, especially in the South African context, it surfaced that innovative learning environments need to be considered. In this learning environment, the playfield needs to be levelled, the preparedness of students for the tasks at hand should not hinder their chances to develop the necessary skills to be successful in the workplace.

In the light of all the above mentioned, games as an instructional method came under scrutiny. The use of game-based learning, where the game serves as the learning opportunity and gamification, where game elements serve as motivational factors in a learning environment were investigated. Games pose opportunities to develop a student's skills without them being aware of the time that elapsed on their involvement (Csikszentmihalyi, 1990). Students have to communicate with each other to be able to collaborate effectively and they lean on their ability to think critically and creatively to excel in the game (Mallory & Guadagno, 2016). As such, games seemed to be the perfect solution to the learning outcomes set for the environment that I had to develop.

The input, process and outcome gaming model, adapted from Garris et al. (2002) was used to structure the inquiry. The input section referred to the generation Z engineering students and the Amazing Race gaming features. The game cycle that includes judgments, behaviour, system feedback and debriefing was labelled as the process followed and the outcomes were design principles that could be employed in game-based learning environments and also students that were exposed to an environment in which they could attain or develop 21st century skills, the 4Cs.

The research questions gave rise to the research design that was discussed in Chapter 3. The Amazing Race learning environment was typified as action research that took place over three years. After realising the potential of a game-based learning environment in the educational arena, the approach was changed from action research to a design experiment (Plomp, 2006). As a first step in the design experiment, a cross-sectional case study was employed to be able to investigate the influence of the environment on the exposure to and attainment of 21st century skills. The student voices were used to describe how this environment shaped their experiences, and as such, a qualitative interpretive approach was followed during the inquiry.

The trustworthiness of the research depends amongst others on the conceptualisation of the study, the data collection procedures, the thoroughness of the analysis and interpretation process and on the presentation of the findings (Merriam & Tisdell, 2016). I believe that the study into enabling learning environments to develop 21st century skills poses useful information to the benefit of everybody in an educational sphere (Lichtman, 2013). The data was collected and analysed following guidelines provided in the literature, and the results discussed in an open conversation with the reader. The research project was approached with an attitude of maximising the good and minimising the harm for science and humanity, and the students were treated with respect (Mertens, 2018).

As the designer of the learning environment, I was closely involved in the whole process, from the planning stage to the data collection and analysis. I had to delineate my own biases and stated that although the research could not be generalised, it could provide useful design principles. These could be employed in an educational scenario and also an in-depth understanding of the influence of a game-based learning environment such as the Amazing Race on the transfer of the 4Cs to under-prepared students.

Chapter 4 painted the educational arena by first commenting on the specific problems faced by Higher Education Institutes in South Africa, especially in the light of our schooling system (Spaull, 2013) and the impurities caused by socio-economic and historic factors (Kraak, et al., 2013). We then considered foundation programs (Grayson, 2010) as a measure to resolve these problems at higher education institutions in South Africa. These foundation programs are structured to assist students to be successful in their studies over five years. Mainstream subjects are augmented with additional modules to fill in the gaps in students' conceptual understanding of the content. In the ENGAGE program, students have Professional Orientation, one of the first-year modules in the five-year extended degree program for engineering students. This module is designed to prepare the students to be successful in their studies and also as a professional in the workplace. The study focussed on a learning environment that was designed for Professional Orientation.

The Amazing Race for Professional Orientation was based on the renowned television series The Amazing Race. The game elements that featured in this game were adapted to fit the educational scenario of the Pretoria campus. Students, in teams of two, received a map of the campus and a clue to their first destination. Upon arrival, they had to complete a roadblock before they received a clue to the next destination. The clues to the destinations and the roadblocks that the students encountered were designed with the learning outcomes, the development of the 4Cs, in mind.

The learning environment developed over three years in which the activity was revised after every iteration. Since the facilities available on campus changes every year, the environment has to be adapted to include new developments and eliminate ineffective stops from the race. The number of students and students with special needs in a specific cohort was also a determining logistical factor that could influence the smooth execution of the game and should, therefore, be considered in following iterations of the learning environment. The description in Chapter 4 centred on the first sub-question*: How can a game such as the Amazing Race be adapted to suit an academic purpose in a higher educational environment?* The academic purpose was the attainment of the 4Cs of 21st century skills. Student reflections were analysed, and even though they were just prompted to comment on their experiences pertaining to the destinations, clues, and roadblocks, many of them commented on the educational value of the learning environment.

> *I honestly enjoyed this module because I am learning a lot of new skills and actually getting experience on how to actually become a professional engineer.* [ES_S10]

Chapter 5 offered a discussion in response to the second research question: *To what extent are the characteristics of games still present, once an existing game has been adapted to serve an academic purpose?* The 12 game characteristics of Prensky (2001a) anchored the discussion where I have once again used the voices of the participants in the study to portray how the students valued the inclusion of these game characteristics and how it added to their experience of the environment as a game. One of the students offered:

> *I am grateful for this Amazing Race, because the students didn't realise that they are learning while having fun.* [RE_S25]

The third question: *To what extent does a game-based learning environment provide the opportunity for the development of the 4Cs (21st century skills)?* was tackled in Chapter 6. Evidence of opportunities to develop communication, collaboration, creativity and critical thinking was interwoven with relevant literature sources to provide a rich, in-depth description of instances where students experienced the value of the activity in terms of the attainment of these skills by using the student and tutor voices. Most of the student comments, even though not instructed to shed light onto it, included a reference to the value of the Amazing Race learning environment in terms of the improvement of their skills:

> *The Amazing Race allowed for a good team working opportunity and helped in improving our communication and thinking skills. Overall, I feel that the Amazing Race was a fun and creative activity. [RE_S59]*

It could thus be said that since the students are communicating in teams while solving problems by being creative and using their critical thinking capabilities while they are immersed in a game, games provide an excellent opportunity to develop 21st century skills.

Game-based learning environments could be the answer to the quest for student engagement in an educational environment. Existing games could be employed especially in skill development modules where the differences in competency levels are starkly noticeable since they offer students the opportunity to be part of an imaginary world where they experience fun while they are concentrating intensely to solve problems (Prensky, 2001b). Even a combination of content and 21st century skills could be embedded in a game-based or gamified learning environment.

The choice of a game for learning purposes depends on the learning objectives of the event, the time constraints and also the facilities available. Games can also be played in a virtual environment. Any existing game could be adapted, provided that the game would lend itself to the necessary changes so that students would be able to reach the learning outcomes by playing the game. The context of the game preferably has to be authentic, and the elements engineered to fit the repertoire of the students who are going to play the game. The 12 game characteristics of Prensky (2001b) prove to be useful in the design of the activities included as part of the game. The rules by which the game is played and the feedback provided on tasks was found to be of importance to the students partaking in the activity.

Creative educators could use the activities developed in the context of the game (that was chosen to drive the learning) to encapsulate the learning outcomes explicitly (to learn facts) or implicitly (to analyse and synthesise information) to reach the outcomes. The gaming environment possesses elements such as obstacles, extra lives and more that could be exploited to optimise learning gains. The winning state is important as everybody likes to win, even if it is an imaginary badge or small chocolate. Winning drives participation. Students also need to reflect on their experiences. Full mastery is possible when students reflect on what they have done and have to evaluate ways to improve on their actions (Bruner, 1996; Rotherham & Willingham, 2009).

I believe that many existing games can be adapted to reach the learning objectives of any module. In this way, learning can be fun.

7.3 DISCUSSION

As could be expected, numerous lessons were learned throughout the research process. In this section, attention will be given to the decisions that were taken with regard to the methodology followed in the research process. I will also attempt to infuse the outcomes of the research project with other projects described in the literature with similar objectives, and conclude with a study-specific reflection of the study.

7.3.1 Methodological reflection

The study focussed on the design of a game-based learning environment that would provide your students with the opportunity to practice and develop their 21st century skills (the content that needs to be transferred), and the principles that could ensure the successful execution thereof. For this purpose, the Amazing Race learning environment and the extent to which this environment lends itself to the exposure to, and attainment of 21st century skills by students enrolled in the ENGAGE program was under scrutiny. The activity evolved over three years before I had decided to evaluate its worth in terms of the exposure to, and the attainment of 21st century skills.

I believe that it was beneficial to the study that the Amazing Race activity was already up and running for three years (from 2015 to 2017) as the first activity that the students encountered as first-year students. Students enrolled for Professional Orientation in 2018 reflected on the value of the Amazing Race to them as students. In this way, most of the logistical problems have been sorted out, and the activity was well-refined in terms of the clues and roadblocks.

It could, however, have been useful if I asked formal feedback in the form of reflections from all of the participants after each iteration of the activity in these years. I expect that in that way, it would have been possible to lessen the noise created by factors such as the climate on the day of the activity and similar student frustrations on the one hand, and positive experiences on the other could be amplified. It would have enabled insight not only into the value of the learning environment in terms of the attainment of these skills, but would also have provided a measure to establish which changes amplified the students' experiences and to what extent. I would also have been able to establish in which contexts these subtle changes proved to be most advantageous. I have also experienced a difference in student attitudes between the different student cohorts, and it would have been insightful to explore the effect of this aspect on the experiences of the students. I imagine that interviews with students who reacted either very positively or very negatively on the experience would also have provided valuable insight into the student experience of the exposure to the 4Cs.

The focus of the study was on finding useful principles to apply in the design process of a game-based learning environment. The three sub-questions were used to provide the depth and the scope to come to a point where I could indeed attempt to provide useful design principles. A description of the process that was followed during the design phase of the learning environment, the elements of games that enhanced the student experience and the possible reasons for the extent that this environment afforded opportunities to develop the 21st century skills, was rendered.

The research questions focussed on an understanding of the scenario at hand and resulted in principles being derived to create game-based learning environments conducive for the development of 21^{st} century skills. The 21^{st} century skills, communication, collaboration, critical thinking, and creativity, could, however not be evaluated in a purely quantitative manner. To investigate the research questions, a qualitative approach to the research was chosen, together with instruments that could aid the research process. The communication skills of students, for instance, are developed in many different environments, and it is therefore not possible to award any improvement in this skill to the influence of a singular activity. It was possible, though, to establish whether the students felt a need to communicate based on the circumstances that they were experiencing during the activity, and their comments on how their progress was influenced by communicating effectively with each other. This type of evidence calls for an interpretive stance where I had to be careful not to impose my own biases on the data.

Since the data was collected in 2018 and I have done the analysis six months after the activity, I could put some distance between my feelings for the activity, having been involved in the course for so many years, and could focus objectively on the reflections of the students. It was also beneficial for the students that some time elapsed before they had to reflect on the activity. This time element could, therefore, be seen as one of the strengths of the methodology followed.

The tutors that took part in the focus group interviews had all participated in the activity in two different capacities. They initially encountered the Amazing Race as first-year students themselves, new to the campus environment in their respective first years as UP students. The second time around, they were part of the teaching team and could see and experience the activity from another perspective, while building upon their experiences as first-year students. As such, they could provide insights from both sides, being a student and also being part of the lecturing team. I believe that these differing perspectives added depth to the study. I was able to crystallise the student comments when compared with those of the tutors in their dual capacity in the focus group interview.

