Fostering critical thinking dispositions in the Technology classroom

by

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Submitted in partial fulfilment of the requirements for the degree

Master of Education

Department of Science, Mathematics and Technology Education

Faculty of Education

University of Pretoria

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September 2020

DECLARATION OF ORIGINALITY

I declare that the dissertation, which I hereby submit for the degree Master 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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DEGREE AND PROJECT	MEd Fostering critical thinking dispositions in the Technology classroom
INVESTIGATOR	Ms Joalise Janse van Rensburg
DEPARTMENT	Science, Mathematics and Technology Education
APPROVAL TO COMMENCE STUDY	18 July 2019
DATE OF CLEARANCE CERTIFICATE	08 September 2020

CHAIRPERSON OF ETHICS COMMITTEE: Prof Funke Omidire

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ACKNOWLEDGEMENT

I would like to express my sincere gratitude to the following people who have supported, motivated and guided me during this journey, without you it would not have been possible:

First and foremost I would like to thank my Heavenly Father for providing me with the opportunity, strength, ability and perseverance to complete this research study.

I would like to acknowledge and thank my supervisor, Dr WJ Rauscher, for offering valuable insights, advice and guidance whenever I needed it.

I further acknowledge and thank all my family, friends and colleagues who supported and motivated me during the process.

I would also like to thank Melissa Labuschagne, the language editor, for her professional and diligent work.

Last but certainly not least I want to thank all the teachers and schools who were willing to participate in this study.

ABSTRACT

The purpose of this study was to investigate and describe how technology teachers foster a positive disposition towards Critical Thinking (CT) in their learners. One of the general aims listed in the South African National Curriculum Statement (NCS) specifically calls for the use of CT to enhance learners' ability to identify and solve problems. In the Curriculum and Assessment Policy Statement (CAPS) for technology, CT is required to successfully solve problems during the design process. The design process, which is central to technology, thus offers many opportunities to nurture CT should teachers be willing to exploit them.

CT consists of two components, namely, CT skills and CT dispositions. CT skills refer to the cognitive abilities of a person, while CT dispositions are concerned with an individual's internal motivation to think critically. A fair amount of research regarding CT focuses on CT skills. The limited research available on CT dispositions reports mostly on its definition, classification, and assessment. The paucity of literature on CT dispositions suggest that teachers cannot draw from existing literature to inform their practice regarding the ways in which one could foster a willingness to think critically. This study, therefore, aimed to improve our understanding of the strategies used by technology teachers to promote CT disposition. The conceptual framework for this study was based on Facione's (2011) seven dispositions towards CT, and was augmented by a description of the design process in technology education. The premise for using this framework is based on the assumption that if an individual is positively disposed towards CT, they will be inclined to critically solve the problems encountered during the design process in technology. The design process further presents the opportunity to nurture CT dispositions.

This study engaged in a qualitative research approach and a multiple case study design to investigate how technology teachers foster CT dispositions in their learners. To this end, 10 senior phase technology teachers were purposefully selected and interviewed. The interviews comprised open-ended questions about each disposition to gain an in-depth understanding of the strategies that teachers use in their classroom. Five of these teachers were then observed for one design-based lesson to explore how these strategies are actualised in the technology classroom.

The analysis of the interview data indicated that the participants used a variety of strategies to foster all the CT dispositions. These strategies were also noted during the observations, with no new strategies being revealed. The strategies included the use of assessments, discussions, the classroom environment, examples, feedback, modelling, questioning and resources. It was found that the participants used four main strategies as initial actions that acted as a platform for, or led to the use of supporting strategies to foster all of the CT dispositions.

Through this study, some strategies that were identified in the literature regarding the nurturing of CT, its skills and dispositions were confirmed. Other strategies were identified as relating to the principles for teaching CT dispositions, while two strategies were recognised that were not mentioned in the literature. It is recommended that further research be conducted on the effectiveness of these strategies, learners' experience of the strategies, and that longer periods of observation be done to include the facilitation of the entire design process.

The research on CT dispositions up until this point has not suggested or described explicit strategies to specifically foster the dispositional component of CT. The findings and conclusions of this study are also not considered as the final answer to this paucity of literature, it does, however, pose as a departure point for further investigation and development.

Keywords: technology teachers; technology education; critical thinking; critical thinking dispositions; design process; problem solving.

LANGUAGE EDITING CERTIFICATE

Exclamation Translations

To whom it may concern

The chapter entitled, "Fostering critical thinking dispositions in the technology classroom" has been edited and proofread as of 05 September 2020.

As a language practitioner, I have a Basic degree in Languages, an Honours degree in French and a Master's degree in Assessment and Quality Assurance. I have been translating, editing, proofreading and technically formatting documents for the past 10 years. Furthermore, I am a member of the South African Translators' Institute (SATI) and the Professional Editors' Guild (PEG).

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Kind regards

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1.1 OVERVIEW OF THE CHAPTER

Chapter 1 serves as an introduction to this study, which aimed to explore and describe how technology teachers foster a positive disposition towards Critical Thinking (CT) in their learners. The background and context section provides a brief overview of the concept of CT, and explains its importance in society and educational institutions. It is argued that the development of CT skills and the fostering of CT dispositions are particularly valuable in technology education. This is followed by the problem statement, which highlights the perception that educational systems do not adequately address and develop CT dispositions. The rationale focuses on the deficiency of research on CT dispositions and explains why it should be important for researchers and teachers to have a better understanding of how CT dispositions are fostered in the classroom. The purpose statement and research questions further demarcate the focus of this study. This is followed by a brief discussion of the research design and methodology that guided this study. This chapter is then concluded with a clarification of the key terms and an outline of the remainder of the dissertation.

1.2 BACKGROUND AND CONTEXT

CT is an essential and necessary 21st century skill (Baum Combs, Cennamo & Newbill, 2009; Duran & Şendağ, 2012; Facione, 2000). Being a strong critical thinker enables an individual to compete and exceed in professional environments and address the complex needs of society (Baum Combs et al., 2009). Bass (1997) avers that the purpose of education is to deliver learners who can respond to an ever-changing and developing society to ensure its continued existence. Van Gelder (2005) agrees and adds that one of the primary goals should be to develop learners' ability and willingness to think critically. For this reason, educational institutions must teach CT to develop citizens who will be active and capable participants in society (Facione, 2000; Van Gelder, 2005; Yang & Chou, 2008).

Facione (2011) explains that CT consists of two components, namely, CT skills and CT dispositions. There is a general consensus that CT, its skills and dispositions,

should be taught, practised, and developed in educational environments (Aizikovitsh-Udi & Cheng, 2015; Kezer & Turker, 2012; Zhang, 2003). In keeping with this consensus, one of the general aims listed in the South African National Curriculum Statement (NCS) specifically calls for the use of CT to enhance learners' ability to identify and solve problems (Department of Basic Education, 2011). Problem solving is an activity and process in which CT is required for the successful generation of viable solutions (Bailin, Case, Coombs, & Daniels, 1999; Halpern, 2014). Problem situations are evident in all aspects of everyday life (Dostál, 2015), and are therefore relevant in all school subjects, including technology.

The design process forms the backbone of technology education as it provides a structure for the teaching and learning of knowledge and skills in the subject (DBE, 2011; Schooner, Nordlöf, Klasander & Hallström, 2017). Problem solving is considered a major component of the design process (Burghardt & Hacker, 2004; Ohemeng-Appiah, 2014). This suggests that CT is vital in the technology classroom to solve problems during the design process (Ohemeng-Appiah, 2014; Schooner et al., 2017). The nature of technology as a subject therefore presents an opportunity for the successful teaching and development of CT. This makes it an ideal environment to investigate how CT is taught and, more specifically in terms of this study, how Grades 8 and 9 technology teachers foster a positive disposition towards CT in their classrooms.

1.3 Problem Statement

Bouygues (2018) finds that society believes schools and educational institutions do not provide enough instruction in CT. Vieira, Tenreiro-Vieira and Martins (2011) are of the opinion that formal education does not effectively foster or adequately address the development of CT. It is possible that people are able to think critically, yet the application and use of CT skills are not evident in society (Facione, 2011; Tishman, Jay, & Perkins, 1993).

Research regarding CT generally focuses on CT skills (Dwyer, Hogan, Harney & Kavanagh, 2017). Some researchers have investigated CT dispositions (Nieto & Saiz, 2011; Van Gelder, 2005; Yang & Chou, 2008), but the literature available is still limited. CT skills are concerned with an individual's cognitive capabilities, while CT

dispositions are concerned with an individual's willingness to think critically (Ennis, 1996; Facione, 2015). To ensure the use of CT skills outside of an instructional environment, it is important to develop a positive disposition towards CT (Facione, Sánchez, Facione & Gainen, 1995; Hendrix, 1999). Teachers, therefore, face the challenge of finding ways to develop learners' disposition towards CT so that they are willing to think critically and use CT skills outside the classroom (Facione, Facione & Giancarlo, 1996).

The Curriculum and Assessment Policy Statement (CAPS) for technology offers many opportunities to foster CT dispositions during the design process. However, a teacher must be willing and committed to exploit these opportunities to foster CT dispositions in the technology classroom (Baum Combs et al., 2009). While the literature mentions some theoretical strategies focussing on the development of CT as a whole (Ennis, 1996; Facione, 2000; Halpern, 2014; Van Gelder, 2005; Yang & Chou, 2008), no accounts were found on the actualisation of CT dispositions in a classroom. The problem therefore is that that teachers cannot draw from existing literature to inform their practice regarding the ways in which one could foster a willingness to think critically.

1.4 RATIONALE AND SIGNIFICANCE

The ability to use CT skills and the dispositions to do so is considered a desirable and essential outcome of education (Abrami et al., 2009; Facione et al., 1996). CT is also deemed a vital part of technology education and problem solving (Schooner et al., 2017). Consequently, it is listed as one of the general aims and is mentioned as part of the subject purpose in the South African NCS for technology (DBE, 2011). The teaching and fostering of CT is therefore regarded as important to technology teachers and educational researchers (Schooner et al., 2017). Ennis (1996) and Halpern (2014) emphasise the importance of not only teaching the theory and skills behind CT, but also cultivating a willingness to use them. A positive disposition towards CT is essential to ensure the behavioural component of CT (Nieto & Saiz, 2011). This internal motivation to think critically does, however, require some amount of instruction in the classroom for its successful development (Halpern, 2014; Nieto & Saiz, 2011).

There is a paucity of research regarding the way in which technology teachers foster a positive disposition towards CT. Yang and Chou (2008) note that many researchers have urged for investigations into CT dispositions. However, researchers answering this call have mostly provided literature regarding its definition, classification and assessment (Yang & Chou, 2008). It is therefore important for educational researchers to further investigate how CT dispositions are, and can be fostered in the technology classroom. This may provide a greater understanding of the strategies that are used in technology classrooms, which could ideally be formalised into teaching guidelines to improve the fostering of CT dispositions. These strategies could also inform and improve teacher training and professional development. This could further enable technology teachers to help learners with problem solving during the design process and could improve the learning and acquisition of CT dispositions in learners. This might prove useful in our 21st century society to improve the use of CT outside educational environments.

1.5 Purpose of the study

The purpose of this study was to explore and describe how technology teachers foster learners' disposition towards CT in their classroom. This study aims to contribute to the emerging body of literature concerning CT dispositions to enhance our understanding of the strategies currently used in technology classrooms. An in-depth understanding of how teachers describe the strategies they use to foster CT dispositions and how these strategies actualise in the technology classroom could add to this emerging body of literature.

1.6 Research questions

The main research question posed in this study was:

- How do technology teachers perceive and actualise the fostering of critical thinking disposition in their classroom?

The following sub-questions guided the inquiry:

1. How do technology teachers describe the strategies they use to develop learners' disposition towards critical thinking in their practice?

2. How are these perceived strategies actualised in their classrooms?

1.7 RESEARCH DESIGN AND METHODOLOGY

This study employed a qualitative research approach guided by the interpretivist paradigm. The multiple case study design was considered an appropriate method to answer the research questions posed. Interviews were conducted and classroom observations were completed to gain an in-depth understanding of the strategies the participating technology teachers used to foster CT disposition in their learners.

1.7.1 Sampling

This study applied a combination of purposive and convenience sampling to select the participants for the two data collection methods: interviews and observations.

For the interviews, each participant was purposefully chosen based on a set of predetermined characteristics and criteria. The participants were Grades 8 and 9 technology teachers from well-resourced schools in Pretoria and Johannesburg. Teachers who fulfilled the stated conditions were contacted and those who were willing to participate were interviewed. Ten interviews were conducted.

Some of the participants who were interviewed were chosen for a classroom observation. The selection for the observations was based on the participants' willingness to be observed and whether they still taught in the areas in Gauteng for which ethical clearance was received from the DBE. Five participants were observed for one design-based lesson respectively.

1.7.2 Instruments and data collection strategy

Data were collected through semi-structured interviews and classroom observations. The interview questions were derived and informed by Facione's (2011) seven dispositions towards CT. These dispositions are: *Inquisitiveness, Analyticity, Systematicity, Truth seeking, Open-mindedness, CT self-confidence* and *Maturity of judgment.* Each participant was interviewed at a place, date and time that suited him or her best. All interviews were audio recorded and transcribed.

The classroom observations were conducted during one design-based lesson that suited the participant and school best. Elements that were noted during the observations include the seven CT dispositions and the eight strategies identified during the interview analysis. Notes were taken during the observations and the lessons were video recorded.

1.7.3 Data analysis

All the collected data were coded and analysed using predetermined and emergent coding and thematic analysis to develop major themes and thoroughly answer the research questions.

For the interviews, initial codes were identified based on the seven CT dispositions as outlined in the conceptual framework. Eight codes emerged from the analysis process regarding the strategies the participants used to foster CT dispositions in their learners. All of the codes applied and developed during the interview analysis were used to code the observation data. All of the data were re-coded a few times to account for the development of codes during the data analysis.

1.7.4 Rigour

A variety of methods were applied to enhance the trustworthiness of this study. These methods include triangulation, the control of bias, and referential or interpretive adequacy to increase the credibility of the findings. Descriptive adequacy, reactivity and purposive sampling were used to improve the transferability of the findings. A thorough audit trail was kept, data triangulation was applied and the code-recode strategy was used during data analysis to strengthen the dependability of this research. Lastly, reflexivity, audit trails and triangulation were used to improve the confirmability of the findings.

1.8 Clarification of key terms

1.8.1 Technology

The term technology originated from the Greek words techné and logos (Dakers, 2005; Mitcham, 1994). Logos means the study of (Dakers, 2005) and techné refers to ‘art’, ‘craft’ or ‘skill’ (Lexico Online Dictionary, 2020f). Technology education is

concerned with the teaching of the broad spectrum of technology, which is "any innovation, change, or modification of the natural environment to satisfy perceived human needs and wants" (ITEEA, 2020, p. 1). In this study, the concept of technology specifically refers to technology as a school subject taught in South Africa to Grades 8 and 9 learners. For this reason, the definition provided by the DBE serves as the meaning of the term: technology is "the use of knowledge, skills, values and resources to meet people's needs and wants by developing practical solutions to problems, taking social and environmental factors into considerations" (DBE, 2011, p. 8).

1.8.2 Problem solving

One of the key skills to teach in technology is "problem solving using the design process" (DBE, 2011, p. 9). Jonassen (2010) refers to the term *problem* as an issue, question or matter that is uncertain, which can and should be examined and solved. Martinez (1998, p. 605) broadly defines problem solving as "the process of moving toward a goal when the path to that goal is uncertain." Moreover, Lawson and Dorst (2009) explain that in its simplest form, the aim of problem solving is to arrive at a valuable solution by exploring consequences, evaluating possibilities, and choosing the most appropriate option or solution. Problem solving is understood in this study as the process of addressing an issue, question or matter by examining the problem context to develop and choose a suitable solution.

Problems are classified into two types, namely, well-structured and ill-structured (Halpern, 2014; Shin, Jonassen & McGee, 2003). Well-structured problems are well defined and provide the necessary information to arrive at a solution (Jonassen, 1997; Lee, Jonassen & Teo, 2011), whereas ill-structured problems are vague and lead to multiple and divergent processes of solving the problem (Halpern, 2014; Jonassen, 2010; Shin et al., 2003).

1.8.3 The design process

The act of designing is considered a process of solving ill-structured problems. Designing in its simplest form is defined as making decisions regarding the beauty and function of objects (Lexico Online Dictionary, 2020c). Designing is further considered to be a "fundamental human activity" (Lawson & Dorst, 2009, p. 24)

where one has to engage with and solve ill-structured problems (Mawson, 2003). There is a process that has to be followed to solve these ill-structured problems. The DBE (2011) describes the design process as iterative and non-linear, involving the following phases: *Investigation*, *Design*, *Make*, *Evaluation* and *Communication*. In the technology curriculum, engaging in the design process is considered a key element that has to be taught (DBE, 2011). In this study, the design process is understood as a non-linear process of solving ill-structured problems by creating solutions through activities that include investigating, designing, making, evaluating and communicating.

1.8.4 Practical Assessment Tasks (PATs)

In the subject of technology, learners have to use the design process when completing Practical Assessment Tasks (PATs). During these tasks, some or all of the aspects of the design process are covered (DBE, 2011). The DBE (2011) describes the PAT as a formal assessment where learners have to apply the skills and knowledge covered during teaching through the use of the design process.

1.9 OUTLINE OF THE REMAINDER OF THE DISSERTATION

Following this chapter, Chapter 2 provides a review of the literature on CT, its skills and dispositions. Research regarding the teaching of CT and the strategies mentioned in the fostering of CT dispositions is discussed. The review further highlights the importance of CT and its value during problem solving and the design process in technology education. The conceptual framework is then described and discussed.

In Chapter 3, the research methodology and design are outlined to explain the process that was followed to collect and analyse the data. In this chapter, the interpretivist paradigm, together with the qualitative research approach and multiple case study design, are discussed. The participants were purposefully chosen, and the criteria concerning the choices made are explained. Additionally, the data collection methods of interviews and observations are discussed, together with the coding procedures and analysis process. Furthermore, the standards of rigour that were applied, as well as the ethical considerations for this study are discussed.

In Chapter 4, the analysis and results of the collected data are discussed and presented. The findings from the interviews are considered first. Here, the answers provided by the participants during the interviews regarding the strategies they used to foster each CT disposition are discussed. This is followed by the findings from the classroom observations. This discussion is structured around the specific strategies that the participants used to foster different CT dispositions. This chapter is concluded by summarising and corroborating the findings.

In Chapter 5, the findings from this study are concluded by answering the research questions. The findings from the interviews are considered to answer the first sub-question, and the findings from the observations to answer the second sub-question. The main research question is then answered by considering the findings from the interviews and observations. This is followed by a discussion of the limitations of this study and possible suggestions for further research. Lastly, the study is consolidated with a conclusion.

1.10 SUMMARY

In Chapter 1, it was stated that CT, and specifically its skills and dispositions, has to be developed by educational institutions and teachers. It was mentioned that it is especially important as part of teaching technology due to the nature of the subject. In technology, learners have to engage in problem solving during the design process, which requires the act of, and presents the opportunity for fostering CT. It was further recognised that research about CT generally focuses on CT skills, and investigations into the dispositional component are limited. This study aimed to contribute to the literature regarding CT dispositions by investigating how technology teachers foster CT dispositions in their classroom. In the chapter, a short discussion on the methodology utilised in this investigation was provided together with a clarification of the key terms and an outline of the dissertation. In Chapter 2, a review of the literature is presented and the conceptual framework is discussed.

CHAPTER 2 REVIEW OF THE LITERATURE

2.1 OVERVIEW OF THE CHAPTER

In Chapter 2, the literature regarding CT and the conceptual framework is discussed. The literature review commences with a description of the concept of *thinking,* followed by a discussion of CT and its two components, namely, skills and dispositions. The teaching of CT is then discussed in terms of its importance in education, the approaches to teaching CT, and the strategies mentioned in the literature. This is followed by a discussion on CT during problem solving and the design process in technology. Lastly, the conceptual framework is described and discussed.

2.2 THINKING

"Thinking is an ordinary learned and voluntary action of the person" that takes place frequently and in varying degrees of intensity (Melser, 2004, p. 137). Most definitions of thinking refer to it as a cognitive process that includes some conceptualisation of the mind (Holmes, 2002). In a broad sense, thinking can be understood as everything that comes to mind or is thought of consciously (Dewey, 2010). Furthermore, it is a process of absorbing and interpreting information through a sequence of phases (Halpern, 2014). Melser (2004) describes the act of thinking metaphorically, referring to the brain or mind as a computer processor. The process can be understood in terms of four operations, namely, input, process, output, and feedback (Humanities Unit, 1995). When information is acquired from the senses, a thought comes to mind and the thinking process begins (Halpern, 2014; Humanities Unit, 1995; Melser, 2004). Thereafter, information is encoded in neural form, and a mental representation or behavioural response is produced (Halpern, 2014; Melser, 2004). As part of the thinking process, decisions are made, and these choices can be reprocessed to produce better solutions or judgments (Humanities Unit, 1995; Melser, 2004). During the thinking process, we engage in a variety of activities and utilise many different skills, one of which is CT (Humanities Unit, 1995).

2.3 CRITICAL THINKING

Many scholars have provided conceptual clarifications of CT, for example, Duron, Limbach and Waugh (2006, p. 160) describe it simply as the "ability to analyse and evaluate information." Bailin et al. (1999) further explain that CT is directed towards the purpose of making up one's mind to fulfil standards of adequacy and accuracy about a specific area of interest. CT, according to Facione (2000, p. 65), is a "self-adjusting process of judging what to believe or what to do in a given context". A critical thinker should be open-minded, purposeful and goal-directed, and have the ability to justify the reasoning behind a decision (Halpern, 2014). The process involves the utilisation of cognitive skills to form, evaluate, reflect on, and improve judgments to increase the probability of a desirable outcome (Ennis, 1996; Facione, 2000; Halpern, 1999). Thus, CT is the practical activity of making decisions through reasonable, reflective thinking (Ennis, 1996) where reflective thinking is the act of suspending judgment while investigations are underway (Dewey, 2010).

A cross-disciplinary international panel of 46 CT experts, participated in a two-year Delphi method research project to study the state of CT and CT assessments. The Delphi team concluded that CT can be described as "purposeful self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as an explanation of evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based" (American Philosophical Association, 1990, p. 3). CT, as understood by the Delphi team, consists of two components that have to be learned, developed, and practised. These are: CT skills and CT dispositions, which offer a framework for conceptualising the qualities of CT (Abrami et al., 2009).

2.3.1 Critical thinking skills

CT skills are cognitive strategies and abilities that aid in the process of making decisions and informed judgements (Ennis, 1996; Facione, 2015; Halpern, 2014). These skills manifest in performance and can be developed through direct instruction when engaging in and completing tasks (Aizikovitsh-udi & Cheng, 2015; Facione, 2000). Table 2.1 illustrates the six core skills and respective sub-skills developed by the Delphi team.

Table 2.1: CT cognitive skills and sub-skills

Core Skills	Sub-skills
Interpretation	Categorisation Decoding significance Clarifying meaning
Analysis	Examining ideas Detecting arguments Analysing arguments
Evaluation	Assessing claims Assessing arguments
Inference	Querying evidence Conjecturing alternatives Drawing conclusions
Explanation	Describing methods and results Stating Results Justifying Procedures Presenting Arguments
Self-regulation	Self-examination Self-correction

Adapted from Association American Philosophical (1990, p. 12)

It is important to note that the six CT skills and sub-skills shown in Table 2.1 are not used in isolation, the thinking process is fluid and continuous, and many skills will be used simultaneously (Halpern, 2014). These skills should be deliberately taught and practised in the classroom to enable learners to recognise when a particular skill is required (Halpern, 2014). In technology, the teaching of CT skills is particularly important during problem solving (Schooner et al., 2017).

Many researchers believe that to be considered a strong critical thinker, one cannot only possess CT skills (Ennis, 1996; Halpern, 2014; Nieto & Saiz, 2011; Yang & Chou, 2008). It is also necessary to be positively disposed towards CT to ensure that these skills are applied; otherwise it will not be used (Nieto & Saiz, 2011; Yang & Chou, 2008). This idea is reinforced by Facione et al. (1996, p. 67), who opine that "we must habitually, not just skilfully, engage in critical thinking."

2.3.2 Critical thinking dispositions

Strong critical thinkers are internally motivated and willing to use CT skills appropriately and in a variety of contexts - they are positively disposed towards CT

(Halpern, 1999; Yang & Chou, 2008). If you are disposed towards something, it means that you are willing or inclined to act or react in a certain way (Lexico Online Dictionary, 2020d). Dispositions are understood as "habitual ways of acting" (Facione, 2000, p. 63) or the "tendency to do something, given certain conditions" (Ennis, 1996, p. 166). It is the consistent internal motivation or willingness to respond to situations and persons in a specific manner by using CT (Facione, 2000; Yang & Chou, 2008). Ennis (1996), Halpern (2014) and Facione (2000) have provided conceptualisations of CT dispositions.

Ennis (1996) considered many researchers' understanding of CT dispositions and his own experiences to develop a framework. He used six criteria to determine the thoroughness of his and others' conceptualisations of CT dispositions. These six criteria are: "Simplicity, comprehensiveness, value, comprehensibility, conformity of its language to our everyday meanings, and the fitting of subordinates (if any) under superordinates" (Ennis, 1996, p. 170). He further mentions a seventh criterion - mutual exclusivity, but notes that it is difficult to follow without compromising the other criteria because the dispositions tend to overlap.

CT dispositions are understood by Ennis (1996, pp. 170–171) in terms of three basic actions, namely: "(1) 'To 'get it right' to the extent possible, (2) To represent a position honestly and clearly, and (3) To care about the dignity and worth of every person." The first action is concerned with the awareness that decisions can be justified and that beliefs are true. The sub-dispositions include the inclination to seek alternatives, consider different views, support positions to the extent that they can be justified, and to be well-informed (Ennis, 1996). The second action denotes that a person is able to represent his or her own and others' positions truthfully and plainly. The sub-dispositions include the willingness to communicate effectively and clearly, maintain focus, pursue and present reason, be aware of the total situation, and reflect on one's own beliefs (Ennis, 1996). The third and last action is not explicitly required by the definition of CT, but Ennis (1996, p. 171) states that without this "correlative disposition", caring for others, CT may become less valuable and more dangerous to society. The sub-dispositions include listening and uncovering another person's reasons and views, being aware of another person's feelings, and understanding and being concerned about another person's welfare (Ennis, 1996).

Ennis' understanding of CT dispositions seems action-focused, with the three basic actions being simple and easy to understand as they conform to everyday language and meaning. These actions and their sub-dispositions could be understood as first seeking and understanding the information available, and being required to be well-informed. It is important to note that this action requires a person to look further than their basic understanding and consider a variety of views and opinions. Thereafter, one should be able to communicate and present these findings in a focused and meaningful manner. As part of this action, it is important to reflect on one's own beliefs. The third and final action is concerned with the intention of the previous two actions. Here, Ennis (1996) communicates that a person who is positively disposed towards CT should also be attentive to and aware of the people around them to be considered a strong critical thinker. Ennis' framework for describing a person's disposition towards CT is valuable in the sense that it is easy to understand because it is expressed in terms of actions. It could be argued that these actions are more a result of being positively disposed to CT rather than the internal qualities of a person who is disposed to it.

Halpern describes the dispositions of CT as relating to a person's attitude towards CT. In order to successful apply CT, one has to develop the attitudes or dispositions of a strong critical thinker (Halpern, 2014). According to the author, the dispositions of a critical thinker will be demonstrated in a person's (1) Willingness to plan, (2) Cognitive flexibility, (3) Persistence, (4) Inclination to be self-critical, (5) Mindfulness, and (6) Consensus-seeking attitude (Halpern, 2014). The first disposition is concerned with the habit of planning and learning. A critical thinker has to learn to check their impulsivity through self-regulation (Halpern, 2014). Secondly, a critical thinker should be open-minded by first gathering information to make informed judgments and respond accordingly. They should be willing to change their beliefs, consider different options and seek information that is not readily available (Halpern, 2014). The third disposition relates to a critical thinker's attitude towards a problem and perseverance to come to a solution. It is about the inclination and ability to stay focused on a task and continuously and consciously engage in the thinking process (Halpern, 2014). Furthermore, to be self-critical is to evaluate and learn from mistakes. A critical thinker has to be willing to self-correct, admit mistakes, and be open to changing their mind (Halpern, 2014). The fifth disposition concerns a critical

thinker's awareness of their thinking processes and thoughts, this implies the inclination to not go through life mindlessly (Halpern, 2014). The last disposition identified by Halpern concerns the understanding that consensus in a group is necessary for action. A critical thinker should be predisposed to pursuing methods of reaching consensus.