One of the strengths of the study stems from the fact that I have not explicitly asked students to evaluate the activity in terms of their experience with regard to the exposure to the 4Cs. They have, regardless of this fact, still spontaneously commented on the value of the activity in this regard. As such, it can be concluded that they really treasured the activity in terms of the exposure and attainment of these attributes, and that their responses were unsolicited and authentic.

This study highlighted the fact that students could be exposed to 21st century skills in an engaging, appealing learning environment that would optimise their learning curves as Generation Z students. The data collected during the study could be used to explore numerous other research focus areas, especially since the case study was the first step taken to change the research methodology from action research to a full-fletched design experiment. An example of the cyclical changes made to the activity included the title of the activity. The name of the intervention, Amazing Race was now used for multiple other, newly developed, activities on the campus. In 2019 this name was changed to become the “Engineering Challenge”, and the activities were amended to be even more engineering inclined, and also to be more challenging as a response to the student comments. Since the Amazing Race game metaphor has now been used in many capacities at our institution, it may be time to move on to a new game, such as *Survivor*, to reshape student experiences (Robson et al., 2015). It would be insightful to repeat the study and compare the responses of the students in 2018, with these of the new intake in 2019. But it will also be valuable to repeat the study where another game metaphor is employed to see whether this change the stated outcome.

The fact that games lean themselves to these types of changes, makes it even more desirable as a learning environment. I believe that I could have used a multitude of different games in my particular learning circumstances, since the game only served as a vehicle to transfer knowledge and support the 21st century skills. I hope that my experiences and the design principles offered will inspire other researchers and learning designers to tap into the potential offered by game-based environments for the learning of any study material, with the added bonus of developing 21st century skills.

7.3.2 Substantive reflection

The challenges faced by employers in the 21st century demand a change in the traditional pedagogically sound education approaches that have been in place for many decades now. The emphasis is no longer only on the need for content knowledge, but increasingly also on specific skill sets that are needed in the new era brought about by technological development.

Numerous research entities pinpoint the specific skills needed to be 21st century attuned, and it is further explored and specified by the professional bodies in different subject fields (ABET, 2003; DHET, 2013; ECSA, 2017; NCREL, 2003; OECD, 2005; P21, 2015; SAQA, 2000). The Partnership for 21st century skills stated that students need foundational literacies (core subjects), competencies with regard to communication, collaboration, critical and creative thinking, and certain character qualities to be successful in the 21st century (p21, 2015).

Since Higher Education Institutes not only have to but also want to deliver employable graduates (Bridgstock, 2009), they have been forced to take extra measures, especially in the South African context. Foundation programs were introduced to bridge the gap between the lack of preparedness of the students due to challenges in the schooling system, and the demands of a tertiary learning environment. Professional Orientation was one of the modules presented as part of an augmented program for engineering students and was structured keeping the development of the skills needed to be successful as a student and engineering graduate, in mind.

The special characteristics of the generation Z-students also pose a number of challenges for the educational system (Giunta, 2017; Jenkins, 2015). Traditional classrooms are challenged (Duderstadt, 2009), and the generation Z-students need to be actively engaged and motivated before meaningful learning could take place (Figueroa-Flores, 2016). Active learning strategies, as a possible answer to many of these challenges faced by educators, came under scrutiny (Prince, 2004). Interesting choices, desirable outcomes, instant feedback on performance and opportunities where students can develop and evaluate their progress in the learning environment (Prensky, 2005) are only a few of the student aptitudes that the teaching strategies have to address.

Numerous researchers (Figueroa-Flores, 2016; Garris et al., 2002; Romero et al., 2015) agree that a game-based learning environment would satisfy these students' inclination to active learning environments. This was confirmed in the study as numerous students commented that they experienced the Amazing Race learning environment as fun and that they would do it again since it was an informative activity that they experienced as beneficial in more than one way. There were students that did not enjoy the endeavour due to the weather, the attitudes of their team members, or just because they were not in the mood to do calculations on the day. I suppose that a variety of reactions could be expected given the diversity of the group.

An attractive element for the application of game-based teaching strategies is the overwhelmingly positive responses from the majority of the students. The game scenario also levelled the educational playfield, so that even the “weaker” students could participate without a feeling of inferiority, and also benefitted from the exposure to the game. Students experienced success just by being able to complete the activity, and since the activity had a final leg where they were afforded another chance to win the prize in a team of six people, another opportunity to attain the 4Cs was fashioned.

During the Amazing Race activity, students encountered many opportunities to learn incidentally. Some of these opportunities were specifically designed, for example, where students recognised the fact that they had to read and also listen carefully to instructions if they wanted to be successful in the Amazing Race.

“Work” can been turned into “Play” (Lepper & Cordova, 1992). The game-based approach to teaching that allowed the development of skills, such as critical thinking, group communication, debate and decision making pointed out by Pivec et al. (2003), was confirmed by the results of this study. To play a game successfully, certain game characteristics were pinpointed by Prensky (2001a). Although these were specified as specifically applying to digital game playing, I have used them as a guiding light in the design of the learning environment and the analysis of the student comments. Students, even not being aware of the fact that I was going to focus on these characteristics, have provided rich descriptions that confirmed the value of each of these for a satisfying experience of the game.

During the research process, I have realised the importance of feedback as pointed out by van Eck (2006). Even though the students were only playing a game, it was evident that they wanted feedback on the problems that they had to solve. Furthermore, all of the activities that they encountered had to be directly connected to the outcome of the game. I have realised through the student comments that activities could not be added haphazardly to realise the learning outcomes of any module. It should be inherently part of the game and influence the outcome thereof.

Some of the student comments revealed the seriousness with which they have approached the activity. Students conversed that they felt discouraged at times when the rules were not applied explicitly, which resulted in some of the students progressing in an unfair fashion. This served as proof that the students did not only need the structure provided by the rules, but they also valued the fact that it was strictly applied in the circumstances. The comments regarding their experiences underlined the fact that they wanted to engage in something meaningful, consistent with what Garris et al. (2002) found in their research on the topic.

Although Huizinga (1955) found that competition pushes students to improve on their existing skills and also to develop new skills, there were a few students that did not value the competitive nature of the game. These students wanted to engage in the activity but preferred to do so in a relaxed setting where they could explore everything that the environment had to offer. Others commented that the competition factor added to their experience of fun while they were actively involved in the game. Interestingly enough, one of the students stressed that the competition factor should not be overemphasised since it ran the risk of overpowering the goal of the activity, namely the realisation of the learning objectives. This calls for careful consideration of the emphasis on certain factors when the activity is being explained to the students.

There were opposing views regarding the difficulty of the activities that the students had to do during the race. Some of the students commented that it was too easy; they did not need their team members to be able to succeed. Others complained about the difficulty and said that the purpose of the Amazing Race was not to struggle. Some of them commented that they overcame their feelings of doubt in their abilities and enjoyed the challenge, while others really struggled and eventually just gave up. To find a balance between the level of difficulty posed by the challenge and the students' skills is crucial since it also influences the students' experiences while being emerged in the game. Student comments confirmed this statement and as such, underlined the notion of the experience of flow as described by Csikszentmihalyi (2008).

Another factor frequently addressed in the literature is the fact that students should be motivated to partake in educational activities. Keller (1987) highlighted four distinct components that could influence the motivation to engage in any activity. These included awakening student interest, establishing relevance, amplifying the students' expectancy of success and enhancing a sense of satisfaction through intrinsic and extrinsic rewards (Keller, 1987).

The Amazing Race was structured to arouse the students' interest in the new environment by including novel and authentic events whereby the students could gain knowledge, not only about the environment but also about the people with whom they were going to spend their tuition years. They had to find answers to the activities structured as roadblocks and clues to progress in the game. In this way, they had to be inquisitive and had to apply critical and creative thinking skills.

Since the learning environment leaned on the completion of small tasks to move to the next stages of the race, the students could experience the positive experience of success in each of these actions. The students commented that they were gratified by completing the tasks in the correct way, based on the immediate feedback that allowed them to continue in the race. What is more, they were also intrigued by the grand prize that was offered as extrinsic motivation. There was an overwhelmingly positive response to the activity that served as an indicator of the motivational level of these students to engage in the activity. Keller's model (1987) for motivation proved to be useful in the design of the Amazing Race activity.

Most of the students commented that they have learned a lot. They expressed their gratitude especially toward the fact that they felt alienated upon arrival at the campus environment. They continued by stating that after the Amazing Race activity they felt comfortable and they had a sense of belonging to a new community. Almost all of the students mentioned the fact that they have met new people and made lifelong connections. These comments confirmed that by being involved in games, students could be exposed to the development of valuable skills, especially with regard to the ability to collaborate effectively in teams (Gee, 2003).

During the Amazing Race activity, the need for negotiating the norms for action and acceptable behaviour was evident. Some of the teams functioned seamlessly even though all of the teams had to resolve their conflicting ideas regarding the different solutions to each of the challenges. Unfortunately, there were students that could not complete the activity successfully as a result of unresolved conflicts and student attitudes with regards to the activity. This is once again stressing the fact that students have to negotiate the norms of accepted behaviour in any collaborative environment. Thereafter, everybody needs to fulfil the associated role expectations when they are engaged in any environment in which they are expected to work in collaboration with others.

The social nature of the game set the stage for the learning of most needed skills in the 21st century workplace. Students not only commented on the fact that they had to communicate effectively in their teams but also discussed the importance of their interpersonal relationships. They commented on the fact that they have worked with people that they have never met before. They have discussed the difference in the expertise between their team members and how they had to bargain to reach a deal in this regard. They elaborated on the way that they had to negotiate within the team to finalise solutions to the challenges, by considering each person's viewpoint. They even mentioned the extent of dependency on each other to reach the finishing line. The fact that they had to learn to listen to each other, was also highlighted. All of these are useful indicators of the value of a gaming environment in exposing students to 21st century skills, especially in terms of collaboration with others.

Games in the educational arena are a welcome change from the traditional kind of instruction and could be implemented successfully in any educational genre. A game-based approach could, aside from realising the educational outcomes of a specific learning event, also enhance the learning experience of students.

7.3.3 Scientific reflection

The three sub-questions that have guided the study were all related to the student experience of the different facets (the destinations, clues and roadblocks) of the Amazing Race, the game-based nature of the race, and finally, how the activities that they encountered exposed them to opportunities to attain 21st century skills, namely the 4Cs.

The analysis of the student comments was done by using the framework that the three questions provided. I have analysed the data from the perspective of the different facets of the Amazing Race activity. A detailed discussion of the design of the Amazing Race environment can be found in Chapter 4, and the student experiences of the different facets were discussed in Chapter 5.

These facets, the destinations, clues and roadblocks, although much needed to host the educational experience, are interchangeable. Different destinations, different modes of navigation, even different activities could also be beneficial to provide the learning environment needed to reach the outcomes of the educational experience. The students commented on the relevance of the destinations, the difficulty of the clues and the roadblocks, the distances that they had to travel and more. Even though these were important to ensure that they were motivated to engage and to stay engaged, any other theme could have been used to set the stage for the learning environment. It is, however, necessary to give special care to factors in connection with the students' experience of the environment (it could also be virtual). As noted by Keller (1987), it should grab their attention, be relevant, and provide opportunities where students could be successful with a feeling of accomplishment after their involvement. It is, therefore, possible to apply the Amazing Race theme in other circumstances with their own restricting features. If the surroundings do not lend themselves to physical activity, it could also be launched as a fully online experience where the students could be participating in a similar activity in any virtual environment.