Halpern's understanding of CT dispositions relating to an attitude towards CT is sensible if one considers the meaning of being disposed to something. Attitude is understood as "a settled way of thinking or feeling," which is typically reflected in behaviour or action (Lexico Online Dictionary, 2020a, p. 1). It is important to note that even though an 'attitude' is considered to be an established position in the mind, this position can take the form of being open to different and opposing views, as expressed by Halpern's second disposition: to be cognitively flexible (Halpern, 2014). Furthermore, to be 'disposed to' indicates that a person is internally motivated to behave in a certain manner. This behaviour can be seen as manifesting in certain actions. Halpern's conceptualisation can therefore also be understood in terms of actions or activities that a person is inclined or willing to complete. However, relating the dispositions to attitudes comes closer to describing the internal qualities of a person disposed to CT rather than the action that follows.

Facione (2000) explains CT dispositions as the characterological attributes of a person, which are consistent yet malleable. Facione thus relates dispositions to attributes. Attributes are the characteristics or inherent qualities of a person or object (Lexico Online Dictionary, 2020b). Dispositions, also referred to as 'habits of the mind', could be considered as traits of a person. These dispositions would thus result in certain attitudes and actions associated with a strong critical thinker.

The international cross-disciplinary panel of 46 CT experts, the Delphi team, initially identified 19 dispositions that were organised into two groups, namely, "Approaches to life and living in general," and "approaches to specific issues, questions or problems" (American Philosophical Association, 1990, p. 25). These dispositions listed under approaches to life and living include (American Philosophical Association, 1990, p. 25):

- "Inquisitiveness with regard to a wide range of issues,

- Concern to become and remain well-informed,
- Alertness to opportunities to use critical thinking,
- Trust in the processes of reasoned inquiry,
- Self-confidence in one's own abilities to reason,
- Open-mindedness regarding divergent world views,
- Flexibility in considering alternatives and opinions
- Understanding of the opinions of other people,
- Fair-mindedness in appraising reasoning,
- Honesty in facing one's own biases, prejudices, stereotypes, or egocentric tendencies,
- Prudence in suspending, making or altering judgments, [and]
- Willingness to reconsider and revise views where honest reflection suggests that change is warranted."

The approaches to specific issues, questions or problems include (American Philosophical Association, 1990, p. 25):

- "Clarity in stating the question or concern,
- Orderliness in working with complexity,
- Diligence in seeking relevant information,
- Reasonableness in selecting and applying criteria,
- Care in focusing attention on the concern at hand,
- Persistence though difficulties are encountered, [and]
- Precision to the degree permitted by subject and circumstances."

From the original 19 dispositions, seven dispositions were identified through a process of factor analysis (Facione, 2011). These dispositions include: Inquisitiveness, Systematicity, Analyticity, Truth seeking, Open-mindedness, CT self-confidence, and Maturity of judgment (Facione, Sánchez & Facione, 1994). Table 2.2 provides a brief description for each of the seven identified dispositions.

Table 2.2 Brief descriptions of the CT dispositions

CT dispositions	Conceptualisation
Inquisitiveness	An inquisitive, critical thinker is intellectually curious and has an eagerness to learn and be well-informed, even if at that moment the application of the knowledge in question is not known.
Analyticity	A person who is positively disposed to analyticity values the application of reasoning, the use of evidence, and the ability to anticipate the consequences of choices.
Systematicity	Being systematic indicates that a person is concerned with the orderly, focused and diligent manner in which relevant information is sought out, and arguments are presented.
Truth seeking	A truth seeker is eager to ask questions and considers alternative opinions to gain the best knowledge, even if it does not support their own beliefs.
Open-mindedness	An open-minded, critical thinker understands, tolerates and respects divergent views and is sensitive towards their own biases.
CT self-confidence	A person who engages in CT self-confidence trusts in their own reasoning process and the soundness of their own judgments when responding to problems.
Maturity of judgment	Maturity of judgment signifies that an individual is judicious about the making, suspending and revising of their decisions.

Descriptions sourced from Aizikovitsh-Udi and Amit (2011); Association American Philosophical (1990); Facione et al. (1994); Ordem (2017); Yang and Chou (2008)

The descriptions presented in Table 2.2 seem to relate to the internal qualities or attributes of a person. Facione (2000) explains that a person can be positively, negatively, or ambivalently disposed towards CT. This suggests that there are also negative dispositions, which are the opposite of the dispositions mentioned in Table 2.2. These 'bad habits' include "being intellectually dishonest (e.g. in the use of data), intolerant (e.g. of opposing ideas), inattentive (e.g. to implications of proposals), haphazard (e.g. procedurally), mistrustful of reason (e.g. hostile toward sound scientific inquiry), indifferent (e.g. toward new findings), and simplistic (e.g. naively dualistic)" (Facione, 2000, p. 74).

The three different conceptualisations developed by Ennis, Halpern and Facione mention similar actions, attitudes, attributes, or inclinations in the descriptions and understanding of different dispositions towards CT. It was decided to use the seven

CT dispositions identified by Facione (2011) as they are well-known, and widely acknowledged and accepted by CT scholars.

2.4 TEACHING CRITICAL THINKING

Teaching CT skills and nurturing a positive disposition towards CT is considered a liberating force in education that can be used as a powerful resource throughout one's personal, social and professional life (Abrami et al., 2009; Aizikovitsh-udi & Cheng, 2015; Facione et al., 1995). Nieto and Saiz (2011) state that CT requires some amount of instruction or teaching since it is unlikely that this higher-order thinking skill will result from maturation. CT is not a by-product of general instructional activities either; one has to actively teach and foster CT (Halpern, 2014; Murawski, 2014). The literature provides limited insights into strategies for fostering CT in classrooms, and insufficient reports on fostering CT dispositions. In the following section, the importance of teaching CT is discussed, as well as the approaches to teaching CT and some strategies to foster CT and CT dispositions.

2.4.1 The importance of teaching critical thinking

It is important to teach CT so that individuals are able to adapt to new situations, and make fair-minded and informed judgments about the world around them (Facione, Facione & Giancarlo, 1996). During the last 20 years, information and technology have changed and transformed rapidly (Duran & Şendağ, 2012). It has become increasingly important for individuals to be able to search for, interpret and analyse information through critical and reflective thinking to make higher-order decisions (Duran & Şendağ, 2012).

Research indicates that CT is beneficial in one's personal and societal life, and is important for successful participation in our 21st century world (Baum Combs, Cennamo & Newbill, 2009; Facione, 2000; Van Gelder, 2005; Yang & Chou, 2008). It is vital for professional success and valuable workplace decision making to name a few (Vieira et al., 2011; Yang & Chou, 2008). This has made the acquisition of CT skills and a positive disposition towards CT valuable (Duran & Şendağ, 2012; Karakoç, 2016). Education is our primary method of preparing individuals for successful participation in society, and should therefore be a method utilised to foster

CT skills and dispositions (Karakoç, 2016; Qing, Ni & Hong, 2010; Zabit, 2010). Fitzgerald and Baird (2011) explain that teaching and fostering CT is important to help learners process and successfully transform information. They also note that CT thinking is a way of approaching the world inside as well as outside of the classroom, and is applicable and essential in all subjects and all phases of school life.

While there is a general consensus that CT should be taught in schools, Bouygues (2018) finds that society perceives schools as not doing enough. She further explains that because of this perception, we should incorporate the teaching of CT in our curricula. Baum Combs et al. (2009) have, however, found that educational standards have been adapted over the years to include CT as one of the essential skills to teach and learn; this is evident in the South African curriculum. The DBE (2011) describes the ability to think critically as one of its general aims, and more specifically, it states that one of the purposes of technology is for learners to develop their CT abilities.

2.4.2 Approaches to teaching critical thinking

There are three approaches to or views on teaching CT, namely, specifist, generalist, and infusion (Abrami et al., 2009; Davies, 2013; Robinson, 2011). Specifists believe that CT is discipline-specific (Davies, 2013), meaning that it needs to be taught in the context of a specific subject domain using the language associated with that discipline (Abrami et al., 2009; Davies, 2013). In contrast, generalists hold that CT is generic in nature and is applicable across all subject domains (Abrami et al., 2009). It is therefore teachable independent of the discipline (Davies, 2013). Facione (2011) states that CT transcends specific subjects; however, certain contexts would require specific knowledge, methods and techniques for its successful utilisation. This leads to the infusion approach, which accommodates both the previous views. CT is understood as a set of generic skills and abilities that can and should be taught in the context of a specific domain (Davies, 2013). Moreover, Davies (2006) notes that teaching CT in a generalist manner in a particular subject context yields greater benefits than just focusing on one or the other.

In South African schools, the infusion approach is followed. CT is seen as a general aim in the South African school curriculum (DBE, 2011). This implies that CT skills

and dispositions should be taught and fostered in all subjects. Duran and Şendağ (2012) explain that the nature of certain subject matter is more conducive to teaching and developing CT skills and dispositions. In this study, it is argued that technology provides an ideal opportunity for the fostering of CT dispositions because of the nature of the subject (see Section 2.5).

2.4.3 Strategies to foster critical thinking and critical thinking dispositions

The literature suggests that educational environments should encourage intellectual development beyond the technical content towards environments where learners engage and respond critically (Aizikovitsh-Udi & Amit, 2011). Some researchers have mentioned strategies to foster and develop CT. The strategies that are referred to frequently include questioning and engaging in discussions (Halpern, 2014; Schooner et al., 2017). Other strategies mentioned in the literature include argument maps, modelling and creating appropriate activities (Facione, 2000; Fahim & Ghamari, 2011; Van Gelder, 2005).

Questioning is considered the cornerstone of CT (Karakoç, 2016) and a strategy that can be utilised to enhance CT (Zabit, 2010). It is generally believed that the school environment should motivate learners to ask questions and reflect on their thinking process (Halpern, 2014). This could be done by providing opportunities for social interaction and solving authentic ill-structured problems (Duran & Şendağ, 2012; Nieto & Saiz, 2011). Ennis (1996, p. 166) explains that his goals in his CT classes are to teach people “to ask pointed questions and build complex conceptualisations.” Schooner et al. (2017) conducted a study in which they investigated Swedish technology teachers’ views on CT. They found that many teachers use and encourage the exploration of concepts by questioning thoughts, ideas and content. Moreover, they found that discussions about technology’s implications aided the questioning process during which comparisons were drawn between different concepts and technological artefacts.

A strategy generally used in conjunction with questioning is discussions. To encourage discussion, Mandernach et al. (2009) suggest the use of learner-centred questions concerning the course content, as well as questions that are applicable to their lives. They further note that when questioning is used to maximise discussions,

it is important to pose questions with no predetermined answer (Mandernach et al., 2009). Furthermore, Fahim and Ghamari (2011) find that oral communication and the expression of ideas are valuable in the fostering of CT. They suggest encouraging it through activities that include debates, group tasks and conversational questions.

Closely related to questioning and discussions is Van Gelder's (2005) strategy of argument maps. He explains that arguments form complex hierarchical structures, which can be diagrammed or mapped out to make the logical reasoning of the argument explicit. Other strategies found in the literature include modelling CT (Facione, 2000), and creating appropriate activities and assessments that encourage and motivate learners to think critically (Fahim & Ghamari, 2011). These strategies focus on teaching CT as a whole as opposed to each disposition separately.

Fahim and Ghamari (2011) state that learners are not equipped with the disposition to think critically, but it can be developed through appropriate instruction. Nieto and Saiz (2011) believe that CT dispositions should be taught before the instruction of skills. Their reasoning for this is that being positively disposed towards CT will result in improvements and a better acquisition of CT skills. Facione et al. (1995) acknowledge this argument, but still encourage the nurturing of both CT skills and dispositions simultaneously as the two are mutually reinforcing. The researcher agrees with Facione et al. (1995), but chose to focus on the dispositional aspect exclusively because of the limited research on this component of CT. Yang and Chou summarise various researchers' principles for teaching CT dispositions (Andrade & Tishman, 1996; Facione et al., 1995; Tishman, Jay & Perkins, 1993). These are to: "(1) Cultivate a culture of reasoned thinking and evidence-based inquiry; (2) Provide models of good thinking behaviour; (3) Provide opportunities for peer interaction around thinking; (4) Evaluate processes, not results only; and (5) Expect and reward virtue" (Yang & Chou, 2008, p. 668).

2.5 CRITICAL THINKING DURING PROBLEM SOLVING AND THE DESIGN PROCESS IN TECHNOLOGY EDUCATION

CT is considered necessary when problem solving and the ability to solve problems is deemed valuable as part of the design process. The design process is regarded as the backbone of technology education in the senior phase (DBE, 2011; Schooner et

al., 2017). In this section, problem solving, technology, and the design process are discussed to clarify their relevance to CT and CT dispositions.

2.5.1 Problem solving

The concept of a 'problem' is generally considered and perceived as a challenging situation or obstacle (Jonassen, 2010). We, as humans, are consistently confronted with contradicting situations that contain obstacles that have to be overcome to achieve a goal (Dorst, 2006; Jonassen, 2010). Jonassen (2010) conceptualises the activity of problem solving as the process through which one finds a path through the problem space towards a solution. It is important that educational institutions teach learners to be willing and inclined to solve problems (Dorst, 2006; Jonassen, 2010; Martinez, 1998).

Problems can be described as being well-structured or ill-structured (Halpern, 2014; Shin et al., 2003). Problems in education are generally well-structured (Halpern, 2014; Jonassen, 1997; Lee et al., 2011; Shin et al., 2003). These types of problems are well defined and present all the necessary information to arrive at a single solution (Jonassen, 1997; Lee et al., 2011). However, the problems one would encounter in life, and professional environments, are more ill-structured (Jonassen, 2010; Lee et al., 2011; Shin et al., 2003). Ill-structured problems are vague and have multiple and divergent solutions (Halpern, 2014; Jonassen, 2010; Shin et al., 2003). In fact, Lee et al. (2011, p. 247) state that ill-structured problems often "possess conflicting goals, incomplete information, multiple solution methods, and multiple criteria for evaluating solutions." This creates uncertainty regarding how a problem should be solved and what concepts, rules, and principles should be applied (Lee et al., 2011). Shin et al. (2003) hold that a good example of solving ill-structured problems is through designing and the design process.

In light of this, according to Fahim and Ghamari (2011), the processes of problem solving and decision making pose the greatest opportunity to think critically. This is because one has to evaluate a variety of sources in order to come to a conclusion and make judgements (Bailin et al., 1999; Fahim & Ghamari, 2011). In problem solving, an individual uses thinking to overcome an obstacle, and decision making is the process through which they select a solution from multiple options (Humanities

Unit, 1995). Both problem solving and decision making are seen as areas where CT should take place to deliver the best results (Bailin et al., 1999). According to Schooner et al. (2017), problem solving and CT are and should always be linked and related to the content in technology.

2.5.2 Technology education

The DBE (2011) states that CT should be developed in the technology classroom, especially when learners are solving problems. The subject creates a stimulating environment in which learners can develop their CT skills and dispositions (Ohemeng-Appiah, 2014).

Technology manifests itself in artefacts, knowledge, activities, and aspects of humanity or volition (Jones, Buntting & De Vries, 2013; Mitcham, 1994). These manifestations do not suggest that there are four components in technology, but rather that these elements function together, especially when one is designing (Jones et al., 2013). During the technological activity of design, technological knowledge and volition come together to create technological artefacts (Mitcham, 1994). According to Burghardt and Hacker (2004), design activities present the opportunity to encourage learners to be active participants, assist in integrating learning across subjects, make them more aware of their thinking processes and encourage them to think about the influence of their designs. Many scholars consider the design process as the core component of technology, and problem solving its inherent activity (Burghardt & Hacker, 2004; Jones et al., 2013; Lawson & Dorst, 2009; Mawson, 2003).

2.5.3 The design process

The International Technology and Engineering Education Association (ITEEA, 2020) describes designing as a decision-making process that aims to solve problems and address wants and needs by developing appropriate products or systems. It is an iterative and dynamic process that differs depending on the context and nature of the design and the individual engaging in the design process (De Vries, 2016; Lawson & Dorst, 2009). Designing is further considered a process that involves activities that can achieve the aims of technology (Ohemeng-Appiah, 2014). Lawson and Dorst (2009) explain that the classic problem-solving process correlates with the general

activities found in the design process. These activities consist of overlapping phases with the aim to create and find a suitable solution to a design problem (Dorst, 2006; Jonassen, 2010; Mawson, 2003). The CAPS for technology identifies these phases as *Investigate*, *Evaluate*, *Design*, *Make* and *Communicate* (DBE, 2011). Throughout these phases, learners have to engage in problem-solving and decision-making processes (Ohemeng-Appiah, 2014; Schooner et al., 2017). Table 2.3 clarifies the different phases and associated activities of the design process as described in the CAPS for senior phase technology education in the South African school curriculum (DBE, 2011).

Table 2.3: The phases of the design process and associated activities (DBE, 2011)

Design Phase	Activities
Investigate	During investigation, learners are required to "gather data and information, grasp concepts, gain insight and find out about new techniques" (DBE, 2011, p. 68). This includes "finding out about contexts and needs, investigating or evaluating existing products... and performing practical tests" (DBE, 2011, p. 12).
Design	The expectation is that learners develop many solutions from which the best solution that fulfils the required need and specifications is chosen. The learners must be able to justify the choice made and thereafter produce 2D and 3D working drawings and "test, simulate and/or model the solution" (DBE, 2011, p. 68).
Make	The result of the making phase is a model of the final design. As part of the design process, learners should be "building, testing and modifying the product or system to satisfy the specifications of the solution" (DBE, 2011, p. 68). Learners are also expected to "reflect on their progress" and "modify their solutions based on problems encountered" (DBE, 2011, p. 12).
Evaluate	Learners are required to evaluate their design against the design brief or predetermined criteria. They should also evaluate the "process followed and suggest sensible improvements or modifications to the solution in terms of fitness for purpose" (DBE, 2011, p. 49).
Communicate	"Learners should be recording and presenting progress in written and graphical forms" throughout the design process (DBE, 2011, p. 12). These include working drawings, artistic drawings, written reports, oral and/or electronic presentations (DBE, 2011). As learners progress through the phases, they should "show increasing use of media, levels of formality and conventions" (DBE, 2011, p. 12).

From Table 2.3, it may seem that the design process is well structured with definite actions and activities. Design problems are, however, considered to be ill-structured, dynamic and complex, with many possible pathways to reach a suitable solution (Burghardt & Hacker, 2004; Jonassen, 2010; Mawson, 2003). These pathways may

vary depending on the specific problem and the individual solving the problem, which makes multiple solutions possible (Jonassen, 2010; Lawson & Dorst, 2009). In technology, the design process is used and practised during Practical Assessment Tasks (PATs) (DBE, 2011). While completing the PAT, learners are expected to engage in a variety of activities and present their findings and solutions to the given problem.

The aim of teaching and developing CT is to produce better problem solvers, communicators, collaborators and innovators by actively engaging in the process of effective thinking (Murawski, 2014). It is vital to provide learners with the opportunity to practice effective thinking while they evaluate and test their ideas (Murawski, 2014). Furthermore, recording or presenting one's thinking is also valuable in practicing CT as it provides an opportunity for assessment and judgment (Fahim & Ghamari, 2011). Fitzgerald and Baird (2011, p. 619) mention practical suggestions from other authors that relate to the activities associated with the design process phases: "To take part in active problem solving in the classroom (Terenzini et al. 1995; Smith 1977), and engage in independent research (Tsui 1999)". When considering these comments made by other researchers, it is clear that the design process offers an ideal opportunity to foster CT. During the design process, learners firstly solve problems, they are also required to communicate and present their ideas, be innovative, and investigate or research the design problem. It is necessary to note that these are opportunities that are available to teachers and not necessarily accounts of how teachers truly foster CT dispositions in their classroom.

2.6 SUMMARY OF THE FINDINGS IN THE EXISTING LITERATURE

- Teaching CT and nurturing CT dispositions are essential in education to equip learners to become successful participants in society (Baum Combs et al., 2009; Duran & Sendag, 2012; Facione, 2000; Fitzgerald & Baird, 2011; Karakoç, 2016; Qing et al., 2010; Van Gelder, 2005; Vieira et al., 2011; Yang & Chou, 2008; Zabit, 2010).
- The South Africa curriculum follows the infusion approach to teaching CT. CT is a general aim in the South African curriculum that must be taught across all subjects in specific subject contexts (DBE, 2011).

- Questioning, discussions, argument maps, modelling, and the formulation of appropriate activities are considered strategies that can be used to foster CT (Ennis, 1996; Facione, 2000; Fahim & Ghamari, 2011; Karakoç, 2016; Mandernach, 2006; Van Gelder, 2005; Zabit, 2010).
- The principles for teaching CT dispositions include to "(1) Cultivate a culture of reasoned thinking and evidence-based inquiry; (2) Provide models of good thinking behaviour; (3) Provide opportunities for peer interaction around thinking; (4) Evaluate processes, not results only; and (5) Expect and reward virtue" (Yang & Chou, 2008, p. 668). Modelling is a strategy that can be used to foster CT dispositions (Facione, 2000).
- During problem solving, one has to engage in CT to make informed judgments and arrive at valuable solutions (Bailin et al., 1999; Fahim & Ghamari, 2011; Schooner et al., 2017).
- In technology education, problem solving is a vital activity in the design process during which the ability to think critically plays an important role (Burghardt & Hacker, 2004; Jones et al., 2013; Lawson & Dorst, 2009; Mawson, 2003; Ohemeng-Appiah, 2014).

2.7 CONCEPTUAL FRAMEWORK

Miles and Huberman (1994) explain that a conceptual framework describes the key components of a research problem. In this section, Facione's framework of CT is discussed, together with the design process described in the CAPS document for technology.

2.7.1 CT skills and CT dispositions are mutually reinforcing

According to Facione (2011), CT consists of two components, namely, cognitive skills and affective dispositions. The skills are considered to be the mental abilities of an individual, and the dispositions are their inclination or internal motivation to use and apply these skills (Facione, 2011). The one does not assure the other, but they are mutually reinforcing, and both are necessary for an individual to be considered a strong critical thinker (Facione, 2000; Facione et al., 1995). Facione and the Delphi team have identified six cognitive skills and seven affective dispositions, which they

concluded are the characterisation of the ideal critical thinker (American Philosophical Association, 1990; Facione, 2011). Figure 2.1 illustrates Facione's conceptualisation of CT.

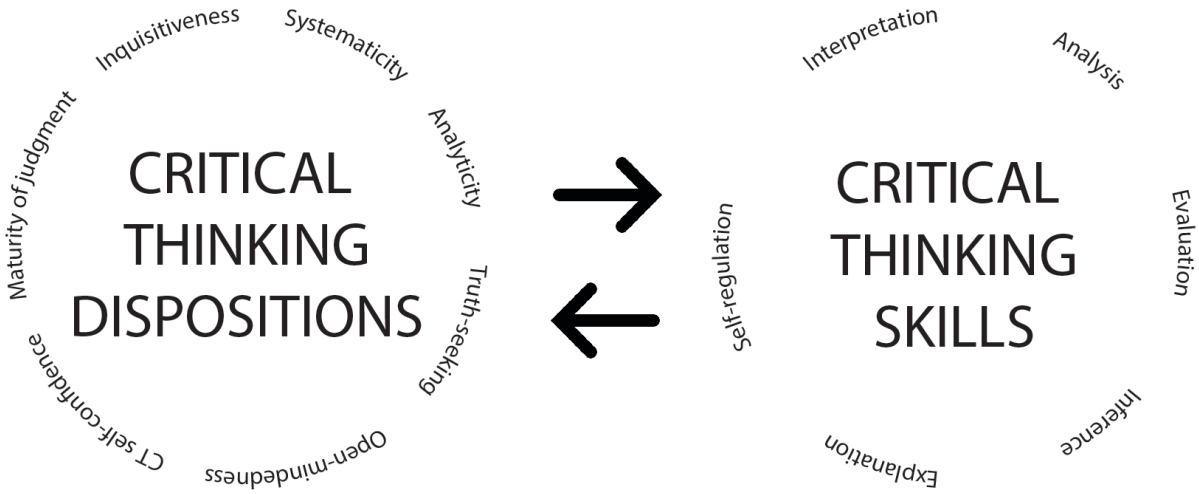


Figure 2.1: CT as conceptualised by Facione (2011)

2.7.2 Design process in technology education

The DBE (2011) states that CT should be developed in the technology classroom. Many regard the design process as the core component of technology, and problem solving its inherent activity (Burghardt & Hacker, 2004; Jones et al., 2013; Mawson, 2003). The IDMEC model is used in this study as it is the prescribed model in the CAPS document for senior phase technology education in the South African school curriculum. This model constitutes that the design process is an iterative, non-linear process that consists of a variety of phases. These phases are: Investigate, Design, Make, Evaluate, and Communicate. In order to understand the design process as part of technology and how it relates to problem solving, the model was further developed to include ill-structured problems as the starting point, and multiple solutions as the result of the design process. Figure 2.2 illustrates the design process in technology as it is conceptualised in this study.

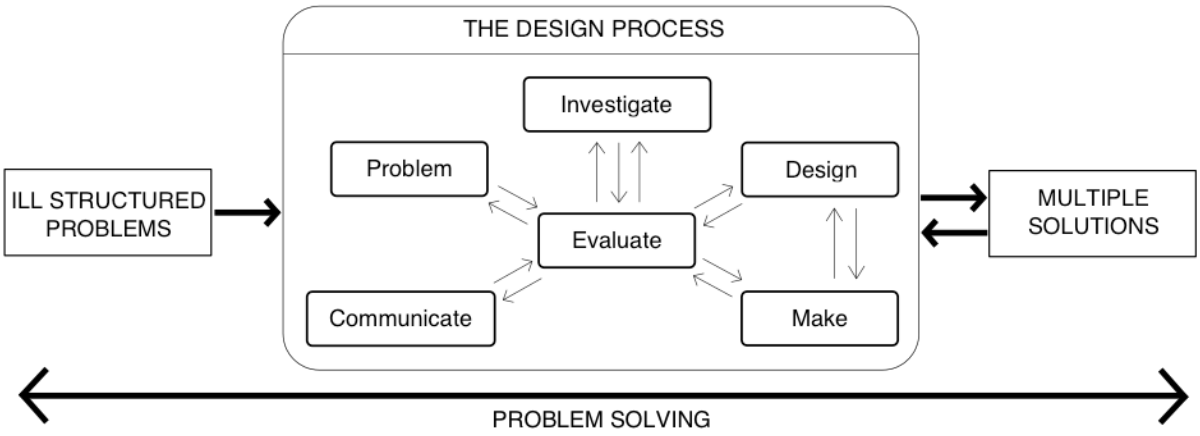


Figure 2.2: The design process in technology (Adapted from DBE, 2011)

2.7.3 The conceptual framework for this study

To address the gap in the literature, this study only focused on the dispositional component of CT. This study further concentrated on the technology classroom and the design process since it provides many opportunities to foster and develop a positive disposition towards CT. The conceptual framework for this study is derived from Facione's (2011) seven dispositions towards CT, together with the DBE's (2011) understanding of the design process in the subject technology. Facione's conceptualisation of the CT dispositions was chosen because it is widely accepted, used and acknowledged by scholars in the field of CT. Furthermore, these dispositions were developed through a rigorous process during which 46 CT experts identified 19 dispositions. The original 19 dispositions were then further reduced to seven dispositions through a process of statistical factor analysis. Additionally, the DBE's (2011) understanding of the design process in technology was included due to the context of inquiry in this study. The study specifically focused on technology teachers in South Africa. Figure 2.3 illustrates the conceptual framework that was used to guide this study.

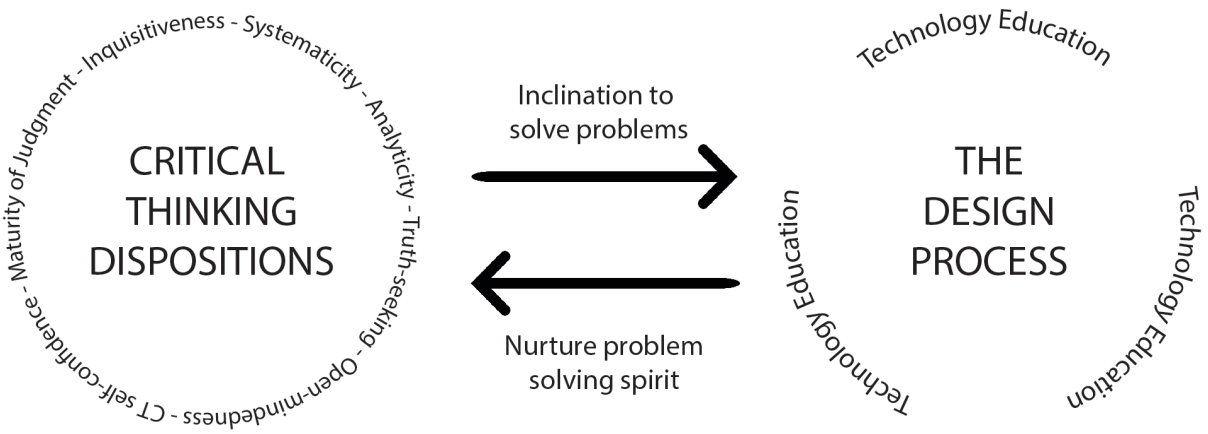


Figure 2.3: The conceptual framework

The conceptual framework depicted in Figure 2.3 consists of two main components, namely, CT dispositions and the design process in technology. These two components are linked through the activity of problem solving. The framework indicates that should an individual be positively disposed towards CT, they will be inclined to critically solve the problems encountered during the design process in technology. The design process in technology presents many opportunities to foster a problem-solving spirit and develop CT dispositions. Teachers must be willing to engage with these opportunities because the willingness to solve or deal with a problem cannot be assumed (Dostál, 2015). When these opportunities are utilised in the classroom, learners' disposition towards CT will develop, and they will be more inclined to solve design problems critically. One of the main questions asked in this study, however, is how technology teachers use the opportunities presented by the design process to nurture a problem-solving spirit and foster a positive disposition towards CT.

2.8 SUMMARY

In Chapter 2, CT was described by considering its two components, namely, CT skills and CT dispositions. In the description, it was noted that Facione's (2011) conceptualisation of CT dispositions focuses on the attributes of a strong critical thinker. It was decided to use the seven CT dispositions identified by Facione because they are well-known, and widely acknowledged and accepted by CT scholars. Thereafter, an explanation was provided as to why it is important to teach CT and the approaches to teaching CT. It was further explained that CT is valuable for successful participation in the 21st century, and it was found that the South African

curriculum follows the infusion approach to teaching CT. Some strategies were identified in the literature to foster CT, together with principles for teaching CT dispositions. This was followed by a discussion on the importance of CT in technology as part of the design process and problem solving. It was pointed out that the design process in technology provides ample opportunities to foster CT dispositions. The conceptual framework was then presented along with Facione's conceptualisation of CT and the design process prescribed by the DBE according to the CAPS document for technology. In Chapter 3, the research design and methodology of this study is described and explained.

CHAPTER 3 RESEARCH DESIGN AND METHODOLOGY

3.1 OVERVIEW OF THE CHAPTER

Chapter 2 provided an overview of the literature concerning CT and the disposition towards CT, together with a discussion on the conceptual framework. In this chapter, the methodology of this study is described and explained by discussing the approach, design, sampling, data collection and data analysis methods to clarify how the data were obtained, and the research questions answered. Firstly, the interpretivist paradigm guiding this study is described and explained. Thereafter, the qualitative research approach employed, which involved using a multiple case study design, is discussed. The methods and reasons for purposive and convenience sampling and the data collection methods of semi-structured interviews and classroom observations are thereafter explained. The process of thematic analysis applied during the analysis of the collected data is then described. Lastly, the rigour and ethical considerations of this study are discussed.

3.2 PARADIGMATIC APPROACH: INTERPRETIVISM

A paradigm is a set of beliefs that represent a particular worldview (Given, 2008). These beliefs are concerned with the philosophical assumptions about the nature of reality and the ways of knowing or creating knowledge (Chilisa & Kawulich, 2012; Morgan, 2007). An interpretivist paradigm was used to guide this study because of its relation to the qualitative research approach. It provides a foundation for the investigation and exploration of the subjective experiences of an individual (Ponterotto, 2005). The ontological, epistemological and methodological implications of using an interpretivist paradigm in this study are discussed next.

The ontology of a paradigm relates to what one believes about the nature of reality (Chilisa & Kawulich, 2012; Sefotho, 2018). Interpretivists conceptualise reality as multiple personal constructions that are relative to the individual (Chilisa & Kawulich, 2012; Maree, 2016; Ponterotto, 2005). This relativist position influenced the choice to interview and observe more than one participant in this study in order to capture their subjective reality.

Epistemology is concerned with how we know what we know about reality, and how this knowledge is constructed (Chilisa & Kawulich, 2012; Sefotho, 2018). Interpretivists believe that knowledge is subjective and context-dependent, and can be constructed by studying and investigating interactions and experiences in their natural environment (Ponterotto, 2005; Taylor & Medina, 2013). Interpretivism yields that there is value in the individual's understanding of the world. Furthermore, the dynamic interaction between the researcher and participant plays an important role in describing the individual's experiences (Ponterotto, 2005). Thus, the interpretivist paradigm allowed the researcher to gain an in-depth understanding of the participants' perceived strategies. This made it possible to also thoroughly describe how these strategies were actualised in the technology classroom.

By considering the ontological and epistemological assumptions of a paradigm, certain approaches and methods seem more applicable than others (Chilisa & Kawulich, 2012). The methodology of a paradigm is concerned with how we acquire knowledge about reality in a meaningful manner, considering philosophical assumptions (Sefotho, 2018). Interpretivism is generally associated with qualitative research, which produces findings that are not generalisable, but are rather an interpretation and analysis of a phenomenon in a specific context (Sefotho, 2018; Taylor & Medina, 2013). Through a qualitative research approach and multiple case study design, one can investigate activities in a specific context (Mason, 2002; Yin, 1994). Additionally, an interpretivist, qualitative approach focuses on understanding a phenomenon from the perspective of the participant. Interviews and observations were chosen as data collection methods to understand the phenomenon from the participants' perspectives. Experiences were investigated through semi-structured interviews during which knowledge about the participants' perceptions was constructed. Furthermore, interactions were studied through classroom observations during which interpretations were made concerning the actualisation of the perceived strategies. This study did not intend to identify or describe an ultimate truth, but rather to report on the strategies used by the participants. Through the interpretation and construction of knowledge, a greater understanding of how CT dispositions are and could be fostered in the technology classroom was gained.

3.3 RESEARCH APPROACH: QUALITATIVE

Qualitative research is characterised as a research approach in which one extracts meaning from experiences in a natural environment (Ary, Jacobs & Sorensen, 2010; Creswell, 2014; Maree, 2016; Neuman, 2014). It seeks to interpret and understand behaviour in a specific context to gain a deeper understanding and produce a rich description of the phenomenon in question (Ary et al., 2010; Creswell, 2003). The aim of this study was to understand and describe how Grades 8 and 9 technology teachers foster CT dispositions in their classroom. The use of the qualitative approach presented the opportunity to provide a rich description of the participants' strategies and how these strategies were actualised in the classroom.

Qualitative research is a form of empirical inquiry where the researcher acts as a human instrument who collects data through fieldwork (Ary et al., 2010; Creswell, 2014). The researcher has to become immersed in the data to gain meaningful insight into the phenomenon (Neuman, 2014). The researcher immersed herself in the data by personally interviewing and observing the participants, as well as organising and analysing the data to gain maximum insight into the perceptions and behaviours of the participants.

The qualitative research process tends to be inductive, fluid and flexible because interactions cannot be fully predicted, and thus important features cannot necessarily be known before they are witnessed (Ary et al., 2010; Creswell, 2003; Mason, 2002; Mohajan, 2018; Neuman, 2014). In this study, the collection and analysis of the data took place simultaneously and consistently by extracting and organising themes to form a representative picture of the chosen participants and their contexts. Since the ways in which teachers foster CT dispositions have not been thoroughly researched, it was possible that important features could not be known at the start of this study. Thus, the qualitative approach, together with the interpretivist paradigm allowed the researcher to interpret and construct meaning and knowledge during and after data collection and analysis.

3.4 RESEARCH DESIGN: MULTIPLE CASE STUDY

A multiple case study design was chosen in conjunction with the interpretivist and qualitative approach. In a multiple case study design, more than one case is investigated in an attempt to understand a specific phenomenon (Ary et al., 2010). This gives the researcher the opportunity to explore the differences and similarities between cases (Maree, 2016).

Findings are usually focused on one of three characteristics, namely, particularistic, descriptive or heuristic (Ary et al., 2010). This study was particular about what and who was under investigation, and it describes how the participating technology teachers fostered CT in the classroom. However, it had a heuristic focus in the sense that the researcher attempted to provide new insights because research regarding how teachers foster CT dispositions is lacking. Furthermore, the multiple case study design's greatest advantage is the potential to conduct an in-depth investigation (Ary et al., 2010; Given, 2008). In order to gain an in-depth understanding, different data collection methods are used, and data is usually gathered over a long period of time (Ary et al., 2010). In this study, two data collection methods were used, and due to time constraints, the data were gathered over a relatively short period of time.

The multiple case study design further focuses on a small number of units to produce a rich description of the behaviour under investigation (Ary et al., 2010; Given, 2008; Maree, 2016; Neuman, 2014). These units must be defined within a "bounded system" (Ary et al., 2010, p. 454), meaning that the cases should have specific characteristics and boundaries. The cases under investigation in this study were those of the participants, who can broadly be defined as Grades 8 and 9 technology teachers. These cases are bounded by their profession and the grades and subject they were teaching. The sampling procedure is further discussed in the next section, Section 3.5.

The case study design does, however, have its weaknesses. It usually lacks breadth and is prone to researcher bias and the influence of prejudice (Ary et al., 2010). The intention in this study was only to consider the sample participants. The issue of breadth within the sample was addressed through the principle of data saturation during data collection, and the determination of the initial sample size. Furthermore,

researcher bias and prejudice were addressed through measures aimed at increasing the credibility and confirmability of this study through the methods discussed in Section 3.8.1 and 3.8.4, respectively.

3.5 SAMPLING: PURPOSIVE AND CONVENIENCE

As part of the qualitative inquiry and multiple case study design method, the participants were purposefully chosen to provide maximum insight into and understanding of the phenomenon (Ary et al., 2010; Creswell, 2014). Purposive sampling is a non-probability sampling method where cases are strategically selected with a specific purpose in mind (Given, 2008; Neuman, 2014). The cases for this study were chosen based on the focus and objective of the research. Furthermore, convenience sampling was applied in the selection of the participants. Convenient sampling makes it easier and quicker to gather data, and is useful when the research is exploratory in nature (Maree, 2016). The intention of this study is to explore and describe how technology teachers foster CT dispositions.

The characteristics and criteria used for the selection of participants included teachers in Pretoria and Johannesburg who teach technology to Grades 8 and 9 learners. Teachers in Pretoria and Johannesburg were specified due to the time constraints of this study, and the researcher's place of residence, making it more convenient to gather the data. Technology teachers were chosen as the teaching of the design process presents many opportunities to foster CT dispositions. Furthermore, Grades 8 and 9 teachers were specifically selected because these are the highest grades in which the subject technology is taught. This potentially presents greater opportunities to foster CT dispositions because of the increased difficulty levels of problem solving. In addition, teachers from well-resourced schools were considered and invited to participate in this study. Resources are "a stock or supply of money, materials, staff, and other assets that can be drawn on by a person or organization in order to function effectively" (Lexico Online Dictionary, 2020e). In this study, a well-resourced school had to at least have adequate educational facilities and learning spaces for teaching to take place. This would include classroom equipment like desks and chairs for all learners, and the availability of textbooks or workbooks, in printed format or electronically. Another asset considered was access to the internet with accompanying electronic personal or school devices for teachers

to utilise during lessons. Some schools had more resources than these stated; this was welcomed because it could provide a broader range of possibilities to foster CT dispositions. The assumption made was that schools that are well resourced would not be limited in the strategies they use and apply compared to a school without the possibility of using resources to aid in the teaching process.

The principle of saturation determined the sample size for the interviews. Data saturation occurs when no new information is gained from new participants (Ary et al., 2010). An initial 10 interviews were conducted with participants during which data saturation occurred, leaving the sample size at 10 participants. Five participants from the same group of participants who were interviewed were chosen for classroom observations. Observations are usually limited to the sites from which a person gains permission (Creswell, 2012). The selection for the observations was based on the participants' willingness to be observed and whether they still taught in the areas in Gauteng for which ethical clearance was received from the DBE.

3.6 Data collection techniques and documentation

In this study, the researcher engaged in semi-structured interviews and classroom observations (Appendices A1 and A2). Interviews and observations allow qualitative research inquiries to not restrict participants' expression of their views (Creswell, 2012). The technology teachers were interviewed and observed to gain a comprehensive understanding of the strategies utilised to foster CT dispositions in the technology classroom. The two collection methods were used to triangulate the collected data and gain an in-depth understanding of the phenomenon.

3.6.1 Interview process and data collection

An interview is understood as a two-way conversation between the researcher and the participant to understand the participant's experiences and opinions on the field of interest (Creswell, 2014; Maree, 2016). In this study, in-person, semi-structured interviews were conducted to explore the participants' perceptions of how they fostered CT dispositions in their classroom. The aim was to answer the first sub-question: *How do technology teachers describe the strategies they use to develop learners' disposition towards critical thinking in their practice?*

The semi-structured format constitutes that an area of interest is chosen with accompanying open-ended questions that are flexible and can be adapted by the researcher during questioning (Ary et al., 2010). Thus, the researcher has some control over information construction during the interview (Given, 2008). This format was chosen to allow the researcher to veer away from the stated interview questions should valuable information come to light or a greater understanding be required. The semi-structured interview format further ensured that questions were asked about all the dispositions and that the set questions could be asked should the participants' answers not yield an opportunity for further discussion. This aided in the interviews being professional and focused on the intention and purpose of the study.

The interview questions were derived from the conceptual framework utilised. Based on the definition of the CT dispositions, specific questions were formulated to gain a better understanding of how the participants fostered CT dispositions in their classrooms. Creswell (2014) states that qualitative interviews generally make use of open-ended questions to elicit the participants' views. All of the questions were open-ended and aimed to encourage the participants to provide detailed answers and not limit their responses. Questions about each disposition were grouped together. A definition and explanation of the particular disposition were provided to ensure that the participants understood their meaning before asking these questions. The participants also received this definition in writing in case they wanted to refer to it during the interview.

All interviews were audio-recorded, brief personal notes were taken after the interview, and the entire conversation was transcribed after its completion. The interviews were conducted after school hours at a date and time that suited the participants best. The interviews took place in various locations suggested by the participants, which included classrooms, offices, tearooms, and coffee shops. Quiet corners in these spaces were selected to reduce the effect of background noise

3.6.2 Observation process and data collection

Observations involve the documentation and recording of everyday activities and behaviour in a systematic and purposeful manner to gain greater insight into a specific phenomenon (Given, 2008; Maree, 2016; Mason, 2002; Stake, 1995).

Through observations, one aims to understand the complex interactions and behaviours that take place in a specific context to capture the participants' real-life experiences (Ary et al., 2010; Creswell, 2012; Given, 2008). In this study, the researcher was a complete observer (Maree, 2016) or non-participant observer (Creswell, 2012). The researcher only observed and did not participate in any activities or consciously influence behaviour. The participants were observed in a natural setting, their classroom, and were video recorded.

Qualitative observations are generally exploratory and are an attempt to uncover unanticipated phenomena (Ary et al., 2010; Given, 2008). It is therefore difficult to know what should be observed and in what the observer should be interested (Mason, 2002). However, an observation schedule derived from the conceptual framework and interview data analysis guided the collection process and the analysis of the data. Field notes were taken during the observation, which provided descriptions of, and reflections on what the researcher heard, saw and understood during and after the observation (Ary et al., 2010; Maree, 2016; Neuman, 2014).

Observations can be used in conjunction with other data collection strategies as it presents an opportunity for researchers to verify data and observe subtleties that may lie outside of the participant's consciousness (Ary et al., 2010; Creswell, 2012; Given, 2008). The data collected from the observations were used to indicate how the strategies identified during the interviews were actualised in the technology classroom. The aim was to answer the second sub-question: *How are these perceived strategies actualised in their classrooms?*

Table 3.1 provides an overview of the activities that took place before, during and after the interviews and observations.

Table 3.1: Summary of data collection activities

	Before	**During**	**After**
Interviews	Set up the interview questions. Organise a date and time for the interview.	Conduct the interview. Audio record the interview.	Reflect and make notes on the interview. Store the audio recordings. Transcribe the interview.
Observations	Set up an observation schedule. Organise dates and times for the observations.	Observe and take field notes. Video record the lesson.	Reflect and make field notes on observations. Store the video recordings.

3.7 DATA ANALYSIS AND INTERPRETATION

The analysis of data in qualitative studies is an iterative and dynamic process (Ary et al., 2010). It aims to "comprehend the phenomenon under study, synthesize information and explain relationships, theorize about how and why the relationships appear as they do, and reconnect the new knowledge with what is already known" (Ary et al., 2010, p. 481). ATLAS.ti, a qualitative data analysis program, was used to organise, locate and code the data. A list of all the codes with a brief description of each is provided in Appendix B. The data in this study were analysed using thematic analysis. As recommended by Braun and Clarke (2006), themes or patterns were identified, analysed and reported on to provide rich descriptions of the collected data.

3.7.1 Analysis and interpretation of the interviews

Nowell, Norris, White and Moules (2017, p. 4) list the phases of thematic analysis as "familiarising yourself with the data; generating initial codes; identifying themes; reviewing these themes; defining the themes and writing the results." The initial familiarisation with the data was through transcribing and checking the accuracy of each interview transcription personally. From the interview transcriptions, the data were organised into basic predetermined categories. Facione's (2000) seven dispositions provided a structure that guided this initial organisation and analysis.

The first phase of working through the data involved coding the design process elements, as discussed in Section 2.7.2. Instances where the participants referred to any element of the design process were coded. After this preliminary examination and coding of the data, notes and initial codes concerning the strategies the participants used to foster CT dispositions were made and identified. This study made use of emergent coding because codes were added and changed as they emerged during the analysis process (Maree, 2016).

In the second phase, the data were coded in terms of the initially identified codes regarding the strategies used by the participants. These strategies were broadly coded since the researcher's understanding was still developing. During this phase, the codes concerning the design process were checked and re-coded where necessary. Here, some codes were revised by considering and reflecting on whether

the design process element in question was mentioned by the participant regarding the fostering of CT dispositions. After this phase, codes were discussed with the researcher's supervisor, and some codes were changed, adapted or merged as part of defining them clearly.

The third phase of coding consisted of all codes being checked, adapted, amended and re-coded as needed. Codes regarding the design process were again checked to ensure that they were mentioned with regard to the fostering of CT dispositions and not merely conversational. Codes about the strategies used were checked against the developed description. During this phase, notes were taken on initial themes to organise and understand the data better.

Themes were reviewed by looking for and grouping together any utterances that were considered relevant. During this review, a fourth phase of working through the data took place where all of the codes were once again checked and changed where necessary when compared to the developed descriptions. Thereafter, the themes were defined to present the analysis and findings in a logical manner. For the interviews, it was logical to discuss the strategies used for each CT disposition separately. During this process, the researcher was consistently immersing herself in the data and reflecting on the process while developing the codes and themes.

3.7.2 Analysis and interpretations of the observations

During the observations, field notes were taken by the researcher. These notes contributed to the initial familiarisation with the data. The audio and video recordings of the five observations were coded, analysed and interpreted separately. Each observation was considered in conjunction with the specific participant's interview to supplement the analysis and interpretation of the data. In line with the interpretivist perspective, each observation was coded, analysed and interpreted before moving on to the next participant to ensure that each participant was analysed regarding his/her specific context.

For the first phase of coding, codes were identified from the interviews about the strategies the participants described using. During the analysis of the interviews, these codes were carefully developed and defined in terms of the participants' answers. This made it possible to identify the actions associated with the codes

during the observed lessons. As part of this phase, notes were taken to clearly define instances and actions when CT dispositions were fostered and should a strategy description be developed further.

The second phase of coding involved the codes concerning the design process. Here, instances where the participants specifically spoke about or referred to elements in the design process were identified and coded. Strong indications of the fostering of specific CT dispositions were also coded during this phase. As part of this phase, the code descriptions for the fostering of CT dispositions were further developed and defined, and the initial codes regarding strategies were checked and re-coded where necessary.

During the third phase of coding, the instances where CT dispositions were fostered were coded. These instances were based on the development and notes created during the first two phases. As part of this phase, all codes regarding the strategies and design process were checked and re-coded where necessary.

The fourth phase of working through the data involved the consideration of the possible themes that emerged. During the previous phase, it was evident that the participants tended to use specific combinations of strategies to foster CT dispositions. All codes were once again checked and re-coded where necessary.

In the fifth phase of working through the data, utterances and instances where the identified themes were evident were noted and grouped. During this phase, some codes were added or removed where necessary. To present the analysis and findings logically, the discussion is structured around each participant's observation and how they fostered CT dispositions during their lesson.

3.8 STANDARDS OF RIGOUR

The rigour in qualitative research is addressed by enhancing the credibility, transferability, dependability and confirmability of a study (Ary et al., 2010; Connelly, 2016). Table 3.2 illustrates the strategies employed to enhance the rigour of this study, followed by a discussion on each aspect.

Table 3.2: Strategies employed to enhance the rigour in this study

Standard of rigour	Strategy employed
Credibility	Triangulation. Control of bias. Referential/interpretive adequacy.
Transferability	Descriptive adequacy. Reactivity. Purposive sampling.
Dependability	Audit trail. Triangulation. Code-recode strategy.
Confirmability	Reflexivity. Audit trails. Triangulation.

3.8.1 Credibility

Credibility is concerned with how believable and consistent the findings are with reality (Ary et al., 2010; Maree, 2016). In order to enhance the truthfulness or credibility of this study triangulation, the control of bias and referential/interpretive adequacy was employed (Anney, 2014; Ary et al., 2010; Creswell, 2014). Structural corroboration was ensured by method triangulation through the gathering of data from interviews and observations (Ary et al., 2010). In other words, the data collected during the interviews were corroborated with the data collected during the observations. Bias was controlled throughout the study by applying reflexivity using self-reflection before, during and after data collection and analysis. Referential and interpretive adequacy was enhanced through thick descriptions of the process and context of the research. Low-inference descriptors were used to convey each participant's context and experiences accurately.

3.8.2 Transferability

Transferability is considered the degree to which a study can be applied to different contexts and groups (Ary et al., 2010; Nowell et al., 2017). The transferability of this study was increased by using descriptive adequacy, reactivity and purposive sampling (Anney, 2014; Ary et al., 2010; Connelly, 2016). Descriptive accuracy was

enhanced by providing rich, detailed and thick descriptions of the study. The limitations of the study are stated in Section 5.4 to provide a greater understanding of the context of the research (Ary et al., 2010). Reactivity was limited by providing detailed descriptions of the methods utilised. This was to ensure a greater understanding of the potential influence of the specific context and research process on the data collected (Ary et al., 2010). Furthermore, purposive sampling also increased the transferability of this study as it provides an opportunity to closely replicate the study (Anney, 2014).

3.8.3 Dependability

Dependability is concerned with how well variation in the findings can be accounted for and explained (Ary et al., 2010). In this study, an audit trail was kept, data triangulation was applied, and the code-recode strategy was employed to increase the study's dependability. During the research process, all choices were documented, and the raw data and interview and observation notes were kept to provide a thorough audit trail. Structural corroboration through triangulation, as discussed in Section 3.8.1, contributed to this study's dependability. Furthermore, the code-recode strategy was employed during data analysis to ensure a deeper understanding of the data patterns, increasing the ability to present the participants' perceptions and behaviours accurately.

3.8.4 Confirmability

Confirmability is considered as "the extent to which the research is free of bias in the procedures and the interpretation of results" (Ary et al., 2010, p. 504). The methods of reflexivity, maintenance of audit trails, and corroboration through triangulation was applied in this study (Anney, 2014; Ary et al., 2010; Creswell, 2014; Given, 2008). Reflexivity was ensured to control bias through regular self-reflection during the research process and detailed descriptions of the methods used. All collected data and notes were kept to provide a thorough audit trail. Lastly, the use of triangulation by collecting data from the interviews and observations increased the confirmability of this study.

3.9 ETHICAL CONSIDERATIONS

Ary et al. (2010) explain four ethical issues that are inherent in qualitative research. These issues include the kind of information obtained, the relationship between the researcher and the participant, reciprocation, and obtaining permission to conduct the research (Ary et al., 2010).

3.9.1 The data

During the interviews and observations, only information related to the research questions and the intention of this study was motivated and accepted. All audio and video recordings, field notes, and transcriptions are stored in a password protected, cloud-based digital storage application. Hard copies on CDs and memory sticks, as well as the paper-based field notes are stored in a locked storage space at the University of Pretoria in the SMTE department. The audio recordings are stored in mp3 format, video recordings in mp4 format and the transcriptions as PDF documents. The data for this study will remain in these storage spaces for 15 years, as mandated by the ethics requirements of the University of Pretoria.

3.9.2 The participants

The participants in this study were adults who did not represent a vulnerable population. No incentives were given, and their participation was completely voluntary. The researcher had no prior contact with any of the participants, and the researcher-participant relationships remained strictly professional throughout the research process. Participation in this study posed no physical or psychological harm. A minor risk, however, was that participants could feel as if they were being judged for their actions or the number of strategies they used during lessons, and they may have felt anxious when their lesson was video recorded. This was countered by reassuring the participants that their identity will remain completely confidential. In this report, pseudonyms are used when referring to the participants and their affiliated schools, and no information is provided that can identify the participants or their schools. The participants were also assured that the focus was on the strategies they used to foster CT dispositions and not whether or not these succeeded or failed.

During the observations, learners were present in the classroom. They did not in any way participate in this study, and no data were collected concerning their identity or work. The parents of the learners who were present during the observations received a letter informing them about the purpose, process and intention of the research. In the letter, it was stated that no information about learners in any form would be used as part of the study or distributed since the focus was on how the teacher fostered CT dispositions. Thus, learners' identity will remain confidential and will not be used or commented on in the final report. The learners received a letter that informed them about the process of observation during the observed lesson. The letter explained what was happening in their classroom, how the video recordings would be used and that their identity is confidential and will not be used or distributed.

3.9.3 Benefits, consequences and reciprocation

There are no explicit benefits or consequences of participation as a result of this study. However, it was relayed to the participants that they may benefit by becoming more aware of the strategies they use to foster CT dispositions in the technology classroom. In terms of reciprocity, all schools and participants will receive feedback on the results and findings of this study. The participants and schools who requested a copy of the final research report will receive one after final submission and feedback.

3.9.4 Permission

Permission and consent were acquired from the Department of Basic Education, the University of Pretoria, and the schools, principals and teachers involved. The research process strictly followed the protocols set out by the ethics committee (Clearance number: SM 19/05/04 from Research Ethics Committee, Faculty of Education, University of Pretoria) and only commenced after ethical clearance was received. The schools, their principals, and the technology teachers were invited to participate in this study through information letters. These letters disclosed the full nature of the study by explaining the purpose, process and intention of this research. The schools, their principals and the participants were only allowed to partake in the research study once informed voluntary consent was given through signed letters of

informed consent. The participants were reminded throughout the process that they were free to discontinue at any time without any negative consequences.

Lastly, it was not the intention of this study to deceive anyone but rather to answer the research questions thoroughly and truthfully to contribute to the existing body of knowledge concerning CT dispositions.

3.10 SUMMARY

In Chapter 3, the paradigmatic and research approach, as well as the research design applied in this study were described and explained. The qualitative research approach and case study design were considered appropriate to gain an in-depth understanding of how technology teachers foster CT dispositions. Furthermore, a description of the sampling and data collection, documentation, analysis, and interpretation methods were provided. Purposive and convenient sampling were used to invite technology teachers to participate in the study. The participants were interviewed and some were observed; the data collected was analysed through thematic analysis. Additionally, the methods to enhance the rigour of this study, as well as the ethical procedures considered were discussed. This account of the research procedure is followed by Chapter 4, where the interpretation and results of the data are discussed.

CHAPTER 4 RESULTS AND DISCUSSION

4.1 OVERVIEW OF THE CHAPTER

In Chapter 3, the methodology regarding the data collection and analysis was described. The results of the analysis are discussed in this chapter. The data were collected through two methods, namely, interviews and observations. The interviews are discussed first. This discussion is structured around the seven CT dispositions and the strategies the participants mentioned during the interviews. Thereafter, discussions on the classroom observations follow. Each observation is discussed separately to consider the participants' individual tendencies to foster CT dispositions. The chapter is concluded with a discussion that consolidates the results from the interviews and observations.