The Amazing Race is not the only game that provides the opportunity to design a learning environment to achieve learning outcomes. Other game scenarios such as *Survivor*, *Scavenger Hunt*, *Who wants to be a Millionaire* or even board games such as *Monopoly,* could be customised to serve as a vehicle for learning objectives as long as the same principles that ensure the engagement of the students are applied.

I have learned that the learning environment, to be experienced as a game, still needed to display the game characteristics as specified by Prensky (2001a). Even though his game characteristics apply to digital gaming, I have found that most of them were equally applicable to the Amazing Race as well. The students' comments, even though they were not explicitly prompted to respond on the appropriateness of a gaming environment and the characteristics thereof, confirmed that the game characteristics had an influence on the overall experience of the game.

Learning objectives are the driving force that affects all of the choices regarding a learning environment. In this case, I wanted to expose the students to an environment in which the sought after 21st century skills could be enhanced. A detailed discussion of the students' views regarding their exposure to communication, collaboration, critical and creative thinking can be found in Chapter 6. I have placed a high value on these student comments, especially since they were not specifically asked to reflect on the activity in this regard, but did so nonetheless. The tutors in the focus group interviews, in contrast, were asked explicitly to give their opinion on the subject of opportunities afforded by the Amazing Race to develop the 4Cs as well. In designing the activity, I had to keep these learning objectives in mind and had to anticipate scenarios in which the most valuable lessons in terms of each of the 4Cs could be learned. The action research was an appropriate approach for the developmental stage of the learning environment since I could tweak the activities to be more effective between the different iterations of the Amazing Race based on the informal feedback after each iteration. In hindsight, it would have been valuable to have had reflective essays for every year of the experiment because then I could have employed changes based on evidence scientifically gathered.

Any learning event provides unintentional learning outcomes, as well. In focusing on the 4Cs, many other unintentional learning opportunities also arise, e.g. how to deal with conflict in the team, how to manage time to be able to finish the activities in time, how to read instructions and comprehend what is expected, to name only a few. The value of any learning environment could be expanded by including short activities to add fun while creating awareness of the importance of other attributes needed to be successful as a student, and as an employee eventually in the workplace.

A gaming environment is especially beneficial to transfer 21st century skills, but could also be used to realise subject-specific knowledge. The emphasis, in the latter, should be on the content, while the game or gaming elements should serve the purpose of keeping the students motivated and engaged. I think that regardless of the learning outcomes of any instructional session, the attainment of 21st century skills should be kept in mind while designing the learning experiences. If there were more opportunities where students were exposed to these skills interwoven with subject-specific content, higher education would be better positioned to deliver, not only knowledgeable subject experts, but also 21st century attuned employees.

7.4 DESIGN PRINCIPLES

The following design principles can be pursued in the development of a game-based learning environment:

- Take stock of the unique characteristics of your student body;
- Consider the hardware and software requirements to take part in the game;
- Fit the characteristics of the learning environment to a relevant game;

- Contextualise the game environment;
- Develop the whole experience by keeping the mechanics of the game, the dynamic interplay of the elements, and the emotional experience of the players in mind;
- Retain the gaming elements of passion and engagement;
- Strike a balance between the level of difficulty of challenges and the sense of success by the students;
- Provide opportunities to learn individually and incidentally by student choice;
- Define rules, set clear success criteria (learning aims) and provide rewards;
- Provide clear instructions and communication with regard to rules and code of conduct;
- Offer elaborate feedback on every element of the game;
- Create a safe environment;
- Ensure seamless logistical execution of the activity;
- Ensure that prior knowledge about the nature of the game is not a prerequisite for playing; and
- Support better transferability of skills by introducing interleaved practice of reflection on the learning environment.

Since the nature of these characteristics is generic, they can be applied to any environment, be it another game that is adapted, or a newly developed one that is designed to ensure student engagement. I have seen that I could, by being aware of these characteristics, conscientiously enhance the gaming experience of the students, by ensuring that some of these characteristics realised in the game. In this way, the students' motivation to engage in the activity was influenced.

7.5 RECOMMENDATIONS

There is a place for game-based learning in Higher Education curricula despite omnipresent time constraints. These gaming activities do not have to be a big, disruptive exercises; they could be played in the lecture venue or could even be hosted as a virtual activity.

The learning objectives define the type of environment that would best facilitate the learning that has to take place. In designing a learning environment, it is important to take stock of the characteristics and prior-knowledge of the students. The implicated proficiencies that the learning environment might compel students to have, also need to be considered.

Students need to understand what is expected of them. The code of conduct in handling conflict of interest, and the guidance and help available during the game, need to be communicated to ensure that all of the students benefit optimally from the experience. This type of event is best served if planned as a team effort, because of the extent of work involved. Tutors are also included as part of the lecturing team since the students seem to be comfortable with people their age. This approach is especially beneficial in teaching 21st century skills because of the differences in approach and skills between the different staff members involved in the team-teaching approach.

During the activity, the progress of the students is monitored and since students may tend to look for ways to fast track through the event, measures to ensure that they complete every instruction need to be enforced to ensure that every student is exposed to the educational experiences planned. When problems arise, solutions have to be offered. It is, therefore, beneficial to have a back-up plan ready to use.

Game-based activities are especially valuable as ice-breaking endeavours upon which further instruction could be built. Fun is an important part of a game-based environment, despite the fact that the activity is part of an academic program. Any content can be embedded as roadblocks, but some of the activities could specifically be designed to promote the experience of fun and to promote teamwork. Teamwork can eliminate feelings of loneliness and foster a learning community that reaches out to each other for help.

No single learning experience can guarantee that students will be better equipped for the 21st century workplace, but if activities are developed to promote 21st century skills apart from delivering the course content, higher education will be better positioned to deliver 21st century natives. Amazing Race is only one of many games that could be employed to deliver subject content. Lecturers could be guided and trained to be able to use a game to their full potential as a teaching strategy.

During the process of research into the learning environment envisaged by the Amazing Race, numerous other questions surfaced. In terms of the design principles identified, it would especially be of value to know whether these principles would be equally valid if another game were played. Or could these principles be useful even in another learning scenario? The influence of a game-based scenario on students who are not "behind" when they join the university, those in the mainstream, could also be investigated. In terms of the learning environment, it would be interesting to know how other games would influence exposure to the 4Cs. Would students benefit from more challenging roadblocks in the sense that it would appeal even more to their critical and creative thinking capabilities, while also demanding more effective teamwork? Where is the locus between too easy or too difficult, and why do some teams just give up while others crave more challenging environments? And how does one prevent this kind of discrepancy? And how can the transition from a dependent to a self-directed student be facilitated? More research is needed to gain insight into these questions and even more so into teaching and learning approaches that motivate students.

7.6 **CONCLUSION**

Games are not considered to be hard work. The worldwide tendency towards solemn and educational hard work contrasts dismally with the enjoyment that play elicits. I wanted to experiment with a creative and innovative approach to teaching to identify applicable design principles. Furthermore, I wanted to look into the potential of this approach to expose students to the attainment of the 4Cs in the Higher Education arena. I could have included more challenging and engineering specific challenges, and it could have intensified the opportunities to attain the 4Cs. Nevertheless, Thomas Friedman said that he is "not sure how you teach that as part of a classroom curriculum, but someone had better figure it out" (Friedman, 2006, p. 106). Game-based learning offers many opportunities to expose students to the 21st century skills needed to be successful in the workplace.

8. REFERENCES

Accreditation Board for Engineering and Technology (ABET). (2015). *Criteria for Accrediting Engineering Programs.* Baltimore, Md: Engineering Accreditation Commission. Retrieved from abet.org: https://www.abet.org/wp-content/uploads/2015/04/criteria-eac-2010-2011.pdf

Adler, P. A., & Adler, P. (1994). Observational techniques. In N. K. Denzin , & Y. S. Lincoln , *Handbook of qualitative research* (pp. 377–392). Thousand Oaks, CA: Sage.

Agrawal, A. K., & Harrington-Hurd, S. (2016). Preparing Next Generation Graduates for a Global. *Journal of Engineering Education Transformations*, *29*(4), 5 - 12.

Amabile, T. M. (1997). Motivating creativity in organizations: On doing what you love and loving what you do. *California management review*, *40*(1), 39-58.

American Management Association (AMA). (2019). *Collaboration Skills - Collaboration* | *AMA*. Retrieved from Amanet.org: https://www.amanet.org/resources/success-skills/collaboration/

Anderson, R. (2008). Implications of the information and knowledge society for education. In J. Voogt, & G. Knezek, *International handbook of information technology in primary and secondary education* (pp.5-22). New York, NY: Springer.

Arch Architects. (n. d.) [Image] *Our-Projects-UP-Study-Center*. Retrieved from https://arcarchitects.co.za/wp-content/uploads/2015/10/Arc-Architects-Our-Projects-UP-Study-Center-04.jpg

Arnold, R. (1991). *Educating for a Change.* Doris Marshall Institute, Toronto, Ontario M6G 1C8.

Arum, R., & Roksa, J. (2011). *Academically adrift: Limited learning on college campuses.* University of Chicago Press.

Astin, A. W. (1999). Student involvement: A developmental theory for higher education. *Journal of College Student Development*, *40*(5): 518.

Autor, D. H., Levy, F., & Murnane, R. J. (2003). The skill content of recent technological change: An empirical exploration. *The Quarterly journal of economics*, *118*(4), 1279-1333.

Ayers, L. R., Beyea, S. C., Godfrey, M. M., Harper, D. C., Nelson, E. C., & Batalden, P. B. (2005). Quality improvement learning collaboratives. *Quality Management in Healthcare*, *14*(4), 234-247.

Azzam, A. M. (2009). Why creativity now? A conversation with Sir Ken Robinson. *Educational Leadership*, *67*(1), 22-26.

Bakhshi, H., Downing, J. M., Osborne, M. A., & Schneider, P. (2017). *The future of skills: Employment in 2030.* London: Pearson.

Barab, S., & Dede, C. (2007). Games and immersive participatory simulations for science education: An emerging type of curricula. *Journal of Science Education and Technology*, *16*(1), 1-3.

Barab, S., & Squire, K. (2004). Design-Based Research: Putting a Stake in the Ground. *The journal of the learning sciences*, *13*(1), 1-14.

Baron, S. (2012, March 22). *Cognitive Flow: The Psychology of Great Game Design*. Retrieved from Gamasutra: http://gamasutra.com/view/feature/166972/cognitive_flow_the_psychology_of_.php

Barrows, H. S. (1984). A specific problem-based, self-directed learning method designed to teach medical problem-solving skills, and enhance knowledge retention and recall. In H. G. Schmidt, & M. L. de Volder, *Tutorials in Problem-Based Learning* (pp. 16-32). Assen, the Netherlands: Van Gorcum.

Barrows, H. S. (1996). Problem-based learning in medicine and beyond: A brief overview. In L. Wilkerson, & W. H. Gijselaers, *Bringing Problem-Based Learning to Higher Education: Theory and Practice* (pp. 3-13). San Francisco: Jossey-Bass.

Bartle, R. A. (2004). Virtual worldliness: What the imaginary asks of the real. *New York Law School Law Review*, *49*, 19.

Basadur, M., Graen, G. B., & Green, S. G. (1982). Training in creative problem solving: Effects on ideation and problem finding and solving in an industrial research organization. *Organizational Behavior and Human Performance*, *30*(1), 41-70.

Bateman, B. (2016, September 23). *Fees Commission hears that many matriculants not ready for university*. Retrieved from Eyewitness News:

http://ewn.co.za/2016/09/23/Basic-Education-depart-provides-insight-of-quality-school-leavers

Bentley, T., & Miller, R. (2006). Personalisation: Getting the Questions Right. *Schooling for Tomorrow: personalising education.* Château de la Muette in Paris, France: OECD.

Berdrow, I., & Evers, F. T. (2011). Bases of competence: A framework for facilitating reflective learner-centered educational environments. *Journal of Management Education*, *35*(3), 406-427.

Bergen, D. (2009). Play as the Learning Medium for Future Scientists, Mathematicians, and Engineers. *American Journal of Play*, *1*(4), 413-428.

Bernstein, R. (2015, January 21). *Move Over Millennials -- Here Comes Gen Z. What Marketers Need to Know About the Next Generation of Consumers*. Retrieved from Advertising Age: https://adage.com/article/cmo-strategy/move-millennials-gen-z/296577/

Berr, J. (2016, May 17). *Employers: New college grads aren't ready for workplace*. Retrieved from CBS news: https://www.cbsnews.com/news/employers-new-college-grads-arent-ready-for-workplace/

Bodnar, C. A., Anastasio, D., Enszer, J. A., & Burkey, D. D. (2016). Engineers at Play: Games as Teaching Tools for Undergraduate Engineering Students. *Journal of Engineering Education*, *105*(1) 147-200.

Bottrell, D. (2009). Understanding 'marginal' perspectives towards a social theory of resilience. *Qualitative Social Work*, *8*(3), 321–339.

Boughey, C. (2007). Educational Development in South Africa: From social reproduction to capitalist expansion? *Higher Education Policy*, *20*(1), 5-18.

Boughey, C. (2013). The significance of structure, culture and agency in supporting and developing student learning at South African universities. *Alternative access to higher education: Underprepared students or underprepared institutions*, 62-88.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101.

Bridgstock, R. (2009). The graduate attributes we've overlooked: enhancing graduate employability through career management skills. *Higher Education Research & Development, 28*(1), 31-44.

Brown, J., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*(1), 32-42.

Brown, S. L. (2009a). Discovering the Importance of Play through Personal Histories and Brain Images: An Interview with Stuart L. Brown. *American Journal of Play*, *1*(4), 399-412.

Brown , S. L. (2009b). *Play: How it shapes the brain, opens the imagination, and invigorates the soul.* Penguin.

Bruner, J. (1996). *The culture of education.* London, England: Harvard University Press.

Bucciarelli, L. L., & Kuhn, S. (2018). Engineering Education and Engineering Practice :| Naproving the Fit. In *Between Craft and Science: Technical Work in the United States* (pp. 210-229). Cornell University Press.

Butrymowicz, S. (2017). *Hechinger report: Most colleges enroll many students who aren't prepared for higher education.* Teachers College at Columbia University.

Byanjankar, R. (2016, September 23). *Inductive and Deductive Approach to Research. Difference between Inductive and Deductive Reasoning to Research with figure and Examples.* Retrieved August 30, 2017, from Slideshare.net: https://www.slideshare.net/RohanByanjankar/inductive-and-deductive-approach-to-research-difference-between-inductive-and-deductive-reasoning-to-research-with-figure-and-examples

Case, J. (2011). Knowledge matters: interrogating the curriculum debate in engineering using the sociology of knowledge. *Journal of Education*, *51*(2),

Cbs.com. (2019). *The* Amazing Race *- CBS.com.* Retrieved from https://www.cbs.com/shows/amazing_race/

Chadha, D. (2006). A curriculum model for transferable skills development. *Engineering Education: a Journal of the Higher Education Academy*, *1*(1), 19-24.

Chakrabarty, R. (2016). *India Today*. Retrieved from Only 7 per cent engineering graduates employable: What's wrong with India's engineers? https://www.indiatoday.in/education-today/featurephilia/story/engineering-employment-problems-329022-2016-07-13

Chang, S., & Zhu, N. (2018). 5: 20: 20: 5 EFFICIENCY. *PUPIL: International Journal of Teaching, Education and Learning*, *2*(2).

Council on Higher Education (CHE). (2013). *A proposal for undergraduate curriculum reform in South Africa: The case for a flexible curriculum structure.* Pretoria: Council on Higher Education.

Chickering, A. W., & Ehrman, S. C. (1996). Implementing the seven principles: technology as lever. *AAHE Bulletin*, *49*(2), 3-7.

Choi, J., & Hannafin, M. J. (1995). Situated cognition and learning environments: Roles, structures, and implications for design. *Educational Technology Research and Development*, *43*(2), 53-69.

Clarke, M. (2018). Rethinking graduate employability: The role of capital, individual attributes and context. *Studies in Higher Education*, *43*(11), 1923-1937.

Coghlan, D., & Brannick, T. (2009). *Doing action research in your own organization (Third ed.).* London: Sage.

Colb, P., Confrey, J., DiSessa, A., Lehrer, R., & Schauble, L. (2003). Design Experiments in Educational Research. *Educational Researcher*, *32*(1), 9-13.

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design Research: Theoretical and Methodological Issues. *The Journal Of The Learning Sciences*, *13*(1), 15-42.

Consultancy.uk. (2015). *Generation Y less satisfied than other generations*. Retrieved from Consultancy.uk: http://www.consultancy.uk/news/2061/generation-y-less-satisfied-thanother-generations

Cordova, D. I., & Lepper, M. R. (1993). Intrinsic Motivation and the Process of Learning: Beneficial Effects of Contextualization, Personalization, and Choice. *Journal of Educational Psychology*, *88*(4), 715-730.

Cornelisz, I., & Van Klaveren, C. (2018). Student engagement with computerized practising: Ability, task value, and difficulty perceptions. *Journal of Computer Assisted Learning*, *34*(6), 828-842.

Cranmer, S. (2006). Enhancing graduate employability: best intentions and mixed outcomes. *Studies in Higher Education*, *31*(2), 169-184.

Crappell, C. (2013). Preparing Gen Z Students for Effective Practice. *American Music Teacher*, *63*(1), 12-17.

Crawford, C. (2003). *Chris Crawford on game design.* Indianapolis, IN: New Riders Publishing.

Creswell, J. W. (2007). *Qualitative inquiry & research design: Choosing Among Five Approaches (2nd ed).* Thousand Oaks, CA: Sage.

Creswell, J. W. (2008). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research (3rd ed.).* Upper Saddle River, NJ: Pearson Education.

Creswell, J. W. (2009). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, third edition.* United States of America: Thousand Oakes, CA: Sage.

Creswell, J. W. (2013). *Qualitative inquiry and research design : Choosing among five traditions (3rd. ed.).* Thousand Oaks, CA: Sage.

Cronje, J. C. (2018). Learning 3.0: Rhizomatic Implications for Blended Learning. In K. A. Persichitte, A. Suparman, M. Spector, & eds, *Educational Technology to Improve Quality and Access on a Global Scale* (pp. 9-20). Springer, Cham.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal performance.* New York, NY: Harper and Row.

Csikszentmihalyi, M. (2008). *Flow: The Psychology of Optimal Experience.* New York, NY: Harper Perennial Modern Classics.

Csikszentmihalyi, M. (2016, December 16). *Mihaly Csikszentmihalyi: All About Flow & Positive Pssychology*. Retrieved from Positivepsychologyprogram.com: https://positivepsychologyprogram.com/mihaly-csikszentmihalyi-father-of-flow/

Damon, W. (1984). Peer education: The untapped potential. *Journal of Applied Developmental Psychology*, *5*(4), 331–343.

Darling, A. L., & Dannels, D. P. (2003). Practicing engineers talk about the importance of talk: A report on the role of oral communication in the workplace. *Communication Education*, *52*(1), 1-16.

Dathan. (2013). *Equip-graduates-workplace-skills*. Retrieved from The Guardian.com: https://www.theguardian.com/careers/careers-blog/equip-graduates-workplace-skills

De Castro, E. L., Penda, M. T., Dolot, J. A., Laguador, J. M., & Dotong, C. I. (2016). Employers' Feedback on the Job Performance of Computer

Engineering Graduates in an Asian Academic Institution. *Asia Pacific Journal of Education, Arts and Sciences*, *3*(3), 55-61.

de Felix, J. W., & Johnson, R. T. (1993). Learning from video games. *Computers in the Schools*, *9*(2-3), 119-134.

de Freitas, S. (2006a). *Learning in Immersive worlds A review of game-based learning.* London: JISC e-Learning Programme .

De Freitas, S. I. (2006b). Using games and simulations for supporting learning. *Learning, Media and Technology*, *31*(4), 343-358.

De Graaff, E., & Kolmos, A. (2003). Characteristics of Problem-Based Learning. *International Journal of Engineering Education*, *19*(5), 657-662.

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior.* New York, NY: Plenum.

Deci, E.L., & Ryan, R. M. (2002). *Handbook of self-determination research.* Rochester, NY: University of Rochester Press.

Dede, C. (2010). Comparing Frameworks for 21st century Skills. In J. Bellanca, & R. Brandt, *21st century Skills: rethinking how students learn* (pp. 51-76). Bloomington, IN: Solution Tree Press.

Deegan, J., & Martin, N. (2018). *Merging work & learning to develop the human skills that matter.* London: Pearson.

DeJarnette, N. (2012). America's children: Providing early exposure to STEM (science, technology, engineering and math) initiatives. *Education*, *133*(1), 77-84.

Denzin, N. K., & Lincoln, Y. S. (2000). *Handbook of qualitative research.* Thousand Oaks, CA: Sage.

Department of Education, Science and Training, Australia. (DEST). (2002). Employability skills for the future. Canberra: Australia Chamber of Commerce and Industry and the Business Council of Australia for the Department of Education, Science and Training

Department of Higher Education and Training (DHET). (2012). *DHET Green Paper for Post-School Education and Training*. Retrieved from Council on Higher Education and Training: http://www.che.ac.za/media_and_publications/draft-legislation/dhet-green-paper-post-school-education-and-training

Department of Higher Education and Training (DHET). (2013). *National Skills Development Strategy III: Progress Report 2011-2013.* Department of Higher Education and Training.

Desjarlais, M., & Smith, P. (2011). A comparative analysis of reflection and self-assessment. *International Journal of Process Education*, *3*(1), 3-18.

Dewey, J. (1923). *Democracy and education: An introduction to the philosophy of education.* New York, NY: Macmillan.

Doyle, A. (2019, May 11). *These are the Communication Skills Employers look for in Employees*. Retrieved from The Balance Careers: https://www.thebalancecareers.com/communication-skills-list-2063779

Driskell, J. E., & Dwyer, J. D. (1984). Microcomputer videogame based training. *Educational Technology*, *24*(2), 11-16.

Du Plessis, I., & Steyn, T. (2006). Academic survival: experiences of a group of at-risk engineering students in the School of Engineering, University of Pretoria. In *Proceedings of the Conference of the European Society for Engineering Education (SEFI).* Uppsala, Sweden: ResearchGate.