4.2 INTERVIEWS

Ten participants from nine schools were interviewed in this study. During the interviews, the participants had to describe how they fostered each CT disposition in their classroom. The interview was structured according to the seven dispositions towards CT. The analysis of the data, and subsequent reporting, were also informed and guided by the seven dispositions presented in the conceptual framework (see Section 2.7). In keeping with this structure, each disposition is discussed separately. The discussion of each CT disposition commences with a short description of the disposition, followed by a table that summarises the results. The strategies identified during the interviews form the columns of the table, and the cells describe the context in which the strategy was mentioned. Thereafter, the strategies that the participants mentioned are discussed and supported by utterances from the interviews.

Eight strategies were identified during the analysis of the data, namely: assessments; discussions; the classroom environment; examples; feedback; modelling; questioning; and resources. *Assessments (As)* involve occurrences where learners had to complete a task, assignment or where the PAT was mentioned. The participants made reference to three components of assessments. They spoke about the scenario or given problem, the instructions or guidelines, and the rubric provided in the assessment brief. *Discussions (Di)* include cases where the teachers would

talk about a topic, concept or idea with the learners. These discussions would take place in class, in groups, or with individual learners. The *classroom environment (En)* considers the atmosphere that the participants created, the structure of their lesson, and any class rules they mentioned. *Examples (Ex)* imply any physical, electronic or mental concept or idea that the participants used to foster CT dispositions. Physical examples refer to any object or model that learners could interact with in class. Electronic examples are images or videos shown to the learners. Mental examples refer to ideas or concepts mentioned to aid in the fostering of CT dispositions. *Feedback (Fe)* involves any formal or informal occurrence where the participants reacted to or provided constructive criticism of a learner's performance or ideas. *Modelling (Mo)* includes occasions where the participants demonstrated a disposition. *Questioning (Qu)* considers direct and leading questions asked by the participants; it also includes rewarding questions asked by learners and responding to learners' questions promptly. Lastly, *resources (Re)* imply any extra physical or electronic aids used in the process of fostering CT dispositions. In the following sections, each disposition will be discussed individually. Each discussion focuses on the ways in which the participants described how they fostered each CT disposition.

4.2.1 Inquisitiveness

An inquisitive, critical thinker is intellectually curious, and has an eagerness to learn and be well-informed, even if at that moment the application of the knowledge in question is not known (Aizikovitsh-Udi & Amit, 2011; Facione et al., 1994; Ordem, 2017; Yang & Chou, 2008). Seven strategies relating to inquisitiveness were identified from the data collected during the interviews. The results are summarised in Table 4.1. A grey cell in the table indicates that the specific strategy was not mentioned to foster the disposition in question. The concepts inside the cells indicate the context in which that strategy was discussed.

Table 4.1: Inquisitiveness interview summary

	As	Di	En	Ex	Fe	Mo	Qu	Re
Inquisitiveness	Problem choice	Class	Atmosphere	Physical Electronic Mental		Demonstration	Direct Leading	Physical Electronic

Table 4.1 reveals that the participants did not mention the use of feedback to nurture inquisitiveness in their learners. During the interviews, the participants mostly spoke about providing resources and examples. When the participants referred to the design process, the investigation phase usually came up with regard to the fostering of inquisitiveness. The investigation phase requires learners to "gather data and information" (DBE, 2011, p. 68) and "investigating or evaluating existing products" (DBE, 2011, p. 12). This seems plausible if one considers that being inquisitive alludes to an eagerness to search for knowledge (Facione et al., 1994). The participants also mentioned questioning usually about and in conjunction with the resources or examples used. Other strategies they referred to include the use of assessments, discussions, modelling, and creating a comfortable classroom environment. Each of these strategies will now be discussed with appropriate and applicable utterances from the interviews.

The use of resources and examples were frequently mentioned by the participants as strategies they used to foster inquisitiveness. The participants often referred to the use of visual triggers like videos, posters, and PowerPoint presentations as resources to encourage learners' intellectual curiosity. They also referred to the use of electronic, physical and mental models as examples to further encourage learners' inquisitiveness.

> *It requires some effort to get videos and other additional materials to build their curiosity* (Participant 7).
>
> *…and then I like to use videos to explain it to them practically* (Participant 3).
>
> *You have to show them videos because they have no clue how some of these things look* (Participant 8).

Videos and electronic resources were used to spark learners' curiosity, explain ideas practically, and expose them to unknown technologies. The participants also referred to the use of videos to help learners see the bigger picture and to help them understand how concepts work and function in reality. Other resources the participants regularly mentioned were posters and PowerPoint presentations. Participants 5 and 7 discussed the use of posters in their classroom to showcase the content of the subject. Furthermore, Participant 9 said that she used PowerPoint presentations to make learners more curious because of its visual capabilities. Participant 3 did, however, mention that learners are overexposed to visual stimulation, and it does not interest them that much anymore. This could possibly make the use of physical and mental models more necessary. Participants 2, 3 and 5 spoke about practically engaging with the content:

> *…physical models with which they can work and ask questions* (Participant 5).
>
> *…there are a lot of assignments in my class, you saw it now, there are assignments everywhere. I have noticed that it is something that makes the children interested* (Participant 3).
>
> *…you give examples which you know they have at home, that you know they see every day* (Participant 2).

These utterances suggest that some of the participants not only used electronic models, images and videos. Some also made use of physical models and assignments, as well as mental images to motivate learners to be more inquisitive through discussions and questioning. Other resources mentioned that could aid the process of fostering learners' inquisitiveness include tablets connected to the internet, social media, textbooks and eBooks, 3D models and 3D printers, and a workshop.

In addition to resources and examples, the participants also made use of assessments, questioning, discussions, modelling, and the classroom environment. With regard to assessments, it was prevalent that the participants considered the investigation phase as an opportunity to foster inquisitiveness.

> *…you have to go and do research about this and figure out by yourself how these things fit together* (Participant 5).

> *…the projects we gave them this year are not textbook bound you would find some information in the textbook, but you have to research more on that* (Participant 8).

Participant 5 explained that learners were expected to do research to determine how they could design, build and solve the problem in the PAT. Participant 8 said that he went even further by creating projects where the information needed was not in the textbook; this required learners to do more research. Thus, the participants found the expectations and instruction in the project brief important in fostering inquisitiveness. Participants 4 and 10 mentioned that the given problem should be intentionally chosen to motivate learners' willingness to be curious about the PAT.

The questions that participants referred to were usually related to examples and resources used. During these interactions, Participant 5 mentioned that discussions are typically a result of asking questions about examples.

> *I ask questions in worksheets where the answer is not in the textbook or on the PowerPoint that they can just read, they must look further and do some more research* (Participant 3).
>
> *If you are interested in it and you can show the children this is interesting, you basically transfer that energy* (Participant 1).
>
> *…you show them videos and they ask you questions and you show them more videos and they ask you even more questions* (Participant 8).
>
> *Changing things visually in class then they become curious, what's happening?* (Participant 6).

Participant 3 specifically referred to asking strategic questions in assessments. The idea is that the answer is not easy to find and that learners are required to search for the information. Participants 1 and 6 spoke about the value of the teacher who models inquisitiveness by being excited, energised and interested in the topic or concepts they are teaching. Participant 6 further mentioned that rearranging the classroom or changing the learning environment is a strategy that makes learners interested in what is going to happen. Some participants also mentioned that creating a classroom environment where learners are comfortable to ask questions and be curious is essential. Participant 9 tries to create a comfortable environment for learners through the utilisation of humour in the form of memes or funny videos.

4.2.2 Analyticity

A person who is positively disposed to analyticity values the application of reasoning, the use of evidence, and the ability to anticipate the consequences of choices (Facione et al., 1994; Yang & Chou, 2008). The participants mentioned seven strategies regarding the fostering of analyticity during the interviews. The results are summarised in Table 4.2. A grey cell in the table indicates that the specific strategy was not mentioned to foster the disposition in question. The concepts inside the cells indicate the context in which that strategy was discussed.

Table 4.2: Analyticity interview summary

	As	Di	En	Ex	Fe	Mo	Qu	Re
Analyticity	Problem choice Guidelines Rubric	Class Group		Physical Electronic	Informal	Demonstration	Direct Leading	Physical Electronic

Table 4.2 shows that the participants did not mention the classroom environment to nurture analyticity. The strategy that the participants referred to most was questioning. If one assumes that the act of asking, answering or thinking about a question requires a person to engage in a reasoning process, then questioning seems relevant to the cultivation of analyticity since it is the application of reasoning. Questioning was generally mentioned in combination with other strategies, especially assessments, discussions, and examples. Additional strategies that the participants spoke about were the use of resources, modelling, and feedback. Each of these strategies will now be discussed with appropriate and applicable utterances from the interviews.

The participants indicated that they frequently used questioning to foster analyticity. The types of questions they asked included direct questioning, requiring a specific answer where learners had to explain their understanding, as well as leading questions to guide learners to the answers.

> *…then they must physically think by themselves, okay he told me this, I understand it like that, so I will try and explain it like this* (Participant 1).

> *When you explain something in class and a child asks you but why then you guide him to the answer but I really want them to think for themselves* (Participant 7).
>
> *I reason with them but I try to pull it out of them rather than just giving it to them* (Participant 1).
>
> *Then we must reason, they sit there and then the children bring examples and then I ask them, "How did you get to this point," a lot of the time it develops into a class discussion* (Participant 4).

Participant 1 asked direct questions where learners needed to think for themselves. Other participants, including Participants 1 and 7, said that when learners asked questions or had difficulty answering questions, they used guiding questions to lead learners to answers rather than providing the solution. Furthermore, Participant 4 spoke about using questions to help learners determine their reasoning process in their designs. Questioning was occasionally mentioned in conjunction with other strategies like discussions, examples, assessments, and feedback. Some of the participants referred to the use of examples and discussions together with questioning to further encourage analyticity:

> *…you can give them examples, as I said a model and this can lead to, ok this is how it works and then they engage in reasoning by themselves* (Participant 5).
>
> *I will show them an example of a picture; try and analyse this, is it a good design, is it a bad design and whoever says it is a good design must justify why* (Participant 9).

Participant 5 explained that he presented an example and told learners to figure out how it worked, and he would ask strategic questions to guide their exploration. Participant 9 provided electronic images of examples and questioned learners on whether or not they believed the design was good or bad and then asked them to justify their belief.

As part of fostering analyticity, the participants frequently referred to the use of assessments, specifically the PAT. The participants mostly spoke about the formulation of the project brief as an opportunity to foster analyticity. It seems that the participants viewed the expectations listed in the design brief and the requirements of the PAT as a way to encourage and require learners to be analytical during the design process. As an example, some of the participants mentioned that the specific requirements concerning the investigation phase and inclusion of a bibliography

motivated learners to analyse their findings and provide evidence. Furthermore, the given problem was considered by some as a strategy to motivate analyticity.

> *Each box needed to have a secret compartment. I am not allowed to find where you could hide stuff away from your parents - that actually made them think more of how will I be able to do this* (Participant 6).

Here, Participant 6 explained that by adding exciting and interesting specifications to a problem, he tried to encourage learners to engage in analyticity from the start of the design process. The participants also used the PAT to ask questions, present scenarios, and give feedback, more specifically about what can go wrong with their design and how they got to their solution.

> *…what will happen if something strong pulls the car and there is nothing underneath and then they must think, okay this is what is going to happen because there is nothing that will support it* (Participant 3).

> *When I have the model in front of me, I start to read and I ask who did this, who did that and then I ask how did you get to here* (Participant 5).

Participant 3 brought the possible consequences of learners' choices to their attention by asking questions regarding a rhetorical scenario. Many other participants, including Participant 5, mentioned that they asked learners to explain their reasoning process and provide evidence of their choices as part of the PAT feedback. Lastly, Participant 9 modelled analyticity by demonstrating processes, like drawing, step by step and explaining each action thoroughly.

4.2.3 Systematicity

Being systematic suggests that a person is concerned with the orderly, focused and diligent manner in which relevant information is sought out and arguments are presented (Aizikovitsh-Udi & Amit, 2011; Facione et al., 1994; Yang & Chou, 2008). Eight strategies relating to systematicity were identified from the data collected through the interviews. The results are summarised in Table 4.3. The concepts inside the cells indicate the context in which that strategy was discussed.

Table 4.3: Systematicity interview summary

	As		Di		En			Ex		Fe	Mo	Qu		Re	
Systematicity	Problem choice	Guidelines	Rubric	Group	Individual	Atmosphere	Lesson structure	Rules	Physical	Electronic	Informal	Demonstration	Direct	Leading	Physical	Electronic

Table 4.3 indicates that the participants used all the identified strategies to nurture systematicity. The participants frequently spoke about the guidelines stipulated in assessments and, more specifically, the PAT project brief. The intention of the guidelines is to guide learners in their approach to inquiry and the presentation and communication of their arguments. Furthermore, many participants referred to creating an organised classroom environment where they would model systematicity. Other strategies that they stated include discussions, examples, feedback, questioning, and resources. Each of these strategies will now be discussed with appropriate and applicable utterances from the interviews.

Assessments, modelling, and the way in which the participants set up their classroom environment were frequently mentioned as ways in which they encouraged and modelled systematicity. The participants relied mostly on the given outline, guidelines, and the rubric to encourage learners to work systematically during assessments.

> *…they have to do the first phase for the first week, this must be finished so that it is systematic* (Participant 3).
>
> *…they get their guideline and they have to stick with it* (Participant 9).
>
> *Tell them exactly what the requirements are, rubrics are a massive thing these days, you need to tell them exactly what you are marking* (Participant 8).

The idea is that the structure provided in the assessment helps and guides learners to order and focus their work. Some of the participants explained that learners were required to hand in specific phases of assessments at specific times, which could encourage them to work more diligently. The participants frequently referred to the project brief when discussing systematicity. Some participants considered the requirements for how the PAT must be compiled and presented by learners as a way

to foster systematicity. The participants explained that the process stipulated in the PAT is systematic and guides learners to present their project in an orderly and focussed manner.

> *…you follow the design process and under that you want everything to be organised, it is once again you follow a certain standard of something, and it must be presented in a certain manner* (Participant 1).

Furthermore, Participants 4 and 5 mentioned that they provided feedback to guide learners to approach tasks more systematically. The participants occasionally mentioned the investigation and communication phases together with the choice of problem. Participant 5 explained that learners have to bring their research to class in order for him to provide feedback. He noted that it made learners more aware of how they searched for information because they knew he would be evaluating it. Participants 3 and 4 said the following about the investigation and communication phases:

> *…we look at their research critically. So, if they just bring something, we tell them you can't just take this and then they must go and look again* (Participant 4).

> *…when they present there are specific questions that they must answer* (Participant 3).

Participant 3 explained that she gave specific questions to learners to guide and structure the content of their PAT to ensure that they effectively communicated their information. Participant 9 mentioned that as part of communicating their design, learners had to evaluate their ideas. She explained that learners had to present and evaluate their product against a list of points provided in the project brief. These points act as a guideline that helps learners present their information systematically.

The participants also referred to their classroom environment and modelling of routine and structure to foster systematicity:

> *I follow a certain routine each time I enter the class* (Participant 1).

> *In my classroom, to stay focused, we stick to themes* (Participant 4).

> *I use PowerPoint so that keeps me in a system* (Participant 9).

Some participants mentioned that they followed a specific routine each day and that there were certain rules that must be followed in their class. The routine was regarding lesson structure, and the rules were concerned with classroom interaction and, more specifically, how to ask questions in class. One way in which Participant 4 kept his classroom environment systematic was by working with content themes. Participant 9 ensured that her lessons were structured and focused by preparing and presenting lessons with PowerPoint slides. Resources, examples, discussions and questioning were also occasionally mentioned as additional strategies the participants used to foster systematicity.

> *…work with examples and if the example does not work or something like that then you try to debate to try and get it right* (Participant 1).

4.2.4 Truth seeking

Being a truth seeker entails being an individual who is eager to ask questions and consider alternative opinions to gain the best knowledge, even if it does not support their own beliefs (Aizikovitsh-Udi & Amit, 2011; Facione et al., 1994; Ordem, 2017; Yang & Chou, 2008). Seven strategies related to cultivating a truth-seeking spirit were identified from the data collected through the interviews. The results are summarised in Table 4.4. A grey cell in the table indicates that the specific strategy was not mentioned to foster the disposition in question. The concepts inside the cells indicate the context in which that strategy was discussed.

Table 4.4: Truth seeking interview summary

	As	Di	En	Ex	Fe	Mo	Qu	Re
Truth seeking	Rubric	Class Group Individual	Atmosphere	Physical Electronic Mental		Demonstration	Direct, Leading Reward Qu Answer promptly	Physical Electronic

Table 4.4 reveals that the participants did not mention the use of feedback to nurture a truth-seeking spirit in their learners. The participants mostly referred to the use of resources and questioning, especially during the investigation phase of the design process. This corresponds with the quality of being a truth seeker, as well as

investigating and asking questions to gain the best knowledge. Discussions, examples, and the classroom environment were also frequently mentioned to guide and require learners to consider alternatives. Other strategies that the participants spoke about include modelling and assessments. Each of these strategies will now be discussed with appropriate and applicable utterances from the interviews.

The participants mentioned that they frequently asked questions to nurture a truth-seeking spirit in their learners. The participants spoke about direct questioning, leading questions, recognising and praising good questions, and answering the questions learners ask immediately.

> *…straight forward if I say to a child, "Listen, but have you looked at everything. Is this the only option that you considered?" Ask directly* (Participant 1).
>
> *…if a child asks a good question, to give credit to that it helps and motivates the guys to ask even more questions and to show more interest in the topic* (Participant 7).
>
> *…if a child asks a question, we stop and search for an answer* (Participant 4).
>
> *…you wouldn't watch the video whole way through, you would stop it intermittently. It is not set questions, it is… you would watch something and then I'd think of something and then just stop and then ask them a question* (Participant 8).

With regard to the teacher asking questions, Participant 1 asked learners directly whether or not they consulted or considered different opinions and options. If they did not, he would instruct them to go back and search for more information. With regard to learners asking questions, Participant 7 mentioned that it is necessary to praise good questions to motivate learners to ask more questions. Furthermore, some of the participants said that whenever a learner asked a question, it was essential to stop and answer them immediately or assist in finding an answer. Lastly, Participant 8 spoke about asking leading questions to encourage learners to be more truth seeking when exposing them to different ideas.

As part of cultivating a truth-seeking spirit, learners must have the opportunity to search for knowledge. The participants mentioned the following resources to assist in the process of searching for knowledge.

> *…extra books in my class that they can use and I am not that strict on cell phone use, I encourage them to use it, especially if they have to do research about specific topics* (Participant 7).

> *…we have free Wi-Fi, we've got a library, we have different textbooks* (Participant 9).

Internet availability and access to books either in the classroom or from a library came up frequently as opportunities for learners to search for knowledge. Participant 5, in particular, mentioned that he had a collection of magazines available in his classroom that learners could use for extra reading and research. Participants 3, 6 and 7 specifically referred to the use of cell phones in the classroom. They allowed their learners to use their cell phones in class to gather information about a topic or concept.

Additional strategies the participants mentioned included examples, discussions, and the classroom environment.

> *…give different examples but what else do you think is there* (Participant 1).

> *I think it helps that a child thinks, 'the teacher will want to help me' and also the fact that my classroom is open after school for the kids to come and work* (Participant 3).

Regarding examples, the participants saw it as their responsibility to provide alternatives to help learners understand different possibilities and encourage them to want to look further. In some instances, the participants mentioned that presenting examples, whether options, ideas or opinions, would facilitate discussions where learners had to listen and interact with the information. Participant 8 said that when they had information in the form of research or different ideas, the group had to evaluate the information through discussions.

> *…well the idea is that they need to have a chat about it in the group; one would be the coordinator* (Participant 8).

He further explained that as part of the project brief, they were required to also evaluate their final design according to specific guidelines, which could possibly make learners more truth seeking since they have to assess the success or failure of their design. Furthermore, Participants 2 and 3 spoke about the importance of making learners feel comfortable and safe in the classroom so that they would be willing to ask questions. Participant 3 tried to achieve this by opening her classroom

after school, and Participant 2 allowed music in his class to build a good relationship with his learners.

To a lesser extent, the participants mentioned modelling and assessments. Participant 4 spoke about the fact that he is a person who likes to ask questions, which is a form of modelling it to the learners. Participant 7 explained that listening to learners' opinions made them more open to alternative suggestions and ideas. Lastly, Participant 8 mentioned that the requirements in assessments encouraged learners to be truth seeking, especially as part of the evaluation phase during the design process.

4.2.5 Open-mindedness

An open-minded, critical thinker understands, tolerates and respects divergent views, and is sensitive towards their own biases (Aizikovitsh-Udi & Amit, 2011; Facione et al., 1994; Ordem, 2017; Yang & Chou, 2008). Six strategies relating to open-mindedness were identified from the data collected through the interviews. The results are summarised in Table 4.5. A grey cell in the table indicates that the specific strategy was not mentioned to foster the disposition in question. The concepts inside the cells indicate the context in which that strategy was discussed.

Table 4.5: Open-mindedness interview summary

	As	Di	En	Ex	Fe	Mo	Qu	Re
Open-mindedness	Rubric	Class Group	Atmosphere	Mental		Demonstration	Direct Leading	

Table 4.5 indicates that the participants did not mention the use of feedback and resources to nurture open-mindedness. During the interviews, the participants mostly referred to discussions when describing how they fostered open-mindedness. It could be argued that in order to understand, tolerate and respect divergent views, one should engage in discussions. Other strategies that were mentioned included questioning, modelling, the classroom environment, and the use of examples. In most cases, these strategies were considered in conjunction with discussions. Each

of these strategies will now be discussed with appropriate and applicable utterances from the interviews.

The participants frequently mentioned discussions when asked how they fostered open-mindedness. These discussions were mostly between the participant and his/her learners, and they occasionally made use of questioning to facilitate these discussions.

> *…discussions and then also how questions are set up* (Participant 4).

> *…you have to make sure that you always start talking it through, "But ok, I understand this, but how do you see it? I see it like this," and then begin to ask questions and talk it out, and I would prefer in front of the class so that the class can see for themselves 'but this is why sir is saying this and why he explains it like this'* (Participant 5).

Most of the participants considered discussions as a good way to expose learners to different options, views and opinions than their own. Participant 4 mentioned that it is crucial to consider the type of questions you ask during these discussions. Furthermore, Participant 5 explained that he preferred to have discussions in front of the learners so that he simultaneously modelled open-mindedness. Participants 1 and 7 spoke about the interaction between group members when working on the PAT during the evaluation and design phases.

> *…if there are just three in a group... then we teach them take the three designs and analyse it now, so then you can look at how they support each other* (Participant 7).

Participant 1 referred to the interaction that takes place in groups as an opportunity for learners to practice being open-minded. Participants 1 and 7 motivated learners to look at the information and ideas presented by each group member, and then evaluate it as a group to decide what is useful and what is not.

To a lesser extent, the participants referred to other strategies like modelling, questioning, examples, and the classroom environment to foster open-mindedness.

> *…if a child tells me, "But sir, I don't agree," then I would say, "ok cool, now please explain to me how you think about it," and then I will take the time to listen* (Participant 7).

> *…If they fixate on something, I try to ask strategic questions* (Participant 1).

> *So, give all the facts and try to make them understand what happens in different environments and to explain what is necessary in those environments* (Participant 1).
>
> *…having discussions, having talks with friends being loud in class and all of that because it actually creates an atmosphere of not corporal matter* (Participant 6).

Participant 7 modelled open-mindedness by allowing learners to disagree with him and then showing them how one listens and considers other's opinions. When learners got stuck in their own beliefs and opinions, Participant 1 asked them strategic questions so that they realised their biases. Furthermore, he provided learners with the facts and explanations about how different contexts work to make them more aware of what is out there. Lastly, Participant 6 commented that it is important that the classroom environment is open and that learners are comfortable to have open discussions. These discussions have to be facilitated, as Participants 7 and 8 mentioned. Participant 9 tried to create this environment by respecting learners and not shooting down their ideas or laughing at them.

It is necessary to note that some participants reacted to questions concerning open-mindedness by stating that technology is not a Life Orientation class. During the interviews, the participants also initially responded to questions regarding open-mindedness by referring to topics outside of technology. This could indicate that the participants were unsure of how one would foster open-mindedness because they did not see how it is relevant to technology. Participant 3 mentioned the following:

> *I think you actually limit learners in the class... I don't think you really foster it so much... in my opinion it is difficult to teach open-mindedness in technology* (Participant 3).

4.2.6 CT Self-confidence

A person who engages in CT self-confidence trusts their own reasoning process and the soundness of their own judgments when responding to problems (Aizikovitsh-Udi & Amit, 2011; Facione et al., 1994; Yang & Chou, 2008). Five strategies relating to CT self-confidence were identified from the data collected through the interviews. The results are summarised in Table 4.6. A grey cell in the table indicates that the specific strategy was not mentioned to foster the disposition in question. The concepts inside the cells indicate the context in which that strategy was discussed.

Table 4.6: CT self-confidence interview summary

	As	Di	En	Ex	Fe	Mo	Qu	Re
CT self-confidence	Problem choice Guidelines	Class	Atmosphere		Informal Formal		Direct Leading	

Table 4.6 shows that the participants did not mention the use of examples, modelling or resources to nurture CT self-confidence. From the analysis of the interview data, it was evident that the participants mostly used assessments, especially the evaluation phase of the design process. Evaluation requires learners to "suggest sensible improvements or modifications to the solution in terms of fitness for purpose" (DBE, 2011, p. 49). When considering that CT self-confidence entails that an individual trusts in their own reasoning process and judgments (Facione et al., 1994), having to evaluate your reasoning process and judgments as part of the PAT assessment is fitting. The participants also mentioned questioning and feedback as part of assessments. In these instances, learners are allowed to complete a task or think for themselves, and receive feedback so that they can practice and improve their reasoning process. The participants also regularly referred to discussions and the classroom environment to provide a space for learners to practise and develop their CT self-confidence. Each of these strategies will now be discussed with appropriate and applicable utterances from the interviews.

The participants frequently referred to the use of assessments, questioning, feedback, discussions and the classroom environment to foster CT self-confidence. The participants answered as follows regarding how they encouraged learners to practise and develop their own reasoning process, and the opportunities available for learners to be reflective:

> *…the whole assessment is about, I try to build their frame of mind so that they will be willing to try something new* (Participant 4).
>
> *…by not just saying, "Listen, put that component there," but rather to say, "What if you add this, how do you think it will influence it?"* (Participant 3).

> *…go and help and say, "Come let us reason why it won't take place here or why it won't happen or what should we change here"* (Participant 5).
>
> *I call them after school and, "Listen here, this is what, this is your project, these are the flaws, these are the flaws in your paperwork. Go home, go see what you did wrong," but I didn't tell them everything* (Participant 6).

Participant 4 tried to set the assessment in such a way as to build a positive attitude in learners so that they wanted to think about the scenario and solve the problem. Participants 3 and 5 reasoned with learners by asking questions, and Participant 6 provided feedback on which learners could reflect and improve in future.

Regarding the PAT assessment, the participants mostly referred to the evaluation phase as an opportunity to foster CT self-confidence, together with fewer mentions about the making, designing and communicating phases:

> *…you give them at least a chance to make changes, the project brings you there and then you give them time for changes* (Participant 5).
>
> *…to give the assignment vague in the sense that I give them guidelines for which they receive marks, but they have to from there for themselves decide or add something on their own* (Participant 4).
>
> *…they evaluate once they finish and I would give feedback* (Participant 8).

Participant 5 provided learners with the opportunity to evaluate their product and make changes so that they could present something of which they could be proud. One could argue that this makes learners more confident in their reasoning process because they could evaluate and improve on it. Participant 4 tried to develop learners' CT self-confidence by having learners add to the assessment criteria of their project. He explained that he gave vague guidelines and then learners had to add their own elements that are relevant to their specific project. Furthermore, Participant 8 mentioned that as part of the design brief, they had to evaluate their design and then he provided feedback. He further explained that through feedback, learners gained a better understanding of their reasoning process and would hopefully improve how they went about the process in future. The following was said about the making, designing and communicating phases:

> *…don't you think there are better ways to do it and then they sit and think about it a little bit and they mess it up, and then they realise 'oh but there are other ways to do this'* (Participant 7).
>
> *…they need to present their prototype, they reflect not only their own work but they reflect on the work of others* (Participant 9).

Participant 7 explained that while learners were designing and making, he asked them if they thought there were better ways to solve their problem. By questioning their actions during these phases, he would encourage them to reason and, in turn, practise and develop their CT self-confidence. Participant 9 explained that by having to communicate and reflect on their design, learners understood what they did wrong, and this could improve their confidence in future.