Duderstadt, J. J. (2009). *Engineering for a Changing World: A Roadmap to the Future of Engineering Practice, Research, and Education.* Ann Arbor, MI: The University of Michigan.

Dwyer, S. C., & Buckle, J. L. (2009). The Space Between: On Being an Insider-Outsider in Qualitative Research. *International Journal of Qualitative Methods*, *8*(1), 54-63.

Early Stage Careers. (2018, February 28). *The Numbers Don't Lie: Students Are Unprepared for the Workplace*. Retrieved from Early Stage Careers: https://www.earlystagecareers.com/esc-articles/2018/2/28/the-numbers-dont-lie-students-are-unprepared-for-the-workplace

EduConnect. (2018). Retrieved from Upgrade your Matric Mark with a Bridging Course : Your Bibliography: EduConnect. (2018). Upgrade your Matric Mark with a Bridging Course https://educonnect.co.za/bridging-courses-bridging-gap-high-school-varsity/

Elmore, T. (2014, October 15). *Contrasting Generation Y and Z*. Retrieved from HuffPost: Parents: https://www.huffpost.com/entry/contrasting-generation-y_b_5679434?ec_carp=4340581423813008686

ENGAGE Student Guide. (2018). *ENGAGE Student Guide*. Pretoria, South Africa: University of Pretoria.

Engelbrecht, J., Harding, A., & Potgieter, M. (2014). Evaluating the Success of a Science Academic Development Programme at a Research-intensive University. *African Journal of Research in Mathematics, Science and Technology Education (SAARMSTE)*, *18*(3), 287–298. http://dx.doi.org/10.1080/10288457.2014.962726.

Engineering Council of South Africa (ECSA). (2017). *Professional Development: Development Process*. Retrieved from Engineering Council of South Africa: https://www.ecsa.co.za/prodevelopment/SitePages/Development%20Proce ss. aspx

English, T. (2016). *Understanding What Makes Enginees Tick: 5 Common Personality Traits*. Retrieved from The Short Sleeve and Tie Club: http://shortsleeveandtieclub.com/understanding-what-makes-engineers-tick-5-common-personality-traits/

Ennis, R. (1987). A taxonomy of critical thinking dispositions and abilities. In J. Baron, & R. Sternberg, *Teaching Thinking Skills: Theory and Practice.* New York,NY: W.H.Freeman.

Erickson, F. (1986). Qualitative Methods in Research on Teaching. In M. C. Wittrock, *Handbook of Research on Teaching (3rd ed.)* (pp. 119-161). New York: Macmillan.

Erikson, M. G., & Erikson, M. (2018). Learning outcomes and critical thinking–good intentions in conflict. *Studies in Higher Education*, 1-11.

Ernst, E. W. (1996). Workplace Changes And Engineering Education Reform. *Proceedings, 1996 Frontiers in Education Conference.* Institute of Electrical and Electronic Engineers.

Explora School of Design and Technology. (2017, May 22). *The 21st century Education.* Retrieved from XPlora Design Skool: http://xdsindia.com/blog/?p=964

Facione, P. A. (2011). Critical thinking: What it is and why it counts. *Insight assessment*, *2007*(1), 1-23.

Feagin, J. R., Orum, A. M., & Sjoberg, G. (1991). *A Case for the Case Study.* Chapel Hill & London: The University of North Carolina.

Figueroa-Flores, J. F. (2016). Gamification and Game-Based Learning: Two Strategies for the 21st century Learner. *World Journal of Educational Research*, *3*(2), 507-522.

Fisher, A. (2011). *Critical thinking: An introduction.* Cambridge university press.

Fisher, K. W. (1980). A Theory of Cognitive Development: The Control and Construction of Hierarchies of Skills. *Psychological Review*, *87*(6), 477-531.

Flick, U. (2011). *Designing Qualitative Researc.* London: Sage.

Flick, U. (2014). *The sage handbook of qualitative data analysis.* London: Sage..*Foundation Programmes*. (2018). Retrieved from Heltasa: http://heltasa.org.za/foundation-programmes/

Fredrickson, B. L., & Joiner, T. (2002). Positive emotions trigger upward spirals toward emotional well-being. *Psychological science*, *13*(2), 172-175.

Frey, C. B., & Osborne, M. A. (2017). The future of employment: How susceptible are jobs to computerisation? *Technological forecasting and social change*, *114*, 254-280.

Friedman, T. L. (2006). *The world is flat: A brief history of the twenty-first century.* New York, NY: Farrar, Straus and Giroux.

Funke, J., Fischer, A., & Holt, D. V. (2018). Competencies for complexity: problem solving in the twenty-first century. In *Assessment and teaching of 21st century skills* (pp. 41-53).New York, NY: Springer, Cham.

Gabriel, D. (2013, March 17). *Inductive and deductive approaches to research* | | *Dr Deborah Gabriel*. Retrieved August 30, 2017, from Deborahgabriel.com: http://deborahgabriel.com/2013/03/17/inductive-and-deductive-approaches-to-research/

Gardner, D. (2000). Self-assessment for autonomous language learners. *Links & Letters*, *7*, 049-60.

Garris, R., & Ahlers, R. (2001, December). A game-based training model: development, application, and evaluation. *Interservice/Industry Training, Simulation & Education.* Orlando, FL.

Garris, R., Ahlers, R., & Driske, J. E. (2002). Games, Motivation, and Learning: A Research and Practice Model. *Simulation & Gaming*, *33*(4), 441-467.

Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in Entertainment (CIE)*, *1*(1), 20-20.

Gee, J. P. (2005). Learning by Design: good video games as learning machines. *E–Learning*, *2*(1), 5-16.

Gijselaers, W. H. (1996). Connecting problem-based practices with educational theory. *New directions for teaching and learning*, *1996*(68), 13-21.

Giunta, C. (2017). An Emerging Awareness of Generation Z Students for Higher Education Professors. *Archives of Business Research*, *5*(4), 90-104.

Glesne, C. (2006). *Becoming qualitative researchers: An introduction* (3rd ed.). Boston, MA: Pearson.

Gorard, S., Roberts, K., & Taylor, C. (2004). What kind of creature is a design experiment? *British Educational Research Journal*, *30*(4), 577-590.

Gözükara, İ., & Çolakoğlu, N. (2016). A research on generation Y students: Brand innovation, brand trust and brand loyalty. *International Journal of Business Management and Economic Research*, *2*(7), 603-611.

Grayson, D. (2010). ENGAGE: An extended degree program at the University of XX in South Africa. *2010 American Society for Engineering Education Annual Conference and Exposition*, (pp. 15.465.1-15.465.11). Louisville, Kentucky.

Grayson, D. (2010). *The Engineering Augmented Degree Programme: increasing access and success in engineering.* Retrieved from Community development: Innovate 4: http://www.up.ac.za/media/shared/Legacy/sitefiles/file/44/1026/2163/8121/theengineeringaugmenteddegreeprogrammeincreasingaccessandsuccessinengineering.pdf

Greener, S. (2008). *Business research methods.* London: BookBoon.

Griesel, H., & Parker, B. (2009). *Higher education South Africa and the South African qualifications authority*. Retrieved from Graduate attributes: http://www.saqa.org.za/docs/genpubs/2009/graduate_attributes.pdf

Guba, E., & Lincoln, Y. (1989). *Fourth generation evaluation.* Newbury Park, CA: Sage.

Halpern, D. F. (1999). Teaching for critical thinking: Helping college students develop the skills and dispositions of a critical thinker. *New directions for teaching and learning*, *1999*(80), 69-74.

Hetton, N., & Smith, D. (1994). Facilitating Reflection: Issues andResearch. *Conference of the Australian Teacher Education Association*, (pp. 1-23). Brisbane, Queensland, Australia.

Hitchcock, D. (2018, July 21). *Critical thinking.* Retrieved from The Stanford Encyclopedia of Philosophy (Fall 2018 Edition), Edward N. Zalta (ed.): https://plato.stanford.edu/archives/fall2018/entries/critical-thinking/

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: a response to Kirschner, Sweller, and. *Educational psychologist*, *42*(2), 99-107.

Hromek, R., & Roffey, S. (2009). Promoting Social and Emotional Learning With Games: “It’s Fun and We Learn Things”. *Simulation & Gaming*, *40*(5), 626-644.

Huizinga, J. (1949). *Homo ludens: A study of the play-element in culture (International library of sociology and social reconstruction. london).* London: Routledge & K. Paul.

Huizinga, J. (1955). *Homo ludens: A study of the play-element in culture.* Boston, MA: Beacon.

Hunicke, R., LeBlanc, M., & Zubek, R. (2004, July). MDA: A formal approach to game design and game research. In *Proceedings of the AAAI Workshop on Challenges in Game AI*, (Vol 4, No. 1, p. 1722).

Hussin, A. A. (2018). Education 4.0 made simple: Ideas for teaching. *International Journal of Education and Literacy Studies*, *6*(3), 92-98.

Igel, C., & Urquhart, V. (2012). Generation Z, meet cooperative learning: Properly implemented cooperative learning strategies can increase student engagement and achievement. *Middle school journal*, *43*(4), 16-21.

Isaacs, S. (2015, January 15). *The Difference between Gamification and Game-Based Learning*. Retrieved from ASCD in Service: http://inservice.ascd.org/the-difference-between-gamification-and-game-based-learning/

Isidori, E., Chiva-Bartoll, O., Fazio, A., & Sandor, I. (2018). Flipped Classroom in Physical Education: Pedagogical Models and Possible Implementation through Web 2.0. *The International Scientific Conference eLearning and Software for Education* (Vol. 3, pp. 274-279). " Carol I" National Defence University.

Jääskelä, P., Nykänen, S., & Tynjälä, P. (2018). Models for the development of generic skills in Finnish higher education. *Journal of Further and Higher Education*, *42*(1), 130-142.

Janesick, V. J. (2000). The choreography of qualitative research design. In N. K. Denzin, & Y. S. Lincoln, *Handbook of qualitative research (2nd edition)* (pp. 379-399). Thousand Oaks, CA: Sage.

Jenkins, R. (2015, June 9). *15-aspects-that-highlight-how-generation-z-is-different-from-millennials-*. Retrieved from Business2community.com: https://www.business2community.com/social-data/15-aspects-that-highlight-how-generation-z-is-different-from-millennials-01244940

Johnson, D. W., & Johnson, R. T. (1979). Conflict in the classroom: Controversy and learning. *Review of Educational Research*, *49*(1), 51-70.

Jonassen, D. H. (1997). Instructional design models for well-structured and ill-structured problem-solving learning outcomes. *Educational technology research and development*, *45*(1), 65-94.

Jonasson, D., Strobel, J., & Lee, C. B. (2006). Every day problem solving in Engineering: Lessons for Engineering Educators. *Journal of Engineering Education*, *95*(2), 139-151.

Juul, J. (2003). The game, the player, the world: Looking for aheart of gameness. *Proceedings of Level-Up: Digital games research conference. M. Coupier and J. Raessens* (eds.) (pp. 30-45). Utrecht: University of Utrecht.

Kaplan, R. (1998). Innovation action research: Creating new management theory and practice. *Journal of Management Accounting Research*, *10*, 89.

Kapp, K. (2014). *GAMIFICATION: Separating Fact From Fiction*. Retrieved from CLOmedia.com: http://ww.w.cedma-europe.org/newsletter%20articles/Clomedia/Gamification%20-%20Separating%20Fact%20from%20Fiction%20(Mar%2014).pdf

Keller, J. M. (1987). Development and use of the ARCS model of instructional design. *Journal of instructional development*, *10*(3), 2-10.

Kennedy, T. J., & Odell, M. R. (2014). Engaging students in STEM education. *Science Education International*, *25*(3), 246-258.

Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *Internet and Higher Education*, *8*(1), 13-24.

Kirillova, A. V., Vinichenkoa, M. V., Melnichuka, A. V., Melnichuka , Y. A., & Vinogradovaa , M. V. (2016). Improvement in the learning environment through gamification of the educational process. *International Electronic Journal of Mathematics Education*, *11*(7), 2071-2085.

Kirk, J., & Miller, M. (1986). *Reliability and validity in qualitative research (Qualitative research methods, v. 1).* Beverly Hills,CA: Sage.

Knowles, M. (1984). *The Adult Learner. A Neglected Species.* Houston, TX: Gulf.

Kode, S., & Sutinen, E. (2017, April). Enhancing Computing Education in India: a design story. In *2017 International Conference on Learning and Teaching in Computing and Engineering (LaTICE)* (pp. 82-86). IEEE.

Kolb, D. A. (2014). *Experiential learning: Experience as the source of learning and development.* London: FT press.

Koster, R. (2005). *A theory of fun for game design.* Scottsdale, AZ: Paragylph Press.

Koster, R. (2014). *A theory of fun for game design* (Second ed.). Sebastopol, CA: O'Reilly Media.

Kothari, C. R. (2004). *Research Methodology. Methods and techniques* (2nd ed.). New Delhi: New Age International Publishers.

Kowal, S., & O'Connell, D. C. (2014). Transcription as a Crucial Step of Data Analysis. In U. Flick, *The sage handbook of qualitative data analysis* (pp. 64-77). London: Sage.

Kozinsky, S. (2017, July 24). *How Generation Z Is Shaping The Change In Education*. Retrieved from Forbes: https://www.forbes.com/sites/sievakozinsky/2017/07/24/how-generation-z-is-shaping-the-change-in-education/#7bb026386520

Kraak, A., Jewison, R., Pillay, P., Chidi, M., Bhagwan, N., & Makgolane, M. (2013). *Review of the current skills development system and recommendations towards the best model for delivering skills in the country.* Human Resource Development Council.

Krippendorff, K. (2019). *Content analysis : An introduction to its methodology* (Fourth ed.). Los Angeles, CA: Sage.

Kronisch, C. (2016). *Gamification – Concepts and Theories.* Retrieved from https://www.academia.edu/24042745/Gamification_Concepts_and_Theories?email_work_card=view-paper

Kruss, G. (2002). Employment and employability: expectations of higher education responsiveness. *Relations between Higher Education and the Labour Market* (pp. 59-107). Sandton: CHE.

Kuh, G. D. (1994). *Student Learning Outside the Classroom: Transcending Artificial Boundaries.* ASHE-ERIC Higher Education Report No. 8.

Kuh, G. D., Cruce, T. M., Shoup, R., Kinzie, J., & Gonyea, R. M. (2008). Unmasking the effects of student engagement on first-year college grades and persistence. *The journal of higher education*, *79*(5), 540-563.

Kuh, G. D. Douglas, KB, Lund, JP, Ramin-Gyumek, J. (1994). Student learning outside the classroom: Transcending artificial boundaries. *ASHE-ERIC Higher Education Report*, (8).

Laal, M., Laal, M., & Kermanshahi, Z. K. (2012). 21st century learning; learning in collaboration. *Procedia-Social and Behavioral Sciences*, *47*, 1696-1701.

Lau, L. K. (2003). Institutional factors affecting student retention. *Education*, *124*(1), 126-136.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge university press.

Lavrakas, P. J. (2008). *Encyclopedia of Survey Research Methods (Sage research methods online).* Thousand Oaks, Calif.: Sage.

Lebow, D. (1993). Constructivist Values for Instructional Systems Design: Five Principles toward a New Minds. *Educational Technology Research and Development*, *41*(3), 4-16.

Lepper, M. R., & Cordova , D. I. (1992). A Desire to Be Taught: Instructional Consequences of Intrinsic Motivation. *Motivation and Emotion*, *16*(3), 187-208.

Levine, M., Jankovic, I. N., & Pali, M. (1982). Principles of Spatial Problem Solving. *Journal of Experimental Psychology: General*, *3*(2), 157-175.

Levin-Goldberg, J. (2012). Teaching Generation TechX with the 4Cs: Using Technology to Integrate 21st century Skills. *Journal of Instructional Research*, *1*, 59-66.

Levy, F., & Murnane, R. J. (2004). *The new division of labor: How computers are creating the next job market.* Princeton, NJ: Princeton University Press.

Lichtman, M. (2013). *Qualitative research for the social sciences.* Thousand Oakes, CA: Sage.

Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology*, *22*, 5-55.

Lincoln, Y. S. , & Guba, E. G. (1985). *Naturalistic inquiry.* Beverly Hills, CA: Sage.

Lincoln, Y. S., & Guba, E. G. (2009). The Only Generalization Is: There Is No Generalization. In R. Gromm, M. Hammersley, & P. Foster, *Case Study Method* (pp. 27-44).

Loewenstein, G. (1994). The Psychology of Curiosity: A Review and Reinterpretation. *Psychological Bulletin*, *116*(1), 75-98.

Longhofer, J., Floersch, J., & Hartmann, E. (2017). A Case for the Case Study: How and Why They Matter. *Clinical Social Work Journal*, *45*, 189–200.

Loveland, E. (2017). Instant generation. *Journal of college admission*, *235*, 34-38.

Luhmann, N. (1992). What is communication? *Communication theory*, *2*(3), 251-259.

Maas, T., Jochim, A., & Gross, B. (2018). Mind the Gap: Will All Students Benefit from 21st century Learning? *Center on Reinventing Public Education*.

Mallory, S. R., & Guadagno, R. (2016). Persuasive Play: Persuasion, Games and Education. *Academia*.

Malone, T. W. (1981). Toward a theory of intrinsically motivating instruction. *Cognitive science*, *5*(4), 333-369.

Malone, T. W., & Lepper, M. R. (1987). Making learning fun: A Taxonomy of intrinsic motivations for learning. In R. E. Snow, & M. J. Farr, *Aptitude, learning, and instruction III. Conative and affective analyses* (pp. 223-253). Hillsdale, NJ: Erlbaum.

ManpowerGroup. (2016). *The talent shortage survey*. Retrieved from ManpowerGroup: https://go.manpowergroup.com/talent-shortage

Maree. (2007). *First steps in research.* Pretoria: Van Schaik Publishers.

Marsick, V. J., & Watkins, K. E. (2001). Informal and incidental learning. *New directions for adult and continuing education*, *2001*(89), 25-34.

Martin, J. (2007). The 17 great challenges of the twenty-first century. *Futurist*, *41*(1), 20-24.

Mason, G., Williams, G., & Cranmer, S. (2009). Employability Skills Initiatives in Higher Education: What Effects Do They Have on Graduate Labour Market Outcomes? *Education Economics, 17*(1), 1-30.

Mathews, H., & McKay, R. (2003). Identifying essential learning skills in students' Engineering education. *Research and Development in Higher Education: Learning for an Unknown Future* (p. vol 26). Hammondville: Higher Education Research and Development Society of Australasia.

Maxwell, J. A. (2002). Understanding and Validity in Qualitative Research. In A. Huberman, & M. Miles, *The Qualitative Researcher's Companion* (pp. 36-62). Thousand Oaks, CA: Sage.

Maykut, P., & Morehouse, R. (1994). *Beginning qualitative researchers: A philosophical and practical.* Washington, DC: Falmer.

McCarter, W. M. (2019, September 27). *Colleges Aren't Graduating Critical Thinkers*. Retrieved from Medium predict: https://medium.com/predict/colleges-arent-graduating-critical-thinkers-3a3036115837

McGonical, J. (2011). *Reality Is Broken - Why Games Make Us Better and How They Can Change the World .* New York, NY: The Penguin Press.

McKenney, S., & Reeves, T. (2014). Educational Design Research. In J. Spector, M. Merrill, J. Elen, & M. Bishop, *Handbook of Research on Educational Communications and Technology* (pp. 131-140). New York, NY: Springer Science + Business Media.

McLellan, H. (1996). *Situated learning perspectives.* Englewood Cliffs, NJ: Educational Technology Publications, Inc.

McNiff, J., & Whitehead, J. (2010). *You and your action research project* (third edition). New York, NY: Routledge.

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research : a guide to design and implementation (Fourth ed., The Jossey-Bass higher and adult education series).* San Francisco, CA: John Wiley & Sons.

Mertens, D. (2018). Ethics of Qualitative Data Collection. In U. Flick, *The Sage handbook of qualitative data collection* (pp. 33-48). London: Sage.

Merton, R. K., & Kendall, P. L. (1946). The focused interview. *American journal of Sociology*, *51*(6), 541-557.

Meyers, N. M., & Nulty, D. D. (2009). How to use (five) curriculum design principles to align authentic learning environments, assessment, students' approaches to thinking and learning outcomes. *Assessment & Evaluation in Higher Education*, *34*(5), 565-577.

Miller, C. R. (1996). Communication in the 21st century: The original liberal art in an age of science and technology. *Center for Communication in Science, Technology, and Management*, 1-7.

Mittelmeier, J., Rienties, B., Tempelaar, D., & Whitelock, D. (2018). Overcoming cross-cultural group work tensions: mixed student perspectives on the role of social relationships. *Higher Education*, *75*(1), 149-166.

Montola, M. (2011). A ludological view on the pervasive mixed-reality game research paradigm. *Personal and Ubiquitous Computing*, *15*(1), 3-12.

Moreau, L. (2003). Leaderless coordination via bidirectional and unidirectional time-dependent communication. *Proceedings of the 42nd IEEE Conference on Decision and Control*, (pp. 3070-3075). Maui.

Morgan, D. L., & Hoffman, K. (2018). Focus Groups. In U. Flick, *The Sage handbook of qualitative data collection* (pp. 250-263). London: Sage.

Morreale, S. P., & Pearson, J. C. (2008). Why Communication Education is Important: The Centrality of the Discipline in the 21st century . *Communication Education*, *57*(2), 224-240.

Moye, J. J., Dugger Jr, W. E., & Starkweather, K. (2018). Learn better by doing. *Technology and Engineering Teacher*, *77*(7), 49.

Murali, S., & Rajaram, Y. (2015). A Study on the Corporate Expectations from Engineering Graduates in India – Bangalore. *IOSR Journal of Business and Management (IOSR-JBM)* , *17*(6) Version III: 01-09.

Mybroadband.co.za. (2018, January 5). *South Africa's real 2017 Matric pass rate – 39.25%*. Retrieved from Mybroadband.co.za: https://mybroadband.co.za/news/government/243498-south-africas-real-2017-matric-pass-rate-39-25.html

National Research Council. (2002). *Learning and understanding: Improving advanced study of mathematics and science in US high schools.* National Academies Press.

National Research Council. (2013). *Education for life and work: Developing transferable knowledge and skills in the 21st century .* National Academies Press.