Other strategies the participants referred to included building self-confidence through the classroom environment, providing feedback, and having discussions. The participants mentioned the following regarding creating a comfortable classroom environment:

> *I start with a funny video about 3min long and then I begin with the class and stuff like that; you want to at least make it fun and tell jokes so that you make the child comfortable* (Participant 5).
>
> *…it is amazing to see if you only, oh that was nice, and you see that self-confidence boost* (Participant 3).
>
> *…just by writing down or giving them a compliment will obviously build their self-esteem and build their confidence* (Participant 9).

Participant 5 created a comfortable environment where learners could practise being confident. Participants 3 and 9 noticed the importance of providing positive feedback during assessments to boost leaners confidence. Lastly, Participant 10 said that he motivated his learners to be confident through class discussions where he occasionally provided false information, and the learners had to notice the incorrect information and argue with him.

4.2.7 Maturity of judgment

Maturity of judgment signifies that an individual is judicious about the making, suspending and revising of their decisions (Aizikovitsh-Udi & Amit, 2011; Facione et al., 1994; Ordem, 2017; Yang & Chou, 2008). Seven strategies concerning the fostering of maturity of judgment were identified from the data collected through the interviews. The results are summarised in Table 4.7. A grey cell in the table indicates that the specific strategy was not mentioned to foster the disposition in question. The concepts inside the cells indicate the context in which that strategy was discussed.

Table 4.7: Maturity of judgment interview summary

	As	Di	En	Ex	Fe	Mo	Qu	Re
Maturity of judgment	Guidelines Rubric		Atmosphere	Electronic	Informal Formal	Demonstration	Direct Leading	Electronic

Table 4.7 reveals that the participants did not mention the classroom environment to nurture maturity of judgment. When analysing the interview data, it was prevalent that the participants mostly referred to the use of assessments to foster maturity of judgment. They considered the requirements of the PAT assessment as an opportunity to foster maturity of judgment. Throughout the design process, it is necessary to make, suspend and revise choices since there are many possible pathways that lead to different conclusions (Burghardt & Hacker, 2004; Jonassen, 2010; Mawson, 2003). Considering that engaging in maturity of judgment implies being judicious about the making, suspending and revising of decisions (Facione et al., 1994), this makes the use of assessments and, more specifically, the design brief relevant to nurture maturity of judgment. Other strategies that the participants mentioned included modelling, discussions, examples, resources, questioning, and feedback. As part of general class interaction, the participants modelled, discussed and asked questions to further encourage maturity of judgment. Electronic examples and resources were also referred to as aids during these interactions. Each of these strategies will now be discussed with appropriate and applicable utterances from the interviews.

The participants often mentioned using assessments, and the design process and brief as a strategy to develop learners' maturity of judgment. The participants generally stated that it 'says so in the assessment requirements': "in the paperwork it states have more than three ideas" (Participant 6). They also mentioned the investigation, design and evaluation phases:

> *…when you design you have to make sure you give them guidelines* (Participant 2).
>
> *…to have a friend or another colleague or peer come take a look at their work and ask them what they think about this design then they can, here is maybe something good what would you have done differently so that the children give each other ideas* (Participant 4).
>
> *I give them headings... it comes to the project's proper set rules and proper set up rubric* (Participant 6).
>
> *…with the evaluation, we ask questions so they got a rubric at the end, so we ask questions and they say 'was it working'* (Participant 9).

Many of the participants referred to the requirements and outline of the PAT assessment alongside the rubrics as ways in which they fostered maturity of judgment. In the PAT, learners are required to make certain choices, and they have to be able to explain and support the decisions they made. As part of the design phase, Participant 4 had peers and colleagues come and critique the learners' designs to help them make a decision about other's ideas and make more mature judgments about their own ideas. Participant 9 tried to accomplish this by providing questions during the evaluation phase of the design process to guide learners' judgment process.

As part of assessments, other strategies like modelling, discussions, examples, resources, questioning, and feedback were also mentioned to aid in the fostering of maturity of judgment. The participants answered the following regarding how they ensured that learners apply sound judgment when they are making or changing their decisions, designs and models:

> *I almost want to immediately say modelling, I try and be a good example for them* (Participant 1).
>
> *I have shown them videos about small scale models where they put it in a wind tunnel* (Participant 8).

> *I simply ask the question why and then they need to tell me* (Participant 8).
>
> *I will also ask questions to make them realise the other options they could have followed* (Participant 9).
>
> *I take projects, swap groups with them or swop people with them, then what's wrong with this project and then it stays nameless but they see who has the project, but they write a little letter on what they think is the problem* (Participant 6).

Participant 1 said that he modelled maturity of judgment to demonstrate to learners how it is done and hopefully encourage them to do the same. Participant 8 showed learners electronic examples of how to judge the success of ideas. He also asked why learners were making or wanting to change their designs to ensure that they were judicious about it. Participant 9 went further with questioning by asking learners strategic questions to assist them to realise what they could do differently. Lastly, Participant 6 fostered maturity of judgment by requiring learners to evaluate each other's work.

It is necessary to point out that the participants occasionally said that it was the learners' responsibility to engage in maturity of judgment. Throughout the interviews, the participants referred to 'self-responsibility' when they discussed some of the other dispositions, but it was especially evident in their answers regarding maturity of judgment.

> *…they have to be willing to try other options* (Participant 4).
>
> *…it actually happens in the groups, if you divided them into groups, they talk about it so it is actually just a discussion* (Participant 10).

Participant 4 mentioned that learners had to be willing; in other words, they had to take self-responsibility. Participant 8 regularly referred to learners' self-responsibility throughout his interview regarding all CT dispositions. It seems that he believed that there is only so much a teacher can do, and most of it depends on the learner wanting to interact and engage. Furthermore, Participant 10 explained that learners tended to engage in maturity of judgment without his assistance, especially when they were working in groups as part of the PAT.

4.2.8 Interview Summary

The analysis of the interview data yielded different strategies that the participants used to foster CT dispositions. Table 4.8 summarises the findings from the interview data.

Table 4.8: Interview summary

	As	Di	En	Ex	Fe	Mo	Qu	Re
Inquisitiveness	Problem choice	Class	Atmosphere	Physical Electronic Mental		Demonstration	Direct Leading	Physical Electronic
Analyticity	Problem choice Guidelines Rubric	Class Group		Physical Electronic	Informal	Demonstration	Direct Leading	Physical Electronic
Systematicity	Problem choice Guidelines Rubric	Group Individual	Atmosphere Lesson structure Rules	Physical Electronic	Informal	Demonstration	Direct Leading	Physical Electronic
Truth seeking	Rubric	Class Group Individual	Atmosphere	Physical Electronic Mental		Demonstration	Direct, Leading Reward Qu Answer promptly	Physical Electronic
Open-mindedness	Rubric	Class Group	Atmosphere	Mental		Demonstration	Direct Leading	
CT self-confidence	Problem choice Guidelines	Class	Atmosphere		Informal Formal		Direct Leading	

Maturity of judgment	Guidelines Rubric		Atmosphere	Electronic	Informal Formal	Demonstration	Direct Leading	Electronic

Table 4.8 indicates that assessments and questioning were used to foster all of the CT dispositions. Discussions, the classroom environment, examples, and modelling were mentioned to foster six of the seven dispositions. The use of resources was further mentioned to foster five of the CT dispositions, while providing feedback was only referred to in the fostering of four of the seven dispositions. Regarding the use of assessments, the participants mostly referred to the rubric and also regularly mentioned the choice of problem and the formulation and provision of guidelines. When engaging in discussions, the participants mostly mentioned class discussion and also made reference to group discussions and individual discussion. Creating a classroom environment conducive to the fostering of CT dispositions was mostly focused on creating a comfortable, open and organised atmosphere. Lesson structure and rules were only mentioned regarding the fostering of systematicity. All types of examples - physical, electronic and mental - were regularly referred to, with electronic examples mentioned the most and mental examples the least. On the occasions that the participants spoke about providing feedback, it generally concerned the informal feedback offered during class interactions with some references made to formal feedback being provided at the end of assessments. The use of modelling was regarding the demonstration of the CT dispositions by the participants. The participants mostly mentioned direct and leading questions when describing the strategy of questioning. It was only concerning the fostering of a truth-seeking spirit that some of the participants mentioned the importance of rewarding and answering learners' questions. Lastly, both physical and electronic resources were stated as aids in the fostering of some CT dispositions, with electronic resources being mentioned slightly more.

From the discussion above, it is also necessary to note that some of the strategies were mentioned in conjunction with or leading to the use of other strategies. There is a strong correlation between the use of examples, more specifically physical and electronic examples, and the use of physical and electronic resources. This is

sensible because one would require resources to showcase physical and electronic examples. Furthermore, when examples were used, the participants generally mentioned that they would also engage in discussions and ask questions about the example. When the participants used questioning, whether direct or leading, it would generally lead to discussions. The use of assessments and the classroom environment acted as a platform for some of the other strategies to be used. The use of assessments provided a platform for asking questions, especially about the design process. It also provided opportunities for formal and informal feedback. The comfortable and open atmosphere to which the participants referred regarding the classroom environment was usually to ensure that learners would be willing to ask questions and engage in discussions. This suggests that the strategies identified during the interview data analysis are not always used in isolation.

In the following section, the data gathered from the classroom observations are discussed. The strategies identified during the interview analysis and the way in which the participants described them guided the analysis of the classroom observations.

4.3 CLASSROOM OBSERVATIONS

Of the 10 participants who were interviewed, five were selected for observation during a design process-related lesson. As discussed in the literature review (Chapter 2), the design process presents many opportunities to foster CT dispositions. Four of the five participants presented a lesson that focused on a PAT, in line with the requirements outlined in the CAPS document. One participant presented a lesson that consisted of a design activity. The data collected from the observations indicate that the participants used combinations of strategies to foster all CT dispositions. The reporting of the observation data therefore focuses on the combination of strategies used by each participant as opposed to the context in which the strategies were presented during the interviews. The observation of each participant is discussed separately by considering the main strategies they used and the supporting strategies that would follow. Each discussion commences with a description of the context of the lesson. This is followed by each participant's specific combination of strategies to foster specific or a combination of dispositions. During the observations, it seemed that the participants did not explicitly foster CT

dispositions, but rather made learners aware of and modelled actions and processes they had to follow during the design process. Creating an awareness of, and modelling the dispositions could lead to learners willingly engaging in these actions and processes, and could therefore contribute to the fostering of CT dispositions. Furthermore, Facione (2000) mentions modelling as an effective strategy to nurture learners' disposition towards CT. Each observation is concluded with a summary of how the participant fostered CT dispositions in their technology classroom.

4.3.1 Observation 1

Observation 1 was conducted at a well-resourced, all-boys school in an urban area. The classroom was big and spacious, with enough single desks and chairs for each learner. The desks were arranged in a linear, traditional classroom manner. The learners remained seated at their desks for the entire lesson. A desk and chair were at the front of the classroom for the teacher. Here, the teacher had a laptop that was connected to a projector, and the projection was displayed on a whiteboard. The teacher remained at the front of the classroom for the entire lesson and only used the whiteboard as a screen for the projection. The organisation of the classroom ensured that all learners could clearly see the teacher and the projection. There was adequate light provided through the windows and artificial lighting for most of the lesson. During the observation, the school experienced load shedding, but the projector and the laptop could still be used because the school had a generator.

A Grade 9 lesson was observed during a late morning period after break. The lesson consisted of an introduction to the PAT for Term 1 about structures. Figure 4.1 is an excerpt of the project brief for this PAT. The teacher explained and discussed the expectations and requirements of the task. The task required learners to design an overwater bungalow for an island resort company. The phases of the design process that were discussed during the lesson included the investigation, design and communication phases.

Project brief

The Island Resort® in Dubai has approached you about designing an "Overwater bungalow". The bungalow must be designed to **extend over the ocean** with a **bridge** extending to the bungalow from the shore. The bungalow must be a **2 bedroom building** with **outside decking** no bigger than 100m² (all included). The **framework** below the bungalow must be 5m high (3m in the water).

The Island Resort® would like to see the following:

- Research
- 3 designs
- Final design
- Model build
- Evaluate

http://www.tahiti.com/hotels/vahine-island-private-resort-2988 (2016/04/24)

Projected time allocation:

	Number of periods
Research & Design brief	Homework
3 different designs	4
Final design	2
Cost calculations & Evaluation	2
TOTAL	**8**

Figure 4.1: Observation 1: Excerpt of the project brief

Participant 8 used a combination of strategies to make learners aware of a few dispositions they needed throughout the phases of the design process. During his interview, Participant 8 regularly mentioned that he used the instructions or guidelines and rubric of the PAT to foster CT dispositions. While explaining the PAT, he modelled analyticity through a class discussion to give learners a better understanding of why the assessment was set up as it was. For example, he used the following specification in the PAT:

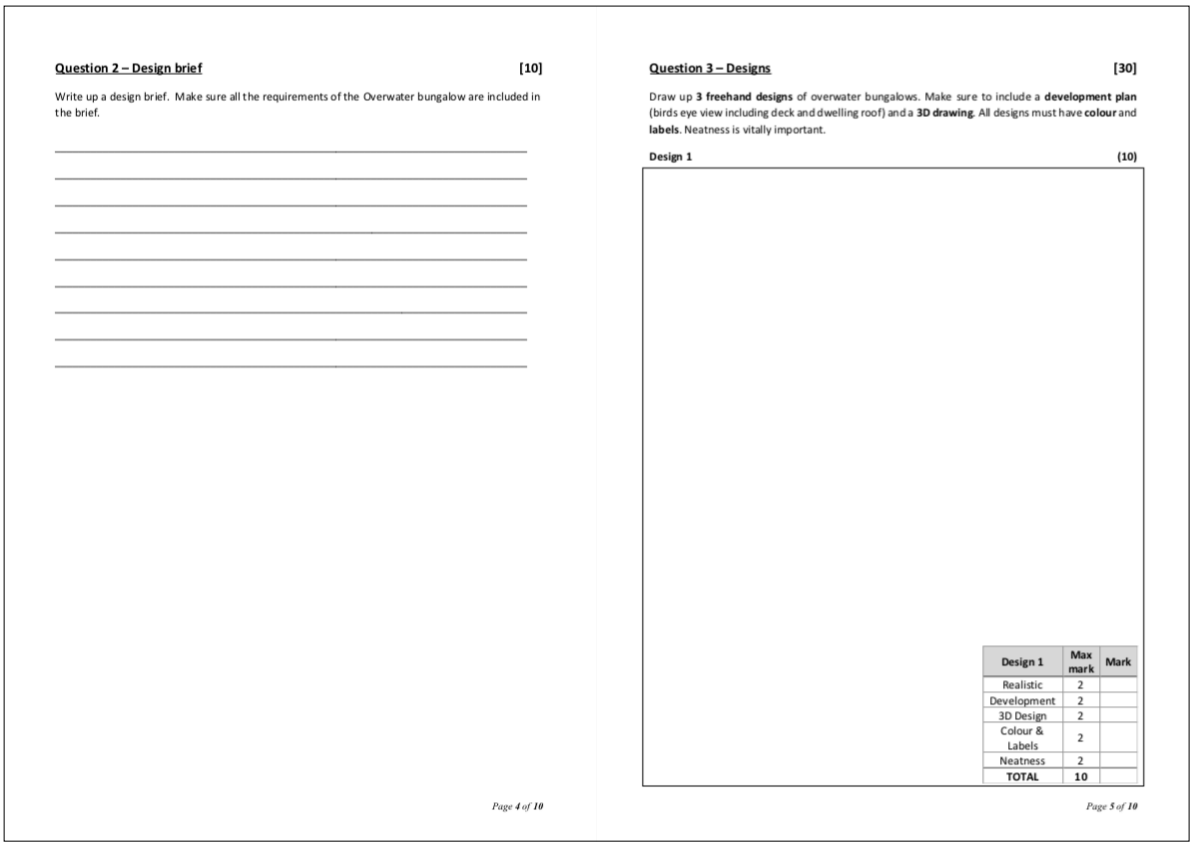
> *The framework below the bungalow must be 5m high (3m in the water)* (Participant 8).

In the class discussion about the specification, he applied reasoning - analyticity - by talking about what would happen if you go deeper into the ocean; the bungalow would be underwater. While explaining and going through the assessment with the learners, he also informed them that they must be willing to engage in maturity of judgment and be truth seeking. He achieved this through modelling these dispositions by providing a mental example of his own reasoning process, implying

analyticity. He presented his own research, in the investigation phase, as an electronic example to learners and through this, he showed them that they have to consider different options and be truth seeking. He further told them they would have to make certain choices based on their research, implying maturity of judgment.

He allowed the learners to participate in the class discussions about his examples should they have a question or want to comment. This was mostly the learners' own responsibility. He rarely asked learners questions to encourage them to engage in these discussions. During Participant 8's interview, it seemed that he believed learners also have a responsibility to engage in class activities without his guidance. One could say that requiring learners to take self-responsibility provides an opportunity to develop and practise an internally motivated willingness, "[a] tendency to do something, given certain conditions" (Ennis, 1996, p. 166) that are specific to CT dispositions. When the learners asked questions, he provided them with the opportunity to practise and develop their CT self-confidence by discussing the answer. Through these discussions, he would model analyticity and maturity of judgment to consolidate the idea/concept/topic under discussion.

Furthermore, the PAT is formulated systematically. During Participant 8's interview, he mentioned that he used the requirements and guidelines in assessments to foster CT dispositions. In the PAT, questions are ordered by numbers with accompanying spaces to answer and complete the section. The questions follow a sensible pattern, starting with the investigation phase, followed by the design brief, then the design ideas and, finally, the technical drawing of the final idea. In this way, he motivated and developed learners' systematicity by requiring them to communicate their PAT in an orderly and focused manner. He also structured the lesson around the PAT, which created a systematic environment since he was presenting and going through the work methodically. Figure 4.2 is an excerpt from the project.



Question 2 – Design brief [10]

Write up a design brief. Make sure all the requirements of the Overwater bungalow are included in the brief.

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Question 3 – Designs [30]

Draw up **3 freehand designs** of overwater bungalows. Make sure to include a **development plan** (birds eye view including deck and dwelling roof) and a **3D drawing**. All designs must have **colour** and **labels**. Neatness is vitally important.

Design 1 (10)

Design 1	Max mark	Mark
Realistic	2	
Development	2	
3D Design	2	
Colour & Labels	2	
Neatness	2	
TOTAL	10	

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Figure 4.2: Observation 1 - Project questions 2 and 3

Figure 4.2 shows questions 2 and 3 with their instructions, a space to answer, and the mark allocation. While Participant 8 discussed the requirements of the assessment, he also consistently modelled a positive disposition towards analyticity and maturity of judgment. He did this by mentioning his own reasoning process and then stating where and when judgments would have to be made. One could assume that him acting in this manner would influence the learners to act in the same manner while completing the PAT.

During this lesson, it was evident that the learners felt comfortable and were eager to ask questions. From the observation, one could deduce that this is because he would immediately address a learner when they had a question, no matter the quality of the question. If he intended to answer the question during the planned lesson, he would tell the learner that he would get to it. This could be a way of modelling systematicity as he planned the lesson in a specific manner and kept to it, and focused on the orderly presentation of the PAT. If the question could be answered by research, he would tell learners to go and investigate their question, possibly presenting an

opportunity where inquisitiveness, an eagerness to learn, is fostered. Participant 8's response to a question from a learner about the height of a bungalow was follows:

> *The fact that you are asking that question is that not something you want to find out, you need to find it out with research* (Participant 8).

Questions from the learners mostly concerned the requirements of the PAT, and sometimes this led to class discussions during which he modelled analyticity, systematicity, and maturity of judgment. This occurred as part of the discussions about the investigation and communication phases of the design process. In these discussions, he went through his own reasoning process in order to explain the PAT's requirements. On occasion, he asked learners direct questions. By asking these questions, he required them to be analytical in order to provide a good answer. He then gave them the opportunity to practice CT self-confidence by presenting their answer in front of their peers. An example of such a question during the lesson is:

> *I wouldn't put an overwater bungalow in Japan, why?* (Participant 8).

At the end of the lesson, he gave an allocated period of time for questions. It seems that, through this action, he created an environment and atmosphere where the learners felt comfortable and were eager to ask questions that could aid in fostering a truth-seeking spirit. It appeared that the learners only asked questions to understand what they could or could not do because they received marks for the PAT. If one considers the act of being indifferent or uninterested as the opposite of being inquisitive (Facione, 2000), then this seems to be an example of where inquisitiveness was fostered.

As part of the lesson, Participant 8 made use of many examples to explain the PAT. He provided his own examples of how to complete and communicate the investigation phase based on the specific PAT. He showed an electronic example of a design brief from another PAT, and showed two videos to encourage learners' design thinking. Going through the example of the investigation phase, he explained and modelled his own reasoning process, analyticity, and through this made learners aware that they have to be open-minded and truth seeking by considering different options during this phase. While he discussed the examples, he mentioned and

modelled the instances where learners must be willing to be analytical and apply sound judgment when analysing the research that they found.

> *In order for you to go and design your own overwater bungalow you need look at existing bungalows and try and see if you could use some of that information* (Participant 8).

Going through the design brief, he modelled and encouraged systematicity while discussing the components that follow each other. He provided starting sentences for the components to focus learners' presentation of the information. These sentences included: "I am going to design and make..." "my client is asking to..." and "the final overall size will be" (Participant 8). Concerning the design ideas shown in the video, as well as mental examples of design ideas given by learners, he modelled his own reasoning process (analyticity), and the choices he would make (maturity of judgment) through discussions with learners. During the interview, he regularly referred to the use of examples and resources, especially videos, during which he would ask questions and allow learners to engage in discussions about the video. The following are the questions asked after he played one of the videos:

> *Do you understand how it stands out as you fly past? So, it has got to be aesthetically appealing, yes there is a lovely coastline there, but look how it stands out. If that is hideously ugly do you think anyone is going to be interested in it?* (Participant 8).

He also provided informal feedback on learners' ideas and examples through class discussions, and asked direct and leading questions which could encourage and provide the opportunity for learners to develop a positive disposition towards analyticity and maturity of judgment. During these discussions, he told learners that they would have to make the decisions, possibly encouraging their CT self-confidence or at least providing an opportunity for them to trust in their own reasoning process.

> *The two specifications pretty much are, you have got a hundred meters square to play with and it's got to be a two-bedroom bungalow, the rest is up to you* (Participant 8).

The observation revealed that Participant 8 fostered CT dispositions in three specific ways. Firstly, through the PAT, its guideline and requirements, and how he explained it. Secondly, the use of questioning by mostly allowing learners to ask questions or

by asking some questions himself. Thirdly, providing examples, mostly electronic examples about the expectations of the design phases as well as videos to show different ideas. The learners' ideas were also used as mental examples. Table 4.9 summarises how Participant 8 fostered CT dispositions during the observed lesson. The top row shows the three main strategies he used, namely, assessment, questioning, and examples. Some of these strategies were utilised with supporting strategies, as indicated in the cells of the table. This differs from the way in which the tables for the interview data were presented, where the *context* of the strategies was communicated in the cells. During the analysis of the observations, it became clear that the participants used a main strategy that would act as a platform for or lead to the use of another strategy. This finding provided greater insight and understanding of how these strategies are actualised in the technology classroom. To illustrate this actualisation, it was decided to communicate supporting strategies that would follow or assist the main strategy in the corresponding cells. The grey cells in the tables designate that the specific strategy was not utilised to foster its corresponding CT disposition. An empty white cell indicates that the main strategy stipulated in the column was used without any supporting strategies being observed.

Table 4.9: Observation 1 summary

	Assessments	**Questioning**	**Examples**
Inquisitiveness			
Analyticity	Discussions Modelling	Discussions Modelling	Discussions Modelling Resources
Systematicity	Environment	Discussions Modelling	Modelling
Truth seeking	Discussions	Environment	Resources
Open-mindedness			Resources
CT self-confidence	Discussions		Feedback

	Assessments	Questioning	Examples
Maturity of judgment	Discussions Modelling	Discussions Modelling	Feedback Discussions Modelling Resources

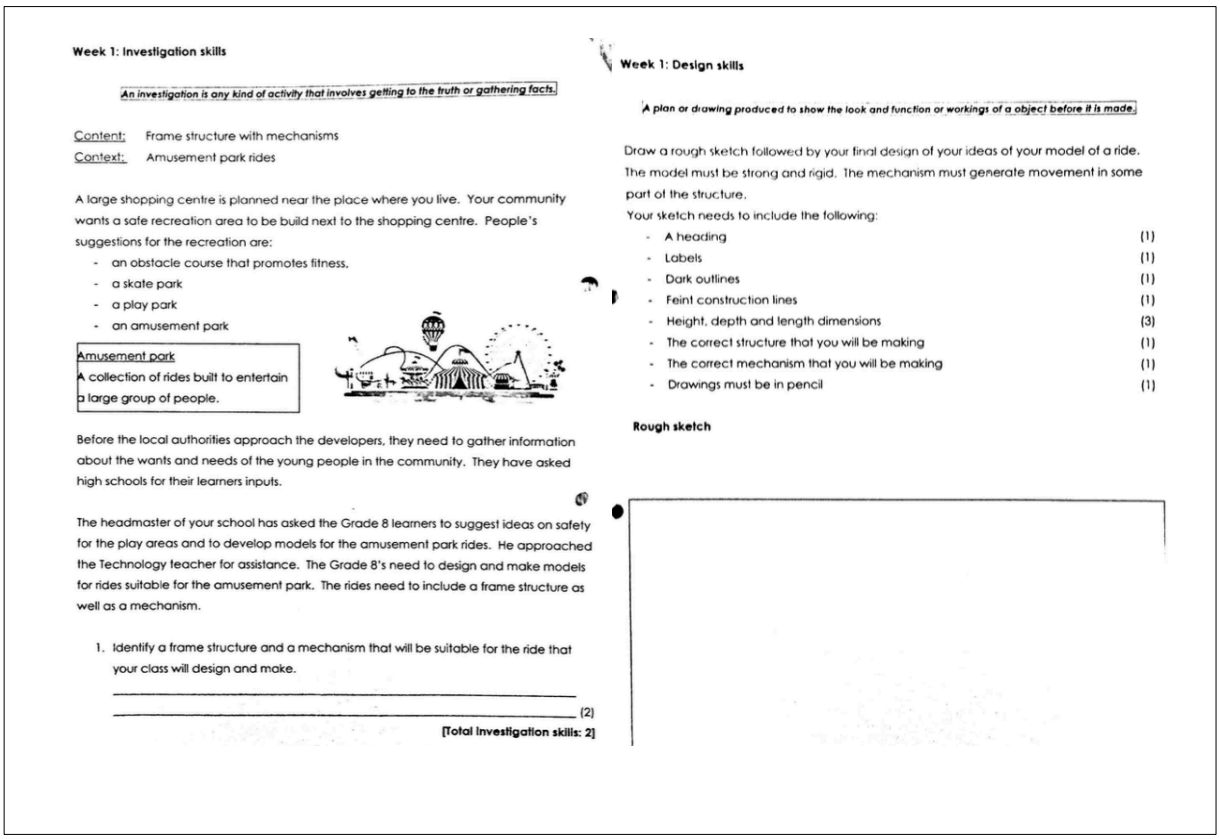
Participant 8 mainly used the PAT guidelines and requirements in the design brief to foster systematicity. The formulation of the PAT was used to guide learners to order and focus their search for relevant information and the presentation of their arguments. The way in which Participant 8 spoke about the PAT further fostered analyticity, a truth-seeking spirit, CT self-confidence, and maturity of judgment. During the observation, a truth-seeking spirit was mostly fostered through questioning. This would be reasonable since being a truth seeker is, among other things, considered an eagerness to ask questions (Facione et al., 1994). Participant 8 created an environment where learners were willing to ask questions and where he responded promptly and respectfully. As part of asking and answering questions, other dispositions like inquisitiveness, analyticity, systematicity, CT self-confidence and maturity of judgment are also fostered. Inquisitiveness, analyticity, systematicity and maturity of judgment were generally modelled when he answered the learners' questions. When he asked learners questions, he would require them to engage in analyticity and then provide them with the opportunity to practice CT self-confidence by answering the question. As for the use of examples, analyticity, systematicity, a truth-seeking spirit, open-mindedness, CT self-confidence and maturity of judgment were fostered in different ways. The examples used were mainly electronic resources presented by Participant 8, but learners' ideas were also occasionally used and discussed as mental examples. According to this analysis and discussion, Participant 8 fostered all of the CT dispositions through a combination of strategies during this observed lesson.

4.3.2 Observation 2

Observation 2 was conducted at a well-resourced school in an urban area. Inside the classroom, there were more than enough single desks and chairs for each learner. The desks and chairs were arranged in a linear, traditional manner with two rows of two desks next to each other. The learners remained seated at their desks for the entire lesson. A desk and chair were at the front of the classroom for the teacher.

Here, the teacher had a laptop that was connected to a projector, and the projection was displayed on a projection screen. While explaining the content, the teacher mostly remained at the front of the classroom, but during the practical section she walked through the classroom. The organisation of the classroom ensured that all learners could clearly see the teacher and the projection. There was adequate light provided by windows and artificial lighting.

A Grade 8 lesson was observed during a mid-day double period. The lesson consisted of an introduction to the PAT for Term 1, structures and mechanical systems, and a practical that required learners to complete the first section of the task. The teacher explained and discussed the expectations and requirements of the task and the choices the learners were going to have to make regarding different elements of their design. The task required the learners to design an amusement park ride. The phases of the design process that were discussed during the lesson included the investigation, design, communication and make phases. The phases that were covered during the practical section were the design phase since the learners had to have already done their research and investigation at home. The following figure is an excerpt from the project brief and practical task lesson.



Week 1: Investigation skills

An investigation is any kind of activity that involves getting to the truth or gathering facts.

Content: Frame structure with mechanisms
Context: Amusement park rides

A large shopping centre is planned near the place where you live. Your community wants a safe recreation area to be build next to the shopping centre. People's suggestions for the recreation are:

- an obstacle course that promotes fitness,
- a skate park
- a play park
- an amusement park

Amusement park
A collection of rides built to entertain a large group of people.

Before the local authorities approach the developers, they need to gather information about the wants and needs of the young people in the community. They have asked high schools for their learners inputs.

The headmaster of your school has asked the Grade 8 learners to suggest ideas on safety for the play areas and to develop models for the amusement park rides. He approached the Technology teacher for assistance. The Grade 8's need to design and make models for rides suitable for the amusement park. The rides need to include a frame structure as well as a mechanism.

1. Identify a frame structure and a mechanism that will be suitable for the ride that your class will design and make.

_____
_____ (2)

[Total investigation skills: 2]

Week 1: Design skills

A plan or drawing produced to show the look and function or workings of a object before it is made.

Draw a rough sketch followed by your final design of your ideas of your model of a ride. The model must be strong and rigid. The mechanism must generate movement in some part of the structure.
Your sketch needs to include the following:

- A heading (1)
- Labels (1)
- Dark outlines (1)
- Feint construction lines (1)
- Height, depth and length dimensions (3)
- The correct structure that you will be making (1)
- The correct mechanism that you will be making (1)
- Drawings must be in pencil (1)

Rough sketch

Figure 4.3: Observation 2: Excerpt of the project brief and practical task

Participant 9 had a definite pattern of asking questions. This corresponds with her interview answers, where she regularly referred to asking strategic or leading questions to foster CT dispositions. During the lesson, she repeatedly asked learners questions to make them think, and through their answers, covered the content. This questioning technique could prompt an inclination of analyticity in the learners. She asked numerous, different questions as part of the investigation, design and communication phases. For most of the questions, she gave learners the opportunity to practise and develop their CT self-confidence by allowing them to respond to the questions. She allowed more than one learner the chance to give their answer, explanation or opinion. In doing this, she was possibly modelling a truth-seeking spirit and open-mindedness by considering different opinions and respecting possibly divergent views. When the learners presented their answers, explanations and opinions, she provided informal feedback, which could develop and increase the trust they placed in their reasoning process (CT self-confidence). After these interactions where she asked a question, she modelled maturity of judgment by concluding what was said or providing an example and explaining the reason for the choices made. After asking the question, "Why do you think people would annotate a sketch?" (Participant 9) and allowing a learner to answer, she responded and concluded the following:

> *Exactly, I might be that person who has never seen an electric toothbrush in my life. So, if you have these buttons here and I don't know it is an on/off button you are going to confuse the client... same with your design today, you label it so you don't confuse me, your client. I want to know exactly what part is what part* (Participant 9).

Participant 9 also made use of examples in electronic form, like the electric toothbrush mentioned in the previous excerpt. When discussing an example, she modelled analyticity, a truth-seeking spirit, and maturity of judgment. She modelled analyticity by first discussing the example in general, and then modelling the reasoning process to apply it to the PAT scenario. By providing many different examples of materials and other elements, as required by the PAT, one could say that she modelled a truth-seeking spirit and possibly motivated learners' inquisitiveness. Furthermore, she made learners aware that they had to apply maturity of judgment by showing different examples and having class discussions on what is expected from them during the investigation, communication, and design

phases. In the following instance, she informed learners of different possibilities concerning the materials and choices they needed to make regarding their design:

> *If we look at material, you have different types of materials, you have wood, steel, you have plastic, you have fiberglass, you have different materials that you can take into consideration when building your ride. That is a specification, you need to be specific about what material you are going to use... don't just say I am going to use strong material* (Participant 9).

Participant 9 also projected a video with numerous examples of amusement park rides. It could be said that she sparked learners' curiosity (inquisitiveness) through these examples and also guided them to be truth seeking by bringing different possibilities to their attention. This coincided with her interview where she mentioned that she used videos and other electronic resources to aid in developing CT dispositions. Furthermore, as part of the class discussions around electronic examples presented or mental examples provided by the learners, she modelled open-mindedness by allowing many learners the opportunity to speak. The following was answered with regard to a question about webbing:

> *Give me a plain example that everyone could understand. *Learner name 1* and then I'll come to *learner name 2*.... you have a different example?* (Participant 9).

In Participant 9's interview, she frequently referred to the guidelines in the PAT and the rubrics of assessments as ways in which she fostered CT dispositions. During this lesson, which was structured around the PAT and how the design brief is formulated and laid out, she modelled systematicity. In her interview, she mentioned that she used PowerPoint slides to keep her lesson ordered and focused. This was evident during the observation as she used the slides to structure and guide the lesson. The organisation of the information was also systematic and, for the most part, matched the sequence of the questions in the PAT. The PAT was set up in an orderly manner; it was divided into different parts that followed each other. This required the learners to work in a specific manner to complete different sections in sequence, possibly fostering systematicity.

Before Participant 9 allowed learners to start working, she opened the floor for questions but eventually stopped because she wanted them to think for themselves.

This possibly required learners to trust in their own reasoning process (CT self-confidence) and also encouraged them to apply their maturity of judgment.

> *No, now you are asking too many questions, I want you to start thinking for yourself* (Participant 9).

While they were designing, she reminded them to consider alternative ideas (be truth seeking) by providing examples, and discussed how and why design ideas may change. The following is an example of an instance where she discussed the development of design ideas.

> *The person who designed the iPhone is not 100% happy with the design of the iPhone last year, he's like, 'you know what, I can develop this, let's bring out a new phone'* (Participant 9).

When the learners asked questions while working, she did not necessarily give the answer, but instead asked them another leading question, possibly cultivating a habit of analyticity (applying reasoning). Some of these questions concerned their reasoning process, where she provided informal feedback, possibly boosting CT self-confidence, and then provided the next step, thus encouraging systematicity. The classroom organisation did not hinder or assist in the fostering of CT dispositions while the learners were working.

In Participant 9's interview, she mentioned the importance of creating a comfortable classroom environment and atmosphere by knowing learners' names, making jokes and treating learners respectfully. During the observation, it was evident that Participant 9 knew the names of her learners and gave a fair chance to everyone to participate in class discussions and ask questions. She also gave praise to learners, acknowledged good and creative answers, and provided informal feedback as a response. It seemed that these actions encouraged a positive disposition to be truth seeking since the learners were eager to answer and ask questions.

It emerged from the observation that Participant 9 made use of questioning and examples, as well as the guidelines of the PAT to foster CT dispositions. She further made use of a practical session during which she created a comfortable classroom environment. Table 4.10 summarises how Participant 9 fostered CT dispositions during the observed lesson. The top row shows the four main strategies she used.

Some of these strategies were utilised with supporting strategies, as indicated in the cells. The grey cells designate that the specific strategy was not utilised to foster its corresponding CT disposition. An empty white cell indicates that the main strategy stipulated in the column was used without any supporting strategies being observed.

Table 4.10: Observation 2 summary

	Questioning	Examples	Assessments	Environment
Inquisitiveness		Resources		
Analyticity		Discussions Modelling		
Systematicity			Modelling Feedback	Assessment Questioning Resources
Truth seeking	Modelling	Discussions Modelling Resources	Discussion	
Open-mindedness	Modelling	Discussions Modelling		
CT self-confidence	Feedback		Discussion	
Maturity of judgment	Modelling Examples	Discussions Modelling		

As part of questioning, Participant 9 asked many direct and leading questions with occasional instances where learners asked questions. She fostered analyticity when asking questions, and CT self-confidence when allowing learners to answer. She further modelled a truth-seeking spirit and open-mindedness by allowing more than one learner to answer, and fostered maturity of judgment as part of consolidating the answers. While the learners were working, she guided them in systematicity and encouraged their CT self-confidence by providing informal feedback when answering their questions. Concerning the examples, Participant 9 made use of mental and electronic examples. She modelled and made learners aware of analyticity and

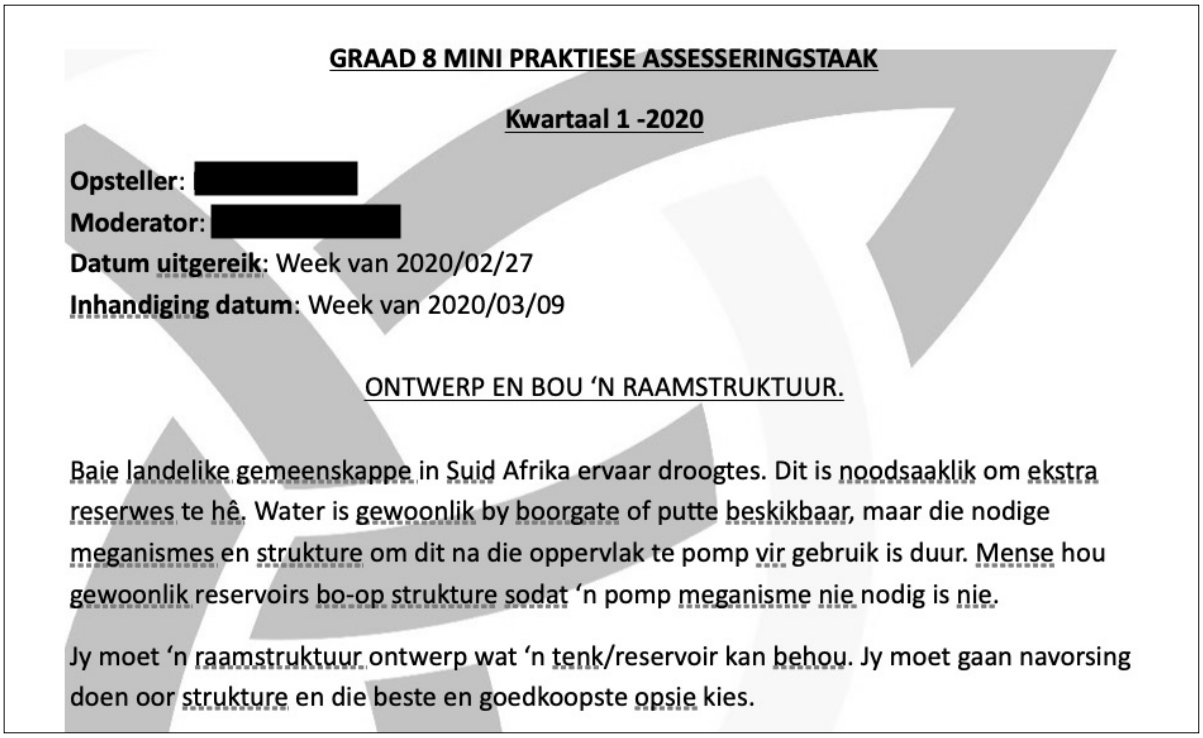
maturity of judgment through discussions about the examples provided. She also fostered inquisitiveness and a truth-seeking spirit by providing more than one example of a specific topic. As for the PAT, Participant 9 mostly fostered systematicity in the project layout and guidelines. Structuring the lesson around the task created a systematic environment, and providing informal feedback guided learners during the assessment activity. Furthermore, the practical session provided an opportunity for Participant 9 to also foster CT dispositions through class, group and individual discussion. She fostered a truth-seeking spirit by discussing the importance of being open to different possibilities. While interacting with learners when they asked questions, she encouraged analyticity, CT self-confidence, and maturity of judgment and further guided them in systematicity. She also fostered a truth-seeking spirit and CT self-confidence by creating a respectful and comfortable environment where learners were willing to ask and answer questions. She further fostered systematicity by organising the environment according to the PAT, as well as using resources and asking and answering questions to guide learners in systematicity. According to this analysis and discussion, Participant 9 fostered all the CT dispositions through a combination of strategies during the observed lesson.

4.3.3 Observation 3

Observation 3 was conducted at a well-resourced school in an urban area. The classroom was big enough to fit eight long tables where four learners could sit comfortably. The tables and chairs were arranged in a linear, traditional manner. The learners remained seated at their desks for the entire lesson, except when they had to organise themselves into groups. The learners could easily arrange themselves in a group around the long tables. From their seated position, they could see the teacher. A desk and chair were at the front of the classroom for the teacher. Here, the teacher had a laptop that was connected to a projector, and the projection was displayed on a whiteboard. The whiteboard was never used except to refer to an already existing list of the design phases. While discussing the PAT, the teacher remained at the front of the classroom. There was adequate light provided by windows and artificial lighting.

A Grade 8 lesson was observed during a late morning period after break. The lesson consisted of an introduction to the PAT for Term 1, which dealt with structures.

During the lesson, the teacher discussed the process and requirements of the PAT with the learners. The task required learners to design a frame structure that could hold a water tank. The phases of the design process discussed during the lesson were the investigate, design, make, evaluate and communicate phases. Figure 4.4 is an excerpt from the project brief.



GRAAD 8 MINI PRAKTIESE ASSESSERINGSTAAK

Kwartaal 1 -2020

Opsteller: [redacted]
Moderator: [redacted]
Datum uitgereik: Week van 2020/02/27
Inhandiging datum: Week van 2020/03/09

ONTWERP EN BOU 'N RAAMSTRUKTUUR.

Baie landelike gemeenskappe in Suid Afrika ervaar droogtes. Dit is noodsaaklik om ekstra reserwes te hê. Water is gewoonlik by boorgate of putte beskikbaar, maar die nodige meganismes en strukture om dit na die oppervlak te pomp vir gebruik is duur. Mense hou gewoonlik reservoirs bo-op strukture sodat 'n pomp meganisme nie nodig is nie.

Jy moet 'n raamstruktuur ontwerp wat 'n tenk/reservoir kan behou. Jy moet gaan navorsing doen oor strukture en die beste en goedkoopste opsie kies.

Figure 4.4: Observation 3: Project design brief excerpt

Participant 1 organised the entire lesson around the guidelines of the PAT. Since the PAT was set up in an orderly and focused manner, systematicity was consistently modelled through the assessment itself, and a systematic environment was created through the lesson structure. He systematically discussed each phase of the design process as set out in the PAT. During one of these class discussions, he provided a mental example of what was expected from learners. There was no use of any images, models or videos that could encourage inquisitiveness since the learners had to go and search for ideas because they could not respond to the images and videos provided by the teacher.

> *You probably recognise the JoJo tanks, those big tanks. So that is a big reservoir in which they can store water, but they put them on top of something so that the water can just flow out instead of them having to pump it up from below* (Participant 1).

As part of the PAT, the learners were required to work in groups. While discussing the design phase, he brought it to learners' attention that they would have to be respectful of their group members' opinions, be open-minded, apply good reasoning, analyticity and be judicious about their choices (maturity of judgment) when considering and deciding on their final design. Lastly, during a discussion with one learner, he modelled analyticity while explaining why the PAT problem is sensible. The following is how he explained the reasoning behind the scenario to the student:

> *A lot of rural areas do not necessarily have pump facilities to pump their water so what they do is they would put a tank on top of a frames structure so that the water can easily flow down* (Participant 1).

Participant 1 asked some direct questions while discussing the PAT. When asking these questions, he required the learners to apply reasoning (analyticity) to formulate an answer, and then provided them with the opportunity to develop and practise their CT self-confidence by allowing a learner to answer the question. After he discussed the entire PAT, he asked the learners questions about each phase of the process to check their understanding. In his interview, he mentioned that he believed that learners must explain their own understanding, and this was evident at the end of the lesson. After a learner answered the question, he summarised the answer through a class discussion. While summarising the answer regarding the identification of a problem, he modelled his own reasoning process (analyticity). During the summary of the investigation phase, he further modelled a truth-seeking spirit and open-mindedness. He also informed learners that they would have to apply good maturity of judgment while making decisions during the PAT.

> *Basically, what we are saying there is they have a shortage of water and they need a place where they can store it, they can't pump it from underground anymore so they are looking for another way to store it* (Participant 1).
>
> *Good, research about the structure, which structure can I use, will I use a big heavy thing that will cost a lot of money or will I make a cheap thing?* (Participant 1).

During Participant 1's interview, he regularly referred to the use of examples to foster learners' disposition towards CT. He mentioned that he would provide numerous examples to communicate the bigger picture and encourage discussions. The use of examples was very limited during this specific lesson. Participant 1 did, however,

make use of the PAT and questioning to foster CT dispositions. Table 4.11 summarises how Participant 1 fostered CT dispositions during the observed lesson. At the top are the two main strategies he used. Some of these strategies were utilised with supporting strategies, as indicated in the cells. The grey cells designate that the specific strategy was not utilised to foster its corresponding CT disposition. An empty white cell indicates that the main strategy stipulated in the column was used without any supporting strategies being observed.

Table 4.11: Observation 3 summary

	Assessments	**Questioning**
Inquisitiveness	Discussions Examples	
Analyticity	Discussions Modelling	Discussions Modelling
Systematicity	Discussions Environment Modelling	
Truth seeking		Discussions Modelling
Open-mindedness	Discussions	Discussions Modelling
CT self-confidence		
Maturity of judgment	Discussions	

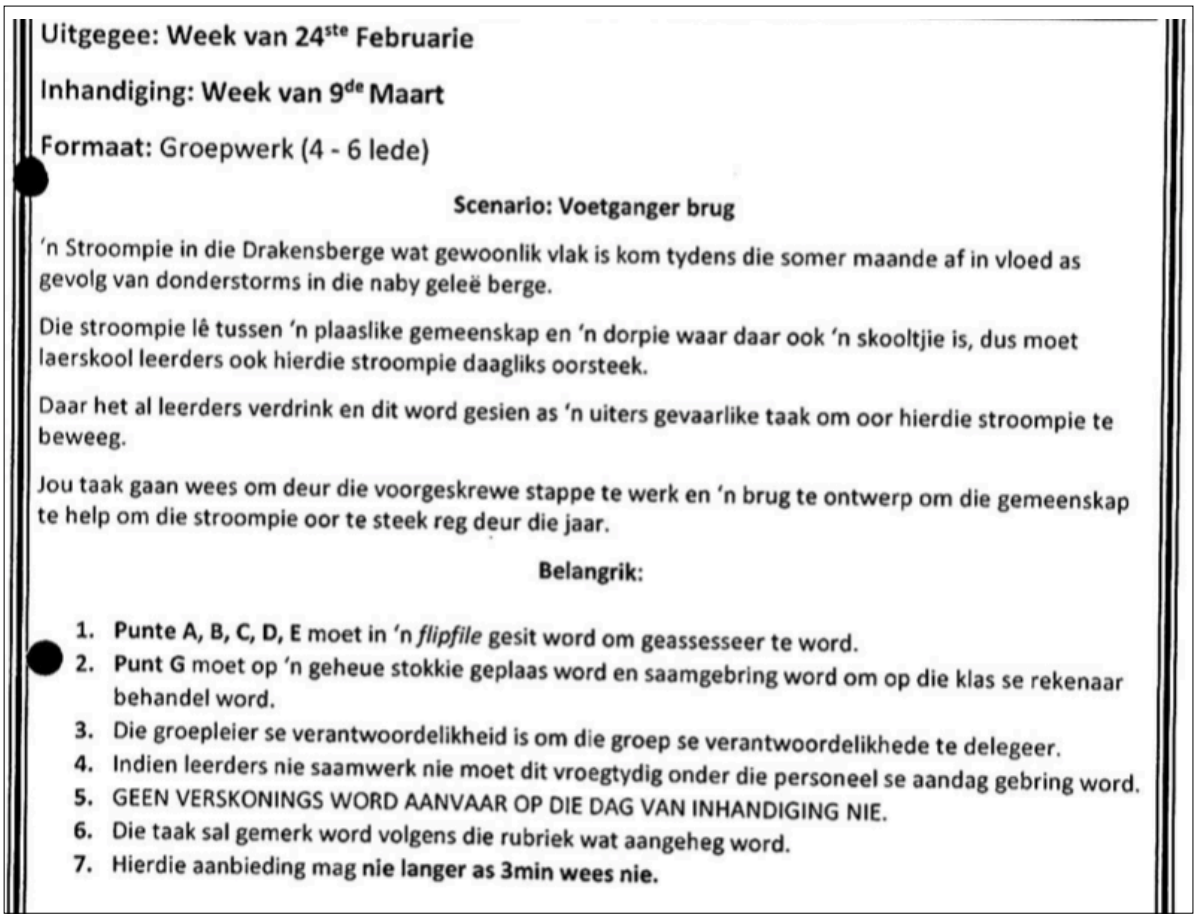
Participant 1 mainly fostered systematicity through the guidelines of the design brief, the lesson structure, and the classroom environment, which followed the process stipulated in the PAT. As part of the guidelines and class discussions about the PAT, he also fostered inquisitiveness, analyticity, open-mindedness and maturity of judgment. Furthermore, he made use of questioning. He fostered analyticity by asking direct questions and then provided the opportunity to develop CT self-confidence by allowing learners to answer. He also fostered a truth-seeking spirit, open-mindedness and maturity of judgment while checking if learners understood

each phase, and summarised the answers by discussing and modelling what was expected. Participant 1 fostered all of the CT dispositions through a combination of strategies during this observation.

4.3.4 Observation 4

Observation 4 was conducted at a well-resourced school in an urban area. The classroom was big and spacious, divided into a workshop and seating area. There were big, rectangular-shaped tables around which four to six learners could sit. The tables were organised in a linear manner, with learners seated around them in groups. The learners remained seated at their desks for the entire lesson, although some individuals occasionally moved around after the lesson was presented. The learners could easily adjust themselves to see the teacher. A desk and chair were at the front corner of the classroom for the teacher. The teacher's papers occupied one of the tables at the front in the middle of the classroom; most of the lesson was presented from this table. While discussing the PAT, the teacher mostly remained at the front of the classroom. When the learners started with their work after the lesson, he walked through the classroom to each table and interacted with each group. There was adequate light provided by windows and artificial lighting.

A Grade 9 lesson was observed during a mid-day period. The lesson consisted of an introduction to the PAT for Term 1 concerning structures. During the lesson, the teacher discussed the process and requirements of the PAT with the learners. There was enough time for learners to start working on their PAT in class, which required them to design a bridge. The phases of the design process that were discussed during the lesson were the investigate, design, make, evaluation and communication phases. The learners had to have already done some research as part of the investigation phase. The following figure is an excerpt from the project brief.



Uitgegee: Week van 24ste Februarie

Inhandiging: Week van 9de Maart

Formaat: Groepwerk (4 - 6 lede)

Scenario: Voetganger brug

'n Stroompie in die Drakensberge wat gewoonlik vlak is kom tydens die somer maande af in vloed as gevolg van donderstorms in die naby geleë berge.

Die stroompie lê tussen 'n plaaslike gemeenskap en 'n dorpie waar daar ook 'n skooltjie is, dus moet laerskool leerders ook hierdie stroompie daagliks oorsteek.

Daar het al leerders verdrink en dit word gesien as 'n uiters gevaarlike taak om oor hierdie stroompie te beweeg.

Jou taak gaan wees om deur die voorgeskrewe stappe te werk en 'n brug te ontwerp om die gemeenskap te help om die stroompie oor te steek reg deur die jaar.

Belangrik:

1. **Punte A, B, C, D, E** moet in 'n *flipfile* gesit word om geassesseer te word.
2. **Punt G** moet op 'n geheue stokkie geplaas word en saamgebring word om op die klas se rekenaar behandel word.
3. Die groepleier se verantwoordelikheid is om die groep se verantwoordelikhede te delegeer.
4. Indien leerders nie saamwerk nie moet dit vroegtydig onder die personeel se aandag gebring word.
5. GEEN VERSKONINGS WORD AANVAAR OP DIE DAG VAN INHANDIGING NIE.
6. Die taak sal gemerk word volgens die rubriek wat aangeheg word.
7. Hierdie aanbieding mag **nie langer as 3min wees nie.**

Figure 4.5: Observation 4: Project design brief excerpt

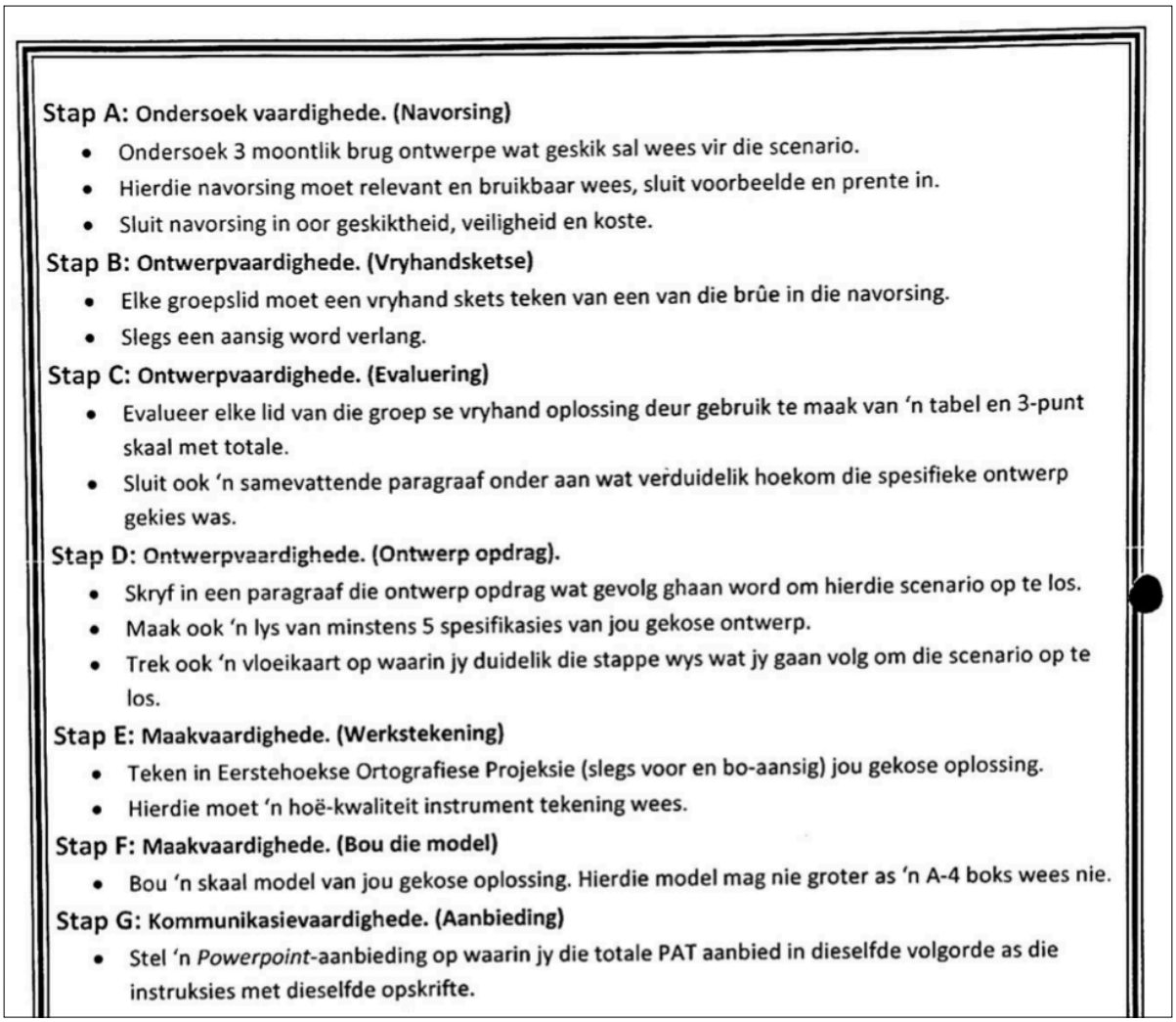
Participant 10 started the lesson by reading through the PAT scenario and thereafter asked a direct question about the research (investigation) phase, with which the learners had already started. On one occasion, he also introduced a scenario after which he immediately asked questions about it, which were as follows:

> *If I drive on the highway, why don't we put a zebra crossing on the highway?* (Participant 10).
>
> *What did you find was the best bridge over a distance that is stable?* (Participant 10).