NCREL & Metiri Group. (2003). *enGauge 21st century skills: Literacy in the digital age.* Chicago: North Central Regional Educational Laboratory.

NCREL. (2003). *enGauge 21st century Skills: Helping Students Thrive in the Digital Age.* Retrieved from enGauge 21st century Skills for 21st century Learners: www.ncrel.org/engauge

New York Film Academy. (2015, February 12). *New York Film Academy: Student Resources*. Retrieved from 6 Elements That Make A Good Multiplayer Game: https://www.nyfa.edu/student-resources/6-elements-make-good-multiplayer-game/

Niman, N. (2014). *The Gamification of Higher Education. Developing a Game-Based Business Strategy in a Disrupted Marketplace.* New York, NY:Springer.

Nisula, A., & Kianto, A. (2016). Group climate and creativity in temporary innovation camp settings. *Creativity and Innovation Management*, *25*(1), 157-171. https://doi.org/10.1111/caim.12168.

Norman, D. A. (1993). *Things that make us smart: Defending human attributes in the age of the machine.* Reading, MA.: Addison-Wesley Pub. Co.

Norton, L. (2018). *Action research in teaching and learning: A practical guide to conducting pedagogical research in universities*: Routledge.

Novak, J. D. (2010). *Learning, creating, and using knowledge: Concept maps as facilitative tools in schools and corporations.* New York, NY: Routledge.

Oblinger, D. (2004). The next generation of educational engagement. *Journal of interactive media in education*, *2004*(1).

Oblinger, D., Oblinger, J. L., & Lippincott, J. K. (2005). *Educating the Net Generation.* Boulder, CO.: EDUCAUSE

Onwuegbuzie, A. J., Dickinson, W. B., Leech, N. L., & Zoran, A. G. (2009). A qualitative framework for collecting and analyzing data in focus group research. *International journal of qualitative methods*, *8*(3), 1-21.

Organisation for Economic Co-operation and Development (OECD). (2005). *The definition and selection of key competencies: Executive summary.* Paris: OECD

Osmani, M., Weerakkody, V., Hindi, N. M., Al-Esmail, R., Eldabi, T., Kapoor, K., & Irani, Z. (2015). Identifying the trends and impact of graduate attributes on employability: a literature review. *Tertiary Education and Management*, *21*(4), 367-379.

O'Toole, S., & Essex, B. (2012). The adult learner may really be a neglected species. *Australian Journal of Adult Learning*, *52*(1), 183-191.

Ozcelik, E., Cagiltay, N. E., & Ozcelik, N. S. (2013). The effect of uncertainty on learning in game-like environments. *Computers & Education*, *67*, 12-20.

P21. (2015). *Framework for 21st century Learning*. Retrieved from Partnership for 21st century Learning: http://www.p21.org/about-us/p21-framework

Palmer, D. (2005). A Motivational View of Constructivist-informed Teaching. *International Journal of Science Education*, *27*(15), 1853–1881.

Patton, M. Q. (2015). *Qualitative research & evaluation methods: integrating theory and practice.* Thousand Oaks, CA: Sage.

Pegg, A., Waldock, J., Hendy-Isaac, S., & Lawton, R. (2012). *Pedagogy for employability*. Retrieved from https://www.heacademy.ac.uk/sites/default/files/ped agogy_for_employability_update_2012.pdf>

Perrenet, J. C., Bouhuijs, P. A. J., & Smits, J. G. M. M. (2000). The suitability of problem-based learning for engineering education: theory and practice. *Teaching in higher education*, *5*(3), 345-358.

Peshkin, A. (1988). In search of subjectivity—one's own. *Educational researcher*, *17*(7), 17-21.

Piaget, J. (1964). Part I: Cognitive development in children: Piaget development and learning. *Journal of research in science teaching*, *2*(3), 176-186.

pICT. (2003). *21st century Skills Framework.* Retrieved from PICT Division of undergraduate studies: https://pict.sdsu.edu/21st.html

Pinnock, R. (2013, September 5). *SA education system is failing pupils, economy*. Retrieved from Cape Times: https://www.iol.co.za/capetimes/sa-education-system-is-failing-pupils-economy-1573771

Pintrich, P. R. (2000). Multiple goals, multiple pathways: The role of goal orientation in learning and achievement. *Journal of educational psychology*, *92*(3), 544-555.

Pivec, M., & Dziabenko, O. (2004). Game-Based Learning in Universities and Lifelong Learning: “UniGame: Social Skills and Knowledge Training” Game Concept1. *Journal of Universal Computer Science*, *10*(1), 14-26.

Pivec, M., Dziabenko, O., & Schinnerl, I. (2003, July). Aspects of game-based learning. In *3rd International Conference on Knowledge Management, Graz, Austria* (pp. 216-225).

Plomp, T. (2006). Educational Design Research: a research appoach to address complex problems in educational practice. *The Fifth International Forum on Educational Technology.* Wuhan, China.

Pousson, J., & Myers, K. (2018). Ignatian Pedagogy as a frame for Universal Design in college: Meeting learning needs of Generation Z. *Education Sciences*, *8*(4), 193.

Prensky, M. (2001a). *Digital Game-Based Learning.* New York,NY: McGraw-Hill.

Prensky, M. (2001b). Fun, Play and Games: What Makes Games Engaging. *Digital game-based learning*, *5*(1), 5-31.

Prensky, M. (2001c). Digital Natives, Digital Immigrants. *On the Horizon*, *9*(5), 1-6.

Prensky, M. (2005). Listen to the Natives. *Educational Leadership: Learning in the Digital Age*, *63*(4), 8-13.

Prensky, M. (2006). *Don't bother me, Mom, I'm learning! How computer and video games are preparing your kids for 21st century success and how you can help.* St. Paul, MN: Paragon House.

Prensky, M. (2007). Fun, Play and Games: What Makes Games Engaging. In *Digital Game-Based Learning* (pp 105-199). St. Paul,MN: Paragon House.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of engineering education*, *93*(3), 223-231.

Redecker, C., Leis, M., Leendert, M., Punie, Y., Gijsbers, G., Kirschner, P., . . . Hoogveld, B. (2011). *The Future of Learning: Preparing for Change*. Retrieved from JRC-IPTS: http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=4719

Reed, J., & Koliba, C. (1995). *Facilitating Reflection A Manual for Leaders and Educators.* John Dewey Project on Progressive Education.

Reeves, T. C. (2000). Enhancing the Worth of Instructional Technology Research through “Design Experiments” and Other Development Research Strategies. *SIG/Instructional Technology.* New Orleans, LA: https://pdfs.semanticscholar.org/c25f/2726efbd87f20bc80772bd16ed16ba28111e.pdf.

Reeves, T. C. (2006). Design research from a technology perspective. In J. Van den Akker, K. Gravemeijer, S. McKenney, & N. Nieveen, *Educational design research* (pp. 52-66). London: Routledge.

Republic of South Africa. (2014). Retrieved from Medium Term Strategic Framework (MTSF) 2014-2019: https://www.gov.za/sites/default/files/MTSF_2014-2019.pdf

Rieber, L. P. (1996). Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. *Educational Technology Research & Development*, *44*(2), 43-58.

Rieber, L. P., Smith, L., & Noah, D. (1998). The Value of Serious Play. *Educational Technology*, *38*(6), 29-37.

Robbins, Lord. (1963). *Higher Education, Report of the Committee on Higher Education.* London: HMSO.

Robson, K., Plangger, K., Kietzmann, J. H., & McCarthy, I. (2015). Is it all a game? Understanding the principles of gamification. *Business Horizons*, *58*(4), 411-420.

Rolfe, G. (2002). Reflective practice: where now? *Nurse Education in Practice*, *2*(1), 21-29.

Romero, M., Usart, M., & Ott, M. (2015). Can Serious Games Contribute to Developing and Sustaining 21st century Skills? *Games and Culture*, *10*(2) 148-177.

Rotherham, A. J., & Willingham, D. (2009). 21st century . *Educational leadership*, *67*(1), 16-21.

Roulston, K., & Choi, M. (2018). Qualitative Interviews. In U. Flick, *The sage handbook of qualitative data collection* (pp. 233-249). London: Sage Publications. Retrieved March 24, 2019, from http://methods.sagepub.com.uplib.idm.oclc.org/book/the-sage-handbook-of-qualitative-data-analysis.

Saad, M. S., & Majid, I. A. (2014). Employers' perceptions of important employability skills required from Malaysian engineering and information and communication technology (ICT) graduates. *Global Journal of Engineering Education*, *16*(3), 110-115.

Sailer, M., Hense, J., Mandl, H., & Klevers, M. (2013). Phsycological Perspectives on Motivation through Gamification. *Interaction Design and Architecture(s) Journal-IxD&A*, *19*, 28-37.

Salkind, N. J. (2010). *Encyclopedia of Research Design.* Accessed online on 20 March 2019 at http://methods.sagepub.com.uplib.idm.oclc.org/reference/encyc-of-research-design/n78.xml.

Saunders, M., & Tosey, P. (2012). *The Layers of Research Design*. Retrieved August 25, 2017, from www.academia.edu/4107831: www.academia.edu/4107831

Savery, J. R., & Duffy, T. M. (2001). *Problem Based Learning: An instructional model and its constructivist framework.* Bloomington: Center for Research on Learning and Technology, Indiana University.

Schofield, J. W. (2002). Increasing the generalizability of qualitative research. In M. A. Huberman, & M. B. Miles, *The qualitative researcher's companion* (pp. 171-203). Thousand Oaks, CA: Sage.

Schön, D. (1987). *Educating the reflective practitioner : Toward a new design for teaching and learning in the professions (1st ed., The jossey-bass higher education series).* San Francisco, CA: Jossey-Bass.

Schön, D. (2004). *The reflective practitioner: How professionals think in action.* New York,NY: Basic Books.

Schwandt, T. (2000). Three Epistemological Stances For Qualitative Inquiry: Interpretivism, Hermeneutics, And Social Constructionism. In N. K. Denzin, & Y. S. Lincoln, *The handbook of Qualitative Research* (pp. 189-213). Thousand Oaks, CA: Sage.

ScienceSation (n .d.) [Image] Mirror Maze 'SciEnza' Science Center Pretoria University. Retrieved from http://scienceation.com/_imagea894.html?album_id=ah1zfmdvb2dsZS1idXNpbmVzcy1zaXRlYnVpbGRlcnIRCxIKUG hvdG9BbGJ1bRjiXQyiAR5zY2llbmNlc2F0aW9uLndvemFvbmxpbmUuY28uemE&image_index=0&pp=home&i=1

Seemiller, C., & Grace, M. (2017). Generation Z: Educating and engaging the next generation of students. *About Campus*, *22*(3), 21-26.

Selingo, J. J. (2018). The New Generation of Students: How Colleges Can Recruit, Teach, and Serve Gen Z*. Chronicle of Higher Education*, 1-5.

Severiens, S., & Schmidt, H. (2009). Academic and social integration and study progress in problem based learning. *Higher Education*, *58*, 59–69.

Shaffer, D. W., Squire, K. R., Halverson, R., & Gee, J. P. (2005). Video games and the future of learning. *Phi Delta Kappan*, *87*(2), 104-111.

Sherer, M., & Eadie, R. (1987). Employability skills: key to success. *Thrust*, *17*(2), 16-17.