Through these questions, Participant 10 required learners to think about the research they had done and the scenario they were confronted with, and come to a conclusion, possibly fostering analyticity. He further provided learners with the opportunity to trust in their own reasoning process, thus practising CT self-confidence by allowing them to explain their answer. While consolidating and answering the questions, he modelled maturity of judgment by being judicious about learners' answers and the decisions made in the example.

When explaining the PAT, he consistently asked direct questions about each phase. This correlates with his interview where he said that he tended to ask random questions during a lesson. The type of questions he asked ranged from reminding the learners about the specifications and the scenario stipulated in the design brief, what they should do in a specific phase, and general questions about the task at hand. Participant 10 mostly used questioning to ensure that the learners were paying attention. He asked specific learners to answer questions and would wait until they answered, even though other learners were willing to provide the answer. By checking that the learners were listening, he required them to be analytical. He further assisted them to trust in their own reasoning process and boosted their CT self-confidence by waiting for them to answer the questions. Generally, the learners gave the correct answer, but if they did not, he guided them to the answer with leading questions.

During Participant 10's interview, he regularly referred to the guidelines and requirements of assessments to foster CT dispositions. This was evident in the observation regarding the PAT itself, as well as his discussions and explanations around the PAT. Through class discussions about the PAT, Participant 10 modelled analyticity and systematicity. He encouraged analyticity through the questions he asked, and he modelled systematicity as part of the design, make and evaluation phases by explaining how to present their information in an orderly and focused manner. He also provided a physical example, a piece of paper, of what was expected from them regarding the design and evaluation phases. As a whole, he described and discussed the entire PAT process systematically, frequently by saying "then we get to your next point" (Participant 10). Figure 4.6 shows the steps and points in the project brief.



Stap A: Ondersoek vaardighede. (Navorsing)

- Ondersoek 3 moontlik brug ontwerpe wat geskik sal wees vir die scenario.
- Hierdie navorsing moet relevant en bruikbaar wees, sluit voorbeelde en prente in.
- Sluit navorsing in oor geskiktheid, veiligheid en koste.

Stap B: Ontwerpvaardighede. (Vryhandsketse)

- Elke groepslid moet een vryhand skets teken van een van die brûe in die navorsing.
- Slegs een aansig word verlang.

Stap C: Ontwerpvaardighede. (Evaluering)

- Evalueer elke lid van die groep se vryhand oplossing deur gebruik te maak van 'n tabel en 3-punt skaal met totale.
- Sluit ook 'n samevattende paragraaf onder aan wat verduidelik hoekom die spesifieke ontwerp gekies was.

Stap D: Ontwerpvaardighede. (Ontwerp opdrag).

- Skryf in een paragraaf die ontwerp opdrag wat gevolg ghaan word om hierdie scenario op te los.
- Maak ook 'n lys van minstens 5 spesifikasies van jou gekose ontwerp.
- Trek ook 'n vloeikaart op waarin jy duidelik die stappe wys wat jy gaan volg om die scenario op te los.

Stap E: Maakvaardighede. (Werkstekening)

- Teken in Eerstehoekse Ortografiese Projeksie (slegs voor en bo-aansig) jou gekose oplossing.
- Hierdie moet 'n hoë-kwaliteit instrument tekening wees.

Stap F: Maakvaardighede. (Bou die model)

- Bou 'n skaal model van jou gekose oplossing. Hierdie model mag nie groter as 'n A-4 boks wees nie.

Stap G: Kommunikasievaardighede. (Aanbieding)

- Stel 'n *Powerpoint*-aanbieding op waarin jy die totale PAT aanbied in dieselfde volgorde as die instruksies met dieselfde opskrifte.

Figure 4.6: Observation 4: Project steps

Participant 10 also made learners aware that they should be open-minded and apply maturity of judgment as part of the requirements of the PAT. The learners were required to work in groups, and he informed them of the fact that everyone in the group had to create a design. He explained that each person's idea would look different, and that the group had to choose the 'best' idea for the make phase. Through this process, they had to be open-minded, respect each other's ideas, and eventually apply maturity of judgment to make a decision.

> *If she comes and says she want to make a hang bridge for some reason and *Learner name* comes and he says he also wants to make a hang bridge, will their hang bridges look the same? So, you can draw a hang bridge and you can draw a hang bridge* (Participant 10).

He also explained to the learners that they had to decide what information they were going to add to their final drawing to effectively communicate their idea, possibly alerting them to the fact that they would have to apply maturity of judgment. Interestingly, when discussing the final presentation of the PAT, he informed learners that all group members had to be able to present their entire design presentation. He explained that he did this because they needed to know what was going on in their PAT and needed to take responsibility for finding out what was happening. This may have required learners to be more inquisitive as they had to stay well informed to receive good marks.

After finishing the lesson, Participant 10 allocated time for questions, possibly creating a more comfortable and open environment and atmosphere where the learners were willing to ask questions (being truth seeking). Thereafter, the learners could start working on their PAT. During this time, he responded to questions from learners by referring them back to the PAT brief, possibly guiding them in their reasoning process (analyticity) and how to be sensible about the decisions they made (maturity of judgment). In response to other questions, he modelled analyticity and CT self-confidence by explaining what he would do and how he thought about it. There was an instance where he provided informal feedback on a learner's freehand design drawings; he said that the one was not sufficient, while the other was a better attempt. In this instance, he was modelling analyticity and maturity of judgment by explaining what he meant and showing what needed to change, why and what the learner should keep. During this practical, the classroom organisation aided in the group discussions since Participant 10 could easily interact with the groups.

Throughout Participant 10's interview, he regularly referred to the use of resources. He would create opportunities and make resources available in the form of physical models and textbooks, but learners had to use and apply these themselves. During this specific lesson, he did not make any resources available. The learners were, however, allowed to take self-responsibility and use their cell phones (a resource) and search for information on the internet. This could encourage a truth-seeking spirit. As part of this lesson, he made use of questioning, the PAT structure, and the classroom environment to foster CT dispositions. Table 4.12 summarises how Participant 10 fostered CT dispositions during the observed lesson. At the top are the

three main strategies he used. Some of these strategies were utilised with supporting strategies, as indicated in the cells. The grey cells designate that the specific strategy was not utilised to foster its corresponding CT disposition. An empty white cell indicates that the main strategy stipulated in the column was used without any supporting strategies being observed.

Table 4.12: Observation 4 summary

	Assessments	Questioning	Environment
Inquisitiveness			
Analyticity	Discussions Modelling	Assessment Discussions	Modelling Feedback
Systematicity	Discussions Modelling		
Truth seeking			Questioning Resources
Open-mindedness			
CT self-confidence			Modelling
Maturity of judgment		Discussions Modelling Assessment	Modelling Feedback

Through the guidelines of the PAT, Participant 10 mainly fostered systematicity. When explaining the outline and requirements, he nurtured analyticity. The specific requirements of the PAT further fostered inquisitiveness, a truth-seeking spirit, open-mindedness, and maturity of judgment. Regarding questioning, he would require learners to engage in analyticity and then provide them with the opportunity to answer, developing CT self-confidence. He further modelled maturity of judgment when consolidating the answers given. When answering the learners' questions during the practical, he referred back to the assessment guidelines to encourage analyticity and maturity of judgment. As part of the practical, he fostered a truth-

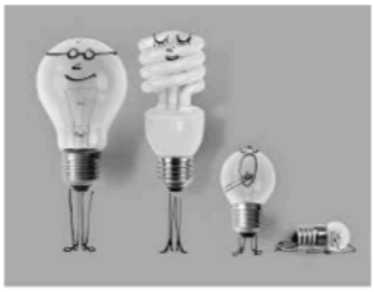
seeking spirit by providing learners with the opportunity to ask questions, and also responding to their questions promptly. Throughout the group discussions, he would provide informal feedback and model analyticity, CT self-confidence, and maturity of judgment. From the analysis and discussion of Participant 10's observation, it is evident that he fostered each CT disposition.

4.3.5 Observation 5

Observation 5 was conducted at a well-resourced private school in an urban area. The classroom had enough trapezium-shaped tables and chairs for each learner. Some chairs were higher than others, and group leaders used the higher chairs. The tables and chairs were arranged to form groups. The learners remained seated at their tables for the entire lesson. From their seated position, they could easily adjust themselves to see the teacher. A desk and chair were at the front of the classroom for the teacher. Here, the teacher had a laptop that was connected to a projector. There was also a whiteboard and numerous other resources available in the classroom, but none of these were used during this specific lesson. While explaining the content and interacting with the learners, the teacher constantly moved around the classroom. There was adequate light provided by windows and artificial lighting.

A Grade 9 lesson was observed during the last period of the day. The lesson consisted of a design activity to be completed in one lesson. The teacher went through the process with the learners by facilitating and guiding them through the different phases. The task required the learners to design packaging for a light bulb that can be used to create a light fixture. During the lesson, the focus shifted from only considering the packaging to also designing the light bulb. The phases of the design process that were discussed and practised during the lesson were the investigate, design, communicate and evaluate phases. Figure 4.7 illustrates the design activity brief.

DESIGN BRIEF



A light bulb company wants to extend their product range by minimising packaging waste. The company decides to develop a new range of light-bulb packaging that transforms into interesting light features. You are tasked with designing a package that will satisfy their want.

Take note of the following:
- Bulbs come in different shapes and sizes
- The packaging needs to contain and protect the bulb
- The light feature can be used in any context of your choice (a nursery, a fish tank, a waiting room, a party, a garden etc.)

Types of light bulbs:

Consider the following:
- Where will you design be used?
- Who are your intended clients?
- What are the important things to know and find out to ensure that your ideas are viable?
- Brainstorm design ideas
- Consider the promising and problematic aspects of your ideas

Figure 4.7: Observation 5 - Design brief (adapted from Kimbell, Wheeler, Miller & Pollitt, 2007)

At the start of the lesson, Participant 4 randomly assigned group leaders for the class activity. One could say that he gave these learners the opportunity to develop their CT self-confidence by having to take the lead in the activity. He made the leaders aware that they would have to apply maturity of judgment since they would have to manage ideas and decisions in order to achieve the outcome. At the start of the lesson, he quickly named the phases of the design process systematically. After that, he discussed the purpose of the whiteboard marker given to each leader. He said

that it could be used for its intended purpose, to write with, or could be applied in another way, like using it as a talking stick. During this discussion, he modelled analyticity by explaining why he would do this and also set the tone of being truth seeking since he was considering alternative uses of the item, which could motivate learners to think further than the obvious. The remainder of the lesson was structured around the activity. During the lesson, he frequently said: “next one to discuss” (Participant 4), which possibly indicates that he guided learners to follow the design process systematically.

While the learners were thinking, discussing, and designing, Participant 4 went to each group and asked them “what are you thinking” or “what is your idea?” The learners then discussed their ideas with him. The organisation of the classroom made it easier for Participant 4 to interact with the groups. When they explained their ideas, he provided positive informal feedback, possibly boosting their CT self-confidence and the trust they placed in their own reasoning process. In some instances, he also modelled and guided them in analyticity and maturity of judgment by summarising their ideas and highlighting the critical elements thereof. Through some of his summaries, he consolidated the essence of their ideas, possibly guiding them to communicate their ideas more systematically. An example of his summary after learners gave an elaborate explanation is as follows:

> *Lights that the doctors use but you don’t have to be blinded when you open your eyes* (Participant 4).

When the learners presented more than one idea, Participant 4 made them aware that they would have to apply maturity of judgment and make a choice because they had limited time, requiring them to engage in reasoning (analyticity).

> *Decide on one of the topics so decide, either pool or phone, don’t do both. It will be too much* (Participant 4).

Furthermore, Participant 4 created opportunities where the groups had to communicate their ideas to the class, and he asked strategic questions to guide them to engage in analyticity and maturity of judgment to explain their designs better. There were a few occasions that discussions started with questions from the learners. These questions were mostly regarding their thinking and reasoning process. To answer these questions, he modelled his own reasoning process,

analyticity, CT self-confidence, and maturity of judgment through a group discussion and by providing mental examples. There was one instance where learners evaluated their idea in their group and wanted to discuss and confirm their findings with Participant 4. He provided informal feedback by recognising that they had applied maturity of judgment, possibly boosting their CT self-confidence, and alerted them to how and where they would communicate these findings, guiding them in systematicity.

Participant 4 mentioned in his interview, and it was evident in the classroom, that he worked at a well-resourced school where they had 3D printers, laser cutters and each learner had a tablet connected to the internet. He used these resources to enhance his lessons and aid in fostering CT dispositions. During this lesson he only encouraged learners to use their tablets for inspiration, possibly motivating an eagerness to learn and be well-informed (inquisitiveness). While discussing the phases of their process, Participant 4 provided mental examples of how to answer each question that was asked. Here, he encouraged open-mindedness by exposing the learners to different ways of answering the questions in the activity.

> *I did tell you to bring your tablets so you can also look online for some inspiration* (Participant 4).

Furthermore, Participant 4 elaborated and expanded on learners' ideas by offering more examples of what they could do or providing different aspects of their idea that they had to consider. In these instances, he was possibly encouraging learners to be more inquisitive, truth seeking and open-minded. He further modelled analyticity to guide them in their reasoning process, and made them aware of where they would have to apply maturity of judgment during the discussions.

> *Or what you can do, what I was thinking is, that roll is loose right, imagine you put a box around it and there is a pin at the bottom, so it's almost like masking tape* (Participant 4).

Participant 4 created a comfortable environment and atmosphere in which learners were more than willing to ask questions, engage in discussions, and actively interact with the content of the lesson. Whenever a learner had a question, he immediately stopped to answer the question, and all questions were validated and answered with respect. During Participant 4's interview, he mentioned that he found it very important

to discuss different ideas from different people. All of the groups and individual learners were provided with the opportunity to answer specific questions, which could motivate them to understand and respect other's views (open-mindedness) and be eager to learn (inquisitiveness) since the learners were exposed to different ideas. In allowing each group to communicate their ideas, he provided them with the opportunity to practise and develop trust in their reasoning process (CT self-confidence). He further boosted their CT self-confidence by providing positive feedback and recognising good ideas and elements by saying "that is a good idea" or "that can work" (Participant 4). He also explained learners' ideas back to them to show that he was listening. It could be said that all of this creates an environment where learners are comfortable and eager to ask questions, fostering a truth-seeking spirit.

Participant 4 mostly used the assessment to engage in class and group discussions; although he also used questioning, provided examples, and created a comfortable classroom environment to foster a variety of CT dispositions. Table 4.13 summarises how Participant 4 fostered CT dispositions during the observed lesson. At the top are the four main strategies he used. Some of these strategies were utilised with supporting strategies, as indicated in the cells. The grey cells designate that the specific strategy was not utilised to foster its corresponding CT disposition. An empty white cell indicates that the main strategy stipulated in the column was used without any supporting strategies being observed.

Table 4.13: Observation 5 summary

	Assessment	**Questioning**	**Examples**	**Environment**
Inquisitiveness			Discussions	Questioning
Analyticity	Discussions Modelling	Discussions Examples Modelling		
Systematicity	Discussions Modelling			
Truth seeking	Discussions		Discussions	

	Assessment	Questioning	Examples	Environment
Open-mindedness			Discussions	Questioning
CT self-confidence	Feedback	Discussions Examples Modelling		Feedback
Maturity of judgment	Modelling	Discussions Examples Modelling		

Analyticity, systematicity, and a truth-seeking spirit were encouraged through mostly group discussions around the assessment. As part of the group discussions, Participant 4 modelled analyticity, CT self-confidence, and maturity of judgment by asking and answering questions. During these discussions about the assessment, he also guided learners in systematicity. He further made use of direct and leading questions with the support of mental examples, discussions, and modelling to foster analyticity, CT self-confidence, and maturity of judgment. Concerning examples, he fostered inquisitiveness, being truth seeking and open-minded by providing and discussing different ideas. He also fostered maturity of judgment by making learners aware of the decisions they would have to make. Furthermore, Participant 4 mainly fostered a truth-seeking spirit by creating a comfortable environment for learners. Allowing everyone an equal opportunity to ask and answer questions and communicate their ideas, he also encouraged inquisitiveness and open-mindedness. He further fostered CT self-confidence by frequently providing feedback and fostered CT self-confidence and maturity of judgment through the way he set up the environment by randomly selecting leaders at the beginning of the lesson. During this lesson, Participant 4 encouraged and fostered all of the CT dispositions through a combination of strategies.

4.3.6 Observation Summary

Table 4.14 is a summary of how the CT dispositions were fostered during all of the observations. Assessments, questioning, examples, and the classroom environment were the main strategies that were utilised by most of the participants with supporting strategies, which included discussions, feedback, modelling, and the use of

resources. The main strategies are communicated in the top row of the table, and the supporting strategies in the cells.

Table 4.14: Observation summary

	Assessments	Questioning	Examples	Environment
Inquisitiveness	Discussions Examples	Modelling	Discussions Resources	Questioning
Analyticity	Discussions Modelling	Assessment Discussions Examples Modelling	Discussions Modelling Resources	Feedback Modelling
Systematicity	Discussions Environment Feedback Modelling	Discussions Modelling	Modelling Resources	Assessment Questioning Resources
Truth seeking	Discussions	Discussions Modelling Environment	Discussions Modelling Resources	Questioning Resources
Open-mindedness	Discussions	Discussions Modelling	Discussions Resources	Questioning
CT self-confidence	Discussions Feedback	Discussions Examples Feedback Modelling	Feedback	Feedback Modelling
Maturity of judgment	Discussions Modelling	Assessment Discussions Examples Modelling	Discussions Feedback Modelling Resources	Feedback Modelling

Table 4.14 concludes the discussion about the observations. In this discussion, it was evident that there are four main strategies that many of the observed participants used to foster all of the CT dispositions. These strategies were identified as the focus when fostering the CT dispositions, acting as a platform for or integrating with supporting strategies that would emerge because of the initial action. These four main strategies were generally used in combination with each other and with supporting strategies to foster all of the CT dispositions. The main strategies include the use of assessments, specifically the project brief; questioning; examples; and the classroom environment.

The formulation of the assessments strongly fostered systematicity through the guidelines in the project brief. The requirements in the brief generally led to the supporting strategy of discussions around the expectations of the project to foster all of the CT dispositions. During these discussions, the participants would also model analyticity and maturity of judgment, and refer to examples to aid in the process of cultivating inquisitiveness. Feedback was generally provided to encourage CT self-confidence in learners and guide them in systematicity. Lastly, the assessment provided a platform for the lesson structure and, in doing so, created an ordered and focused classroom environment.

Through the use of questioning, analyticity and CT self-confidence were consistently fostered. When the participants asked a question, they would require leaners to apply analyticity and then provide them with the opportunity to practice their CT self-confidence. The participants tended to model maturity of judgment and systematicity as a response to the answers provided by learners to the questions they asked. They also modelled many of the other dispositions as part of discussions and examples presented after a question was asked. On occasion, the assessment, feedback, and the classroom environment were also used as supporting strategies to questioning. The answering of questions led some participants to refer back to the assessment to motivate analyticity and maturity of judgment or provide the opportunity for feedback to foster CT self-confidence. Lastly, the act of allocating time for questions at the end of the lesson led to creating a classroom environment where learners were provided with the opportunity to be truth seeking.

The use of examples generally led to discussions to foster inquisitiveness, analyticity a truth-seeking spirit, open-mindedness, CT self-confidence, and maturity of judgment. When an example was provided by a participant or one of the learners, a discussion would usually follow and the participants generally modelled analyticity, a truth-seeking spirit, and maturity of judgment during these interactions. Some of the participants made use of resources, usually PowerPoint presentations, to visually present examples to the learners. Through these presentations, they would model analyticity, systematicity, and maturity of judgment by providing an ordered and focused example. They further made use of the resources to nurture inquisitiveness, a truth-seeking spirit, and open-mindedness by exposing learners to a variety of

possibilities. Providing feedback was occasionally used when commenting on learners' ideas and examples to foster CT self-confidence and maturity of judgment.

The last main strategy, the classroom environment, was not necessarily a strategy used from which supporting strategies would explicitly flow. It was rather a strategy that had been cultivated over time to act as a platform for the fostering of a variety of CT dispositions. Firstly, the atmosphere and opportunities that the participants created in the classroom environment to ask questions encouraged learners' inquisitiveness and open-mindedness. They further created a comfortable and open classroom environment that strongly encouraged a truth-seeking spirit. The learners were willing to ask questions and some were allowed to use their cell phones as a resource to search for knowledge. By structuring the lesson around the project brief, which strongly fosters systematicity, using questioning to guide learners and utilising resources in the form of slides to structure the lesson meant that the participants created an environment in which orderly and focused communication were important. While the learners were working, the participants further created an environment that was conducive to CT by providing feedback and modelling analyticity, CT self-confidence, and maturity of judgment.

It is worth mentioning that modelling and discussions were used to support all of the main strategies numerous times. This indicates that having a discussion or modelling a disposition usually followed or was a result of using one of the main strategies. The four main strategies were also occasionally used as supporting strategies a similar amount of times. This suggests that even the main strategies can be a result of using another strategy. As for the use of resources and providing feedback, the participants used these supporting strategies the least. The use of resources was not observed for the fostering of CT self-confidence and providing feedback was not observed for nurturing inquisitiveness, a truth-seeking spirit and open-mindedness. This does not suggest that these strategies were deemed as less valuable or were not used; it only indicates that they were not witnessed during the five observations.

All of the dispositions were fostered across the four main strategies with supporting strategies, and all the strategies identified during the interviews were observed. In the following section, the results of the interview and observation data are consolidated through a comparative discussion.

4.4 Discussion

Eight strategies used by these technology teachers to foster CT dispositions emerged from the analysis of the data collected during the interviews. These strategies include: assessments; discussions; classroom environment; examples; feedback; modelling; questioning; and resources. During the interviews, the participants mentioned at least five of the strategies used to nurture each CT dispositions with systematicity being the only disposition fostered by using all of the strategies.

Assessments, specifically design tasks, were the most frequently mentioned strategy in discussing the nurturing of all of the CT dispositions. This made observing a lesson concerning a design activity an appropriate context for witnessing the fostering of CT dispositions. This corresponds with the literature, which indicates that the design process presents an ideal opportunity to foster CT dispositions. It is argued that problem solving and decision making are key processes in the design process (Lawson & Dorst, 2009; Ohemeng-Appiah, 2014; Schooner et al., 2017). These activities are considered instances where CT should take place to deliver the best results (Bailin et al., 1999).

Questioning was the only other strategy referred to in order to foster all of the CT dispositions during the interviews. Ennis (1996) holds that questioning is essential, especially the ability to ask pointed questions. Schooner et al. (2017) further find that Swedish technology teachers tend to use questioning to explore concepts and ideas critically.

The use of discussions, the classroom environment, examples, and modelling were mentioned to foster most of the CT dispositions. The participants frequently mentioned the use of discussions, the classroom environment, and examples to foster a variety of dispositions, but only some described the act of modelling the dispositions, even if it was regarding most of the dispositions. Resources were also frequently mentioned, even if it was only in relation to fostering five of the seven dispositions.

Concerning discussions, Yang and Chou (2008, p. 668) mention that it is important to "provide opportunities for peer interaction around thinking" to teach and encourage CT dispositions. As for modelling, Facione (2000) states that it is useful in fostering CT dispositions. Yang and Chou (2008, p. 668) also discuss the principles for teaching CT dispositions to "provide good models of good thinking behaviour." The classroom environment can be associated with these principles to "cultivate a culture of reasoned thinking and evidence based inquiry" (Yang & Chou, 2008, p. 668). This could relate to the structure of lessons and the rules to be followed in the classroom environment. From the literature review conducted in this study, no explicit research was found regarding the use of examples or resources. It is, however, possible that these strategies may form part of assessments, questioning, and discussion.

The main strategies utilised during the observations included the use of assessments, questioning, examples, and the classroom environment. This means that these strategies were evident in both the interview and observation data. The participants further referred to modelling during the interviews which was observed as a strong supporting strategy during the observations. Furthermore, engaging in discussions, as mentioned during the interviews, also functioned as a strong supporting strategy during the observations. Interestingly, the use of a wide range of resources came up frequently during the interviews to aid in the fostering of CT dispositions. This was not as evident during the observed lessons; the only resources visible in some of the observations were PowerPoint presentations, hard copy assignments, and access to the internet through mobile devices. Furthermore, the use of feedback was only mentioned or utilised a limited amount of times during the interviews and observations, but was still considered a valuable strategy by some of the participants.

When considering each disposition, the strategies that the participants mentioned during the interviews to foster inquisitiveness, systematicity and a truth-seeking spirit corresponded with those witnessed during the observations. For systematicity, this included all of the strategies. As for inquisitiveness and a truth-seeking spirit, the strategy of providing feedback was not mentioned during the interviews or noted during the observations to foster either. The strategies to which the participants referred regarding analyticity, open-mindedness, CT self-confidence, and maturity of

judgement were all observed in these lessons, together with some additional strategies. During the observation, the classroom environment was used to foster analyticity, which was not mentioned during the interviews. The use of resources was observed as an additional strategy to nurture open-mindedness. Modelling and the use of examples were witnessed to foster CT self-confidence, and discussions were used to nurture maturity of judgment during these lessons. Moreover, providing feedback was not referred to or observed to cultivate open-mindedness, and the use of resources was not mentioned or noted to foster CT self-confidence.

Even though there were some strategies that were not used to foster certain CT dispositions, many of the strategies overlapped and supported the use of other strategies. The interview questions were structured around each disposition separately. This made it seem that a combination of strategies could foster specific dispositions, however, during the observations it was evident that a combination of strategies was used to cultivate a combination of CT dispositions. Table 4.15 amalgamates the findings from the interview data (see Table 4.9), and the findings from the observations data (see Table 4.14). In the interview analysis, eight strategies were identified alongside the context in which the participants referred to the strategy. During the observation analysis, it was noted that the participants used a main strategy that acted as a platform for or led to the use of supporting strategies. In Table 4.15, these findings are combined to illustrate how the participants fostered a positive disposition towards CT. The main strategies are presented at the top, followed by the supporting strategies. The context in which each strategy was referred to and used is listed in the cells.

Table 4.15: Strategies used to foster a positive disposition towards critical thinking

Main strategies			
Assessments	**Environment**	**Questioning**	**Examples**
Problem choice	Atmosphere	Direct	Physical
Guidelines	Lesson structure	Leading	Electronic
Rubric	Class rules	Reward	Mental
		Answer	
Platform for using other strategies		Leads to the use of other strategies	

Supporting strategies			
Discussions	**Modelling**	**Feedback**	**Resources**
Class Group Individual	Demonstration	Informal Formal	Physical Electronic

Table 4.15 indicates that there are four main strategies and four supporting strategies that the participants used to foster a positive disposition towards CT. The four main strategies represent the initial action taken by the participants. These actions would act as a platform for or lead to the use of other strategies. When a main strategy is used, another main strategy may follow or a supporting strategy would be used. Many different combinations of these strategies could be used to foster a positive disposition towards CT.

The main strategies of assessments (Fahim & Ghamari, 2011) and questioning (Halpern, 2014; Schooner et al., 2017; Zabit, 2010), as well as the supporting strategies of discussions (Fahim & Ghamari, 2011; Mandernach, 2006) and modelling (Facione, 2000) were found in the literature regarding the fostering of CT, its skills, and dispositions. The main strategy of the classroom environment and supporting strategy of providing feedback relate to the principles for teaching CT dispositions as summarised by Yang and Chou (2008). The three main strategies – assessments, environment and questioning – and the three supporting strategies – discussions, modelling and feedback – corroborate the strategies mentioned in the literature to nurture CT and CT dispositions. No explicit literature was found regarding the use of examples or resources to foster CT dispositions. Furthermore, no clear research about how the strategies are used and how they actualise in the classroom were found either. Strategies were usually mentioned separately with no indication of other strategies being used simultaneously.