Shuman, L. J., Besterfield-Sacre, M., & McGourty, J. (2005). The ABET "professional skills"-Can they be taught? Can they be assessed? *Journal of engineering education*, *94*(1), 41-56.

Sica, L. S., Veneri, A. D., & Miglino, O. (2012). Exploring new technological tools for education: Some prototypes and their pragmatical classification. *Methodologies, Tools and New Developmements for ELearning*, 107-128.

Simons, H. (2009). *Case study research in practice.* Los Angeles, CA: Sage.

Sims, K. (n. d.) [Image] How to make a three pendulum Rotary Harmonograph. Retrieved from https://www.google.com/imgres?imgurl=http://www.karlsims.com/harmonograph/harmonograph.jpg&imgrefurl=http: //www.karlsims.com/harmonograph/&h=905&w=720&tbnid=V6FRhNBtu7ps8M&tbnh=252&tbnw=200&usg=K_pkuzKFyB-FYIkjqd4AczGrmVT5g=&hl=en-ZA&docid=EfjUrq6QfVgWPM

Singh, A. P., & Dangmei, J. (2016). Understanding the Generation Z, the future workforce. *South-Asian Journal of Multidisciplinary Studies*, *3*(3), 1-5.

Slavin, R. E. (1996). Research on cooperative learning and achievement: What we know, what we need to know. *Contemporary educational psychology*, *21*(1), 43-69.

South African Qualifications Authority (SAQA). (2000). Retrieved from The National Qualifications Framework and Curriculum Development : http://www.saqa.org.za/docs/pol/2000/curriculum_dev.pdf

Sowden, P. T., Pringle, A., & Gabora, L. (2015). The shifting sands of creative thinking: Connections to dual-process theory. *Thinking & Reasoning*, *21*(1), 40-60.

Spaull, N. (2013). *South Africa's Education Crisis: The quality of education in South Africa 1994-2011.* Johannesburg: Centre for development & enterprise.

Spradley, J. P. (2016). *Participant observation.* Long Grove, IL:Waveland Press.

Squire, K. (2011). Video games and learning. *Teaching and participatory culture in the digital age*.

Stake, R. E. (2000). Case studies. In N. K. Denzin, & Y. S. Lincoln, *Handbook of qualitative research* (2nd ed.) (pp. 435-454). Thousand Oaks, CA: Sage.

Steyn, T. (2005). Academic support for under-prepared students - does it pay off? *Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition* (pp. 10.120.1 - 10.120.13). American Society for Engineering Education.

Steyn, T., & Du Plessis, I. (2007). Competence in mathematics–more than mathematical skills? *International Journal of Mathematical Education in Science and Technology*, *38*(7), 881-890.

Sweetser, P., & Wyeth, P. (2005). GameFlow: a model for evaluating player enjoyment in games. *Computers in Entertainment (CIE)*, *3*(3), 3-3.

Sweetser, P., Johnson, D., Wyeth, P., & Ozdowska, A. (2012, July). GameFlow heuristics for designing and evaluating real-time strategy games. *Proceedings of the 8th Australasian Conference on Interactive Entertainment: Playing the System*, (p. 1). ACM.

Teed, R. (2018). *Starting Point*. Retrieved from Games: Why use Games to teach?: https://serc.carleton.edu/introgeo/games/whygames.html

Tekinbas, K., & Zimmerman, E. (2003). *Rules of play : Game design fundamentals.* TCambridge, MA.: MIT Press.

The Amazing Race-CBS.com. (n.d.). Retrieved from CBS: https://www.cbs.com/shows/amazing_race

Thiagarajan, S. (1999). Team activities for learning and performance. In H. D. Stolovitch, & E. J. Keeps, *Handbook of Human Performance Technology* (pp. 518-544). San Francisco: JosseyBass/Pfeiffer.

Thijssen, J. G., Van der Heijden, B. I., & Rocco, T. S. (2008). Toward the Employability−−Link Model: Current Employment Transition to Future Employment Perspectives. *Human Resource Development Review*, *7*(2), 165-183.

Thomas, D. R. (2006). A General Inductive Approach for Analyzing Qualitative Evaluation Data. *American Journal of Evaluation*, *27*(2), 237-246.

Thomas, G., & Myers, K. (2015). *The Anatomy of the Case Study.* London: Sage. Retrieved March 18, 2019, from https://us-sagepub-com.uplib.idm.oclc.org/en-us/nam/the-anatomy-of-the-case-study/book237966.

Tomlinson, M. (2018). Conceptions of the value of higher education in a measured market. *Higher Education*, *75*(4), 711-727.

Thompson, C., Sanchez, J., Smith, M., Costello, J., Madabushi, A., Schuh-Nuhfer, N., & Rivers , D. (2018). Improving undergraduate life science education for the biosciences workforce: overcoming the disconnect between educators and industry. *CBE—Life Sciences Education*, *17*(3), es12.

Throndahl, K. L., Velmurugan, G., & Stentoft, D. (2018). The Significance of Problem Analysis for Critical Thinking in Problem-Based Project Work. In A. K. WANG. Sunyu, *7th International Research Symposium on PBL : Innovation, PBL and Competences in Engineering* (pp. 430-439). Aalborg, Danmark: Aalborg Universitetsforlag. International Research Symposium on PBL.

Tinto, V. (2007). Research and practice of student retention: What next? *J.College student retention*, *8*(1), 1-19.

Tong, L. F. (2003). Identifying essential learning skills in students' Engineering education. In *Learning for an Unknown Future, Proceedings of the 26th HERDSA Annual Conference* (p. 388). Christchurch, New Zealand: Higher Education Research and Development Society of Australasia, Inc.

Torr, L. (1991). Academic support in the history department, University of Natal, Durban. In *Proceedings of the 6th Conference of the South African Association for Academic Development.* University of the Witwatersrand, 5-7 December 1991.

Trier, U. (2002). Twelve countries contributing to DeSeCo: A summary report. In D. Rychen, L. Salganik, & M. MaLaughlin, *Definition and selection of key competences. Contributions to the second DeSeCo symposium* (pp. 27-59). Geneva, Switzerland: 11-13 February.

University Of Pretoria. (2018a, November 26). *University of Pretoria appoints new Vice-Chancellor and Principal*. Retrieved from University of Pretoria:

https://www.up.ac.za/news/post_2735543-university-of-pretoria-appoints-new-vice-chancellor-and-principal

University of Pretoria. (2018b). *Hands on science.* Retrieved from http://www.up.ac.za/en/sci-enza-hands-on-science-wetenskap-in-aksie/article/24305/about-us

University of Pretoria, (2018c) *Yearbooks 2018*. Retrieved from University of Pretoria: http://www.up.ac.za/en/yearbooks/2018/programmes/view/12136002

U. S. Department of Labor. (1991). *What work requires of schools: A SCANS report for America 2000.* Washington DC: U.S. Department of Labor. Retrieved from http://wdr.doleta.gov/SCANS/whatwork

U. S.National Academy of Engineering. (2004). *The engineer of 2020. Visions of engineering in the new century.* Washington DC: The National Academic Press.

Van Breda, A. D. (2018). Resilience of vulnerable students transitioning into a South African university. *Higher Education*, *75*(6), 1109-1124.

Van den Akker, J. (1999). Principles and methods of development research. In N. N. J. van den Akker, *Design methodology and developmental research in education and training* (pp. 1-14). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Van den Akker, J., Gravemeijer, K., & McKenney, S. (2006). *Educational design research.* Routledge.

Van Eck, R. (2006). Digital game-based learning: It's not just the digital natives who are restless. *EDUCAUSE review*, *41*(2), 16.

Van Wyk, B. (n. d.). *University of the Western Cape.* Retrieved from Research design and methods Part 1: https://www.uwc.ac.za/Students/Postgraduate/Documents/Research_and_Design_I.pdf

Vandercruysse, S., Vandewaetere, M., & Clarebout, G. (2012). Game-based learning: A review on the effectiveness of educational games. In *Handbook of research on serious games as educational, business and research tools* (pp. 628-647). IGI Global.

Vest, D., Long, M., & Anderson, T. (1996). Electrical engineers' perceptions of communication training and their recommendations for curricular change:

Results of a national survey. *IEEE Transactions on Professional Communication*, *39*(1), 38-42.

Volbrecht, T., & Boughey, C. (2004). Curriculum responsiveness from the margins? A reappraisal of African Development in South Africa. In G. H. (ed.), *Curriculum responsiveness: Case studies in higher education.* Pretoria: South African Universities Vice-Chancellors Association (SAUVCA).

Voogt, J., & Roblin, N. P. (2010). *21st century Skills. Discussienota.* Enschede: Universiteit Twente.

Vygotsky, L. S. (1978). *Mind in society (*M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.).

Wagner, T. (2008). Even our “best” schools are failing to prepare students for 21st century careers and citizenship. *Educational leadership*, *66*(2), 20-25.

Wiedmer, T. (2015). Generations Do Differ: Best Practices in Leading Traditionalists, Boomers, and Generations X, Y, and Z. *Delta Kappa Gamma Bulletin: International Journal for Professional Educators, Austin*, *82*(1), 51-58.

Wikimedia (n.d.) Old Merensky Library, University of Pretoria.jpg. Retrieved from https://commons.wikimedia.org/wiki/File:Old_Merensky_Library,_University_of_Pretoria.jpg

Willig, C. (2014). Interpretation and Analysis1. In U. Flick, *The Sage handbook of qualitative data analysis* (pp. 136-149). London: SAGE.

Wilson , K. A., Bedwell , W. L., Lazzara , E. H., Salas , E., Burke , C. S., Estock , J. L., . . . Conkey , C. (2009). Relationships Between Game Attributes and Learning Outcomes. *Simulation & Gaming*, *40*(2), 217-266.

Wood, S. (2018, August 3). *Recent Graduates Lack Soft Skills, New Study Reports*. Retrieved from Diverse Education: https://diverseeducation.com/article/121784/

Wyman, N. (2018, August 3). *Forbes*. Retrieved from Hiring Is On The Rise, But Are College Grads Prepared For The World Of Work?: https://www.forbes.com/sites/nicholaswyman/2018/08/03/hiring-is-on-the-rise-but-are-college-grads-prepared-for-the-world-of-work/#614383b14e7e

Yin, R. (2014). *Case study research: Design and methods (Fifth ed., Applied social research methods series, v. 5).* Los Angeles, CA: Sage.

Yin, R. K. (1984). *Case study research: design and methods* (1st ed.). Beverly Hills, CA.: Sage.

Yuan, Y., Fu, K., Venter, B. P., & Hainey, T. (2019). Ethics as a Game? Towards a Framework for Game Design. Sociology Mind. *Sociology Mind*, *9*(3), 135-150.

Zaharim, A., Yosoff, Y. M., Omar, M. Z., & Muhamad, N. (2009). Employers' perceptions and expectation toward engineering graduates: a study case. *Proceedings of the 6th WSEAS international conference on Engineering education.* ResearchGate.

9. ANNEXURES

9.1 **ANNEXURE A: INSTRUCTIONS FOR REFLECTIVE ESSAY**

9.2 **ANNEXURE B: GUIDING QUESTIONS FOR THE FOCUS GROUP INTERVIEW**

9.3 **ANNEXURE C: IT PROFICIENCY SURVEY**

9.4 **ANNEXURE D: END OF FIRST SEMESTER SURVEY**

See DVD.