4.5 SUMMARY

In Chapter 4, the results and discussions on the analysis of the collected data were presented. The discussion on the interviews was structured around the seven CT dispositions. Each disposition was discussed in relation to the strategies referred to by the participants and the context in which they used them to foster specific CT

dispositions. Thereafter, each observation was discussed separately. The discussion was structured around each participant and their own combination of strategies used to foster CT dispositions. When comparing the results of both data sets, all of the strategies mentioned in the interviews were noted during the classroom observations. It was concluded that a combination of four main strategies were used with supporting strategies to foster a positive disposition towards CT. In Chapter 5, the findings, limitations and significance of this research are discussed to conclude the study.

CHAPTER 5 SUMMARY AND CONCLUCIONS

5.1 OVERVIEW OF THE CHAPTER

This study investigated how Grades 8 and 9 technology teachers describe the strategies they use to foster CT dispositions. The researcher also observed how these strategies were actualised in the classroom. Chapter 5 serves as a summary and conclusion to the research process and findings. It commences with an overview of the previous chapters, and a discussion of the research questions. This is followed by a description of the limitations of this study and recommendations for future research. Lastly, a conclusion is provided to consolidate the dissertation.

5.2 SUMMARY OF THE CHAPTERS

In Chapter 1, it was pointed out that CT, and its skills and dispositions are important to achieve personal and professional success in life. Educational institutions play an important role in preparing children for this accomplishment and should be committed to teaching CT. There is a perception that schools are not doing enough in this regard. The research regarding CT is mostly focused on CT skills and there is a paucity of literature concerning the dispositional component. Being disposed to CT indicates that a person is willing to use and apply CT skills. It is important to engage in CT and be inclined to think critically during problem solving. The subject technology offers many opportunities to foster CT dispositions due to the need for problem solving during the design process. Since the nature of technology education and the design process present many opportunities to think critically, the study aimed to investigate how technology teachers foster a disposition towards CT. The intention was to gain a greater understanding of the strategies used by teachers, which would ideally improve our approach to the learning and acquisition of CT dispositions in learners.

A review of the current literature and the conceptual framework were presented in Chapter 2. The literature review commenced with a discussion of CT, and its associated skills and dispositions. It was found that to be considered a strong critical thinker, one must have CT skills and also be disposed towards CT. Thereafter, the importance of and approaches to teaching CT were explained and described. Being

a strong critical thinker is valuable in our ever changing and transforming society, and it is important that instruction is given in this regard by educational institutions. The approach followed by the South African curriculum is the infusion approach where CT is seen as a generic skill to be taught across all subjects with the support of subject-specific content. Some strategies were found in the literature concerning the teaching of CT, which include the use of questioning, discussions, assessments, and modelling. Regarding the dispositional component of CT, the literature presented only principles that could be followed to develop learners' internal willingness to think critically. This was followed by a discussion on problem solving as an important skill to teach in technology and the design process. Furthermore, the conceptual framework for this study was explained. The framework was informed by Facione's (2011) seven dispositions towards CT, and the design process stipulated in the CAPS document for technology. The framework indicates that if an individual is disposed towards CT, they would be inclined to solve design problems presented in technology critically. In turn, the design process in technology presents the opportunity to nurture a problem-solving spirit and cultivate a positive disposition towards CT.

In Chapter 3, the research design and methodology employed in this study were described and discussed. The interpretivist paradigm, together with the qualitative research approach and a multiple case study design, was chosen. This allowed the researcher to gain an in-depth understanding of the participants' perceived strategies. It also made it possible to describe how these strategies are actualised in the technology classroom. The participants were purposefully chosen to gain an in-depth understanding of how technology teachers foster CT dispositions. Through the data collection methods, which consisted of interviews and observations, and a thematic analysis of all the data sets, this understanding was obtained. To address the rigour of the data collection and analysis, various strategies were used to improve this study's credibility, transferability, dependability and confirmability. The chapter concludes with the ethical considerations regarding the data, participants, permissions and benefits, consequences, and reciprocation.

The analysed data and discussion of the findings were presented in Chapter 4. The discussion commenced with a report on the interview data. This report was

structured around the seven CT dispositions. Each disposition, along with the strategies that the participants mentioned to nurture them were discussed separately. It was found that the participants described a combination of eight strategies to foster all of the dispositions. Thereafter, each classroom observation was presented by looking at how each participant fostered CT dispositions during one design-related lesson. All of the strategies identified during the interviews were observed. The observations provided greater insight into how these strategies are used. In the interview data, it was noted that the participants used a combination of strategies to foster a specific disposition. During the observations, it was evident that the participants used main strategies in conjunction with supporting strategies to foster a combination of CT dispositions. The chapter was concluded with a comparative discussion on the interview and observation analysis and results.

5.3 REVISITING THE RESEARCH QUESTIONS

The purpose of this study was to explore and describe how technology teachers foster a positive disposition towards CT in learners. The inquiry was guided by one main question and two sub-questions. Interviews were conducted to answer sub-questions 1, and classroom observations to answer sub-question 2.

The main research question is:

How do technology teachers perceive and actualise the fostering of critical thinking disposition in their classroom?

5.3.1 Sub-question 1

How do technology teachers describe the strategies they use to develop learners' disposition towards critical thinking in their practice?

Ten technology teachers were interviewed to determine how they described the strategies that they used to foster learners' disposition towards CT. Eight strategies were identified during the analysis of the interview data. These strategies include: the formulation of assessments; encouraging and engaging in discussions; the creation of a comfortable classroom environment; providing examples; giving feedback; modelling the dispositions; asking questions; and using resources.

The participants described the eight strategies being used in different ways. *Assessments* were generally mentioned by referring to the task rubric together with the choice of problem for design projects and the provided guidelines or instructions. From their descriptions, the participants used the formulation of assessments to guide and require learners to engage in CT. The participants further spoke about engaging in and encouraging *discussions*. They mostly referred to class discussions but would also occasionally use group and individual discussions to foster CT dispositions. Many of the participants spoke about creating a classroom *environment* that is conducive to CT. They predominantly spoke about creating an atmosphere where learners feel comfortable to apply and practise the CT dispositions. Also relevant to the classroom environment was the lesson structure and class rules, which the participants used to keep the environment ordered and focused. The participants further described a combination of physical, electronic and mental *examples* to cultivate a positive disposition towards CT. They described providing informal *feedback* during class interactions and design process activities, as well as formal feedback after the completion of projects or assessment phases. The participants also spoke about *modelling*, demonstrating the dispositions to learners to motivate them to act in the same manner. They further referred to using *questioning* to encourage an internal willingness to think critically. The participants mostly described the use of direct and leading questions to ask questions or make learners aware of their actions, and to lead them to a solution. Lastly, the participants described the use of physical and electronic *resources* to aid in nurturing CT dispositions.

The use of assessments and questioning came up frequently regarding all of the CT dispositions. Followed by discussions, the classroom environment, examples and modelling that were used to foster most of the dispositions. The use of resources was mentioned frequently, but only to foster five of the seven dispositions. Lastly, providing feedback was referred to a limited amount of times, and only in terms of fostering four dispositions.

5.3.2 Sub-question 2

How are these perceived strategies actualised in their classrooms?

Five of the ten teachers were observed during a design-based lesson to determine the practical application and actualisation of these strategies in the classroom. During the classroom observations, all of the strategies identified in the interviews were noted. Similar to the strategies that were prominent during the interviews, the participants frequently made use of the assessment and questioning to nurture a positive disposition towards CT. Most of the participants regularly used discussions; created a comfortable, open, respectful and orderly classroom environment; used examples; and modelled the dispositions. The use of resources, which was frequently mentioned in the interviews, was not as evident during the observations. Finally, the provision of feedback was mentioned and observed only a limited number of times during the interviews and observations.

The eight strategies that the participants described during the interview actualised in the classroom as four main strategies – assessments, questioning, examples, environment – and four supporting strategies – discussions, modelling, feedback, and resources. It was evident that the use of assessments, questioning, examples, and the classroom environment acted as a platform for or led to the use of the supporting strategies, and occasionally other main strategies. Discussions and modelling were supporting strategies that were frequently observed to be the result of using one or more of the main strategies. Providing feedback and the use of resources were not noted as frequently, but were still observed in the process of fostering a positive disposition towards CT.

Table 5.1 summarises the findings of this study and answers the main research question, which is *How do technology teachers perceive and actualise the fostering of critical thinking disposition in their classroom?* The table illustrates the way in which the participants used eight strategies to foster CT dispositions. The four main strategies: assessments; environment; questioning; and examples are presented at the top of the table. This is followed by the four supporting strategies: discussions; modelling; feedback; and resources. The context in which each strategy was referred to and used is listed underneath each main or supporting strategy respectively.

Table 5.1: Strategies used to foster a positive disposition towards critical thinking

Main strategies			
Assessments	**Environment**	**Questioning**	**Examples**
Problem choice	Atmosphere	Direct	Physical
Guidelines	Lesson structure	Leading	Electronic
Rubric	Class rules	Reward	Mental
		Answer	
Platform for using other strategies		Leads to the use of other strategies	
Supporting strategies			
Discussions	**Modelling**	**Feedback**	**Resources**
Class	Demonstration	Informal	Physical
Group		Formal	Electronic
Individual			

Table 5.1 shows the four main strategies and four supporting strategies that the participating technology teachers used to nurture CT dispositions. These strategies were not used in isolation; the use of a main strategy would generally lead to or act as a platform for another strategy. The main strategies designate the initial action taken by a teacher in the process of cultivating a positive disposition towards CT. This action would be followed by the use of another main strategy or supporting strategies. Supporting strategies are strategies that generally occur as a result of or in conjunction with other strategies. A combination of the strategies mentioned in Table 5.1 was used to foster a positive disposition towards CT.

5.4 LIMITATIONS OF THIS STUDY

In this section, the limitations of this study concerning the sample size, sample profile, and the duration of the study are discussed.

Purposive and convenience sampling were used in the selection of participants. Ten technology teachers were chosen to participate in this study, five of whom were observed for one lesson. This is not a particularly large sample, especially with regard to the five teachers who were observed. During the interviews, data saturation

occurred, but for the observations, only the teachers who were willing to be observed and who still taught in the areas for which permission was received from the schools and the Department of Basic Education participated. This study can therefore only report on descriptions from a small number of technology teachers and provide a limited account of the actualisation of the strategies in the classroom.

The selected teachers all taught at well-resourced schools situated in Pretoria and Johannesburg. The intention was to select teachers who would not be limited by the resources they had available to foster CT dispositions. The prevailing consideration was to ensure that the researcher was able to easily gather the data. This sample profile is not exhaustive, and is limited to a very specific group of teachers. Furthermore, this study only considered how teachers describe the way in which they foster CT dispositions and how these perceived strategies are actualised in the classroom. Learners' opinions, experience or ideas about their teacher's strategies were not considered. This study is therefore limited to the experiences and intention of the teachers who worked at specific schools in specific areas.

The data collection phase of this study was completed over a seven-month period. The interviews started during the third term of the school year and, due to regulations stated by the Department of Basic Education, observations could only commence the following year in Term 1. The five teachers who were observed were only observed for one lesson and a small component of the design process. The fact that only one lesson was observed indicates that no conclusions could be made about the fostering of CT dispositions during the entire design process or school year.

5.5 Recommendations for future research

In this section, recommendations for further research are discussed. The recommendations include considering a greater number and variety of participants, investigating the effectiveness and success of the identified strategies, and longer periods of observation.

5.5.1 Inclusion of a variety of participants

Very specific schools and teachers were chosen to participate in this study. Participants from well-resourced schools were purposefully considered. It is

important to note that even though many participants referred to the use of resources in the interviews, their actualisation was not as strong during the observations. This suggests that teachers from under-resourced schools may not necessarily be limited by resource availability in the classroom and could possibly provide more ways of fostering CT dispositions. Even though qualitative, case study research is characterised by fewer cases (Creswell, 2012), a wider range of participants from a variety of contexts could provide more insights into the fostering of CT dispositions and possibly reveal more strategies.

In qualitative research, the researcher is generally present during data collection, which may influence the participants' responses and actions (Creswell, 2014; Mohajan, 2018). As part of the interviews, the participants could describe ideal situations or strategies that they would like to use but were not necessarily using in their classrooms at the time of this study. During the observations, it was possible that the participants were influenced by the presence of the researcher, which could result in them acting differently than they would normally. Since learners are the receivers of the strategies their teachers use during a school year, it may be valuable to include their views and how they think their teachers foster CT dispositions. This could provide a more in-depth understanding of the strategies that are truly applied and noticeable in the classroom.

5.5.2 Further investigation of identified strategies

Through the data collected, this study has identified eight strategies that the participants used to foster CT dispositions. In the discussion on the interview data, it was evident that there were different ways in which the strategies could be used and applied in the classroom. The conceptualisation of each strategy generally included sub-components like the use of examples, which considered physical, electronic and mental examples. To gain a deeper understanding of the identified strategies, further investigation into the specific nature and application of these strategies is recommended. Furthermore, there is a possibility that some strategies would be more prevalent and applicable to certain design process elements. Investigating the relationship between strategies and design process elements could also provide a more extensive and thorough understanding of these strategies.

This study only reports on the strategies that these technology teachers perceived that they used, and the strategies observed during one lesson for five participants. No opinions from the teachers or learners regarding its effectiveness were investigated. Since the findings are only an account of the strategies mentioned and used by the participants, conclusions about the value of each strategy cannot be determined by the data gathered in this study. Investigating the effectiveness and success of these identified strategies to foster CT dispositions could yield valuable findings and present important contributions to this emerging body of literature.

5.5.3 Longer periods of observation

The nature of the case study design is long periods of investigation through different data collection methods to gain an in-depth understanding of the phenomenon (Ary et al., 2010). The five technology teachers who participated in the observations were each only observed for one design-related lesson. All of the lessons were either an introduction to the Practical Assessment Task or concerning the initial phases of the design process. Longer periods of observation are recommended to include the entire design process, which could lead to a greater understanding of how strategies are used during the different phases of the design process. It is also possible that certain strategies could be more prominent or that new strategies may be discovered if an extended observation is conducted.

5.6 Conclusion

There is a perception that schools are not providing enough instruction or adequately addressing the development and fostering of CT (Bouygues, 2018; Vieira et al., 2011). The literature regarding this finding is mostly focused on CT skills, whereas investigations into the dispositional component of CT are lacking. If one considers the importance of CT to achieve success in life, it should be essential for educational researchers to further investigate how CT dispositions are and could be fostered in the classroom. This study deemed the context of the technology classroom as valuable because of the necessity of problem solving during the design process. The argument is that the design process presents many opportunities for the fostering of CT dispositions.

This study aimed to contribute to the emerging body of literature concerning CT dispositions. The intention was to enhance our understanding of the strategies currently used in technology classrooms to foster CT dispositions. The literature mentioned some strategies for the fostering of CT – skills and dispositions – but with no accounts of its actualisation in the classroom. From the eight strategies identified, three corresponded with the strategies found in the literature that are used to nurture CT, namely, assessments (Fahim & Ghamari, 2011); questioning (Halpern, 2014; Schooner et al., 2017; Zabit, 2010); and discussions (Fahim & Ghamari, 2011; Mandernach, 2006). The classroom environment and feedback corresponded with the principles for teaching CT dispositions (Yang & Chou, 2008) and modelling a strategy, as mentioned by Facione (2000). These six strategies, therefore, substantiate the strategies mentioned in the literature and were used and applied by the participants in their classrooms. As for the use of examples and resources, which were frequently mentioned in the interviews, and examples featuring as one of the main strategies during the observations, no explicit literature was found on this. The use of examples and resources may form part of other strategies, but the strong indication of their use leads to the conclusion that they are strategies in their own right.

The research on CT dispositions up until this point has not suggested or described explicit strategies to specifically foster the dispositional component of CT. The findings and conclusions of this study are also not considered as the final answer to this lack of literature, but pose as a departure point for further investigation and development.

LIST OF REFERENCES

Abrami, P. C., Bernard, R. M., Borokhovski, E., Wade, A., Surkes, M. A., Tamim, R., & Zhang, D. (2009). Instructional Interventions Affecting Critical Thinking Skills and Dispositions: A Stage 1 Meta-Analysis. *Review of Educational Research*, *78*(4), 1102–1134. https://doi.org/10.3102/0034654308326084

Aizikovitsh-Udi, E., & Amit, M. (2011). Developing the skills of critical and creative thinking by probability teaching. *Procedia - Social and Behavioral Sciences*, *15*(2011), 1087–1091. https://doi.org/10.1016/j.sbspro.2011.03.243

Aizikovitsh-Udi, E., & Cheng, D. (2015). Developing Critical Thinking Skills from Dispositions to Abilities : Mathematics Education from Early Childhood to High School. *Creative Education*, *6*(March), 455–462.

American Philosophical Association. (1990). *Critical thinking- A statement of expert consensus for purposes of educational assessment and instruction. Recommendations prepared for the committee on pre-college philosophy.* (No. Doc. No. ED 315-423.). California State University, Fullerton. ERIC.

Anney, V. N. (2014). Ensuring the quality of the findings of qualitative research: looking at trustworthiness criteria. *Journal of Emerging Trends in Educational Research and Policy Studies*, *5*(2), 272–281. https://doi.org/10.3109/08941939.2012.723954

Ary, D., Jacobs, L. C., & Sorensen, C. (2010). *Introduction to Research in Education*. *Wadsworth Cengage Learning*. Belmont: Wadsworth.

Bailin, S., Case, R., Coombs, J. R., & Daniels, L. B. (1999). Conceptualizing critical thinking. *Journal of Curriculum Studies*, *31*(3), 285–302. https://doi.org/10.1080/002202799183133

Bass, R. V. (1997). The purpose of education. *Educational Forum*, *61*(2), 128–132. https://doi.org/10.1080/00131729709335242

Baum Combs, L., Cennamo, K. S., & Newbill, P. L. (2009). Developing Critical and Creative Thinkers : Toward a Conceptual Model of Creative and Critical Thinking. *Educational Technology*, *49*(5), 3–14.

Bouygues, H. L. (2018). The State of Critical Thinking: A new look at reasoning at

home, school, and work. Reboot Foundation. https://doi.org/10.1002/cc.193

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1017/CBO9781107415324.004

Burghardt, M. D., & Hacker, M. (2004). Informed Design: A Contemporary Approach to Design Pedagogy. *Technology Teacher*, *64*(1), 6–8. Retrieved from https://www.hofstra.edu/pdf/academics/colleges/seas/ctl/ctl_informeddesign_003.pdf

Chilisa, B., & Kawulich, B. (2012). Selecting a research approach: paradigm, methodology and methods. In *Doing social research a global context* (pp. 1–21). McGraw-Hill Higher Education.

Connelly, L. M. (2016). Trustworhiness in Qualitative Research. *Medsurg Nursing*, *25*(6), 435–436.

Creswell, J. W. (2003). *Research design: Qualitative, Quantitative, and mixed method approaches* (Edition 2). Thousand Oaks: Sage Publications.

Creswell, J. W. (2012). *Educational Research* (Edition 4). Boston: Pearson Education.

Creswell, J. W. (2014). *Research design: Qualitative, Quantittive and Mixed Methods Approaches* (Edition 4). Los Angeles: Sage Publications.

Dakers, J. (2005). Technology education as solo activity or socially constructed learning. *International Journal of Technology and Design Education*, *15*(1), 73–89. https://doi.org/10.1007/s10798-004-6196-1

Davies, W. M. (2006). An ‘infusion’ approach to critical thinking: Moore on the critical thinking debate. *Higher Education Research & Development*, *25*(2), 179–193. https://doi.org/10.1080/07294360600610420

Davies, W. M. (2013). Critical thinking and the disciplines reconsidered. *Higher Education Research and Development*, *32*(4), 529–544. https://doi.org/10.1080/07294360.2012.697878

DBE. (2011). *Curriculum and Assessment Policy Statement Grades 7-9 Technology*. Republic of South Africa: Government Printing Works.

De Vries, M. J. (2016). *Teaching about Technology* (Edition 2). Dordrecht: Springer International Publishing. https://doi.org/10.1007/978-3-319-32945-1

Dewey, J. (2010). What is thought? In *How we think*. Boston: D. C. Health and Company.

Dorst, K. (2006). Design Problems and Design Paradoxes. *Design Issues*, *22*(3), 4–17. https://doi.org/10.1162/desi.2006.22.3.4

Dostál, J. (2015). Theory of problem solving. *Social and Beahvioural Science*, *174*, 2798–2805. https://doi.org/10.1016/j.sbspro.2015.01.970

Duran, M., & Şendağ, S. (2012). A preliminary investigation into critical thinking skills of urban high school students: Role of an IT/STEM program. *Creative Education*, *3*(2), 241–250. https://doi.org/10.4236/ce.2012.32038

Duron, R., Limbach, B., & Waugh, W. (2006). Critical Thinking Framework For Any Discipline. *Interrnational Journal of Teaching and Learning in Higher Education*, *17*(2), 160–166. https://doi.org/10.1016/j.nepr.2006.09.004

Dwyer, C. P., Hogan, M. J., Harney, O. M., & Kavanagh, C. (2017). Facilitating a student-educator conceptual model of dispositions towards critical thinking through interactive management. *Educational Technology Research and Development*, *65*(1), 47–73. https://doi.org/10.1007/s11423-016-9460-7

Ennis, R. H. (1996). Critical Thinking Dispositions: Their Nature and Assessability. *Informal Logic*, *18*(1996), 165–182. https://doi.org/10.1353/jge.2007.0011

Facione, P. A. (2000). The Disposition Toward Critical Thinking: Its Character, Measurement, and Relationship to Critical Thinking Skill. *Informal Logic*, *20*(1), 61–84. https://doi.org/10.22329/il.v20i1.2254

Facione, P. A. (2011). Critical Thinking: What it is and why it counts. Millbrae: The California Academic Press.

Facione, P. A., Facione, N. C., & Giancarlo, C. A. F. (1996). The motivation to think in working and learning. *New Directions for Higher Education*, (96), 67–79. https://doi.org/10.1002/he.36919969608

Facione, P. A., Sánchez, C. A., & Facione, N. C. (1994). Are College Students Disposed to Think ? Paper presented at the Sixth International Conference on

Thinking. Boston: ERIC Doc: ED 368-311.

Facione, P. A., Sánchez, C. A., Facione, N. C., & Gainen, J. (1995). The Disposition Towards Critical Thinking. *The Journal of General Education*, *44*(1), 1–25.

Fahim, M., & Ghamari, M. R. (2011). Critical thinking in education: Globally developed and locally applied. *Theory and Practice in Language Studies*, *1*(11), 1632–1638. https://doi.org/10.4304/tpls.1.11.1632-1638

Fitzgerald, J., & Baird, V. A. (2011). Taking a step back: Teaching critical thinking by distinguishing appropriate types of evidence. *PS - Political Science and Politics*, *44*(3), 619–624. https://doi.org/10.1017/S1049096511000710

Given, L. M. (2008). *The Sage Encyclopedia of Qualitative Research Methods*. (L. M. Given, Ed.). Los Angeles: Sage Publications. Retrieved from https://books.google.com/books?id=y_0nAQAAMAAJ&pgis=1

Halpern, D. F. (1999). Teaching for Critical Thinking. *New Directions for Teaching and Learning*, (80), 69–74.

Halpern, D. F. (2014). *Thought and knowledge - An introduction to critical thinking* (Edition 5). New York: Psychology Press.

Hendrix, B. E. (1999). Critical Thinking Dispositions : The Need for a Balanced Curriculum in Collegiate Critical Thinking Courses. *Critical and Creative Thinking Capstones Collection*, *Paper 144*. Retrieved from http://scholarworks.umb.edu/cct_capstone/144

Holmes, I. (2002). What Is Called Thinking? *The Journal of Critical Psychology, Counselling and Psychotherapy*, *2*(1), 33–39. https://doi.org/10.5840/teachphil200124334

Humanities Unit. (1995). Teaching Thinking for Effective Learning. Hong Kong: Curriculum Development Institute. Retrieved from https://www.edb.gov.hk/attachment/en/curriculum-development/kla/pshe/reference-and-resources/effective_learning_eng.pdf

ITEEA. (2020). Technology Education vs Educational Technology. Retrieved 26 May 2020, from https://www.iteea.org/51801.aspx

Jonassen, D. H. (1997). Instructional Design Methods for Well-Structured and

Illstructured Problem-Solving Learning Outcomes. *ETR&D*, *34*(1), 65–94. Retrieved from http://www1.folha.uol.com.br/ciencia/880408-bahia-inicia-uso-de-inseto-transgenico-contra-dengue.shtml

Jonassen, D. H. (2010). How does problem solving vary? In *Learning to Solve Problems: A handbook for designing problem-solving learning environments* (pp. 1–24). New York: Routledge.

Jones, A., Buntting, C., & De Vries, M. J. (2013). The developing field of technology education: A review to look forward. *International Journal of Technology and Design Education*, *23*(2), 191–212. https://doi.org/10.1007/s10798-011-9174-4

Karakoç, M. (2016). The significance of critical thinking ability in terms of education. *International Journal of Humanities and Social Science*, *6*(7), 81–84. Retrieved from http://www.ijhssnet.com/journals/Vol_6_No_7_July_2016/10.pdf

Kezer, F., & Turker, B. (2012). Comparison of the critical thinking dispositions of (studying in the secondary science and mathematics division) preservice teachers. *Procedia - Social and Behavioral Sciences*, *46*(2012), 1279–1283. https://doi.org/10.1016/j.sbspro.2012.05.288

Kimbell, R., Wheeler, T., Miller, S., & Pollitt, A. (2007). *e-scape portfolio assessment*. London: Goldsmiths.

Lawson, B., & Dorst, K. (2009). *Design Expertise*. Oxford: Elsevier Ltd.

Lee, C. B., Jonassen, D., & Teo, T. (2011). The role of model building in problem solving and conceptual change. *Interactive Learning Environments*, *19*(3), 247–265. https://doi.org/10.1080/10494820902850158

Lexico Online Dictionary. (2020a). Attitude. Retrieved 29 July 2020, from https://www.lexico.com/en/definition/attitude

Lexico Online Dictionary. (2020b). Attribute. Retrieved 29 July 2020, from https://www.lexico.com/en/definition/attribute

Lexico Online Dictionary. (2020c). Design. Retrieved 26 May 2020, from https://www.lexico.com/en/definition/design

Lexico Online Dictionary. (2020d). Disposed. Retrieved 8 June 2020, from https://www.lexico.com/en/definition/disposed

Lexico Online Dictionary. (2020e). Resources. Retrieved 8 June 2020, from https://www.lexico.com/en/definition/resources

Lexico Online Dictionary. (2020f). Techne. Retrieved 26 May 2020, from https://www.lexico.com/en/definition/techne

Mandernach, B. J. (2006). Thinking Critically about Critical Thinking: Integrating Online Tools to Promote Critical Thinking. *InSight : A Journal of Scholarly Teaching*, *1*(1), 41–50.

Mandernach, B. J., Forrest, K. D., Babutzke, J. L., & Manker, L. R. (2009). The Role of Intructor Interactivity in Promorting Critical Thinking in Online and Face-to-Face Classrooms. *MERLOT Journal of Online Learning and Teaching*, *5*(1), 49–62.

Maree, J. G. (2016). *First steps in research* (Edition 2). Pretoria: Van Schaik.

Martinez, M. E. (1998). What Is Poblem Solving? *Phi Delta Kappa International*, *79*(8), 605–609. Retrieved from http://www.jstor.org/stable/20439287

Mason, J. (2002). *Qualitative Research*. London: Sage Publications.

Mawson, B. (2003). Beyond 'the design process': An alternative pedagogy for technology education. *International Journal of Technology and Design Education*, *13*(2), 117–128. https://doi.org/10.1023/A:1024186814591

Melser, D. (2004). *The act of thinking*. Massachusetts: The MIT Press. https://doi.org/10.1093/mind/fzl447

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (Edition 2). Sage Publications.

Mitcham, C. (1994). *Thinking through Technē*. Chicago: The University of Chicago Press. https://doi.org/10.1080/13528165.2005.10871446

Mohajan, H. (2018). Qualitative research methodology in social sciences and related subjects. *Journal of Economic Development*, *7*(1), 23–48. https://doi.org/10.1007/BF01591250

Morgan, D. L. (2007). Paradigms Lost and Pragmatism Regained. *Journal of Mixed Methods Research*, *1*(1), 48–76. https://doi.org/10.1177/2345678906292462

Murawski, L. M. (2014). Critical Thinking in the Classroom... and Beyond. *Journal of*

Learning in Higher Education, *10*(1), 25–30. https://doi.org/10.1021/acs.jchemed.6b00406

Neuman, W. L. (2014). *Social Research Methods: Qualitative and Quantitative Approaches* (Edition 7). Essex: Pearson Education Limited.

Nieto, A. M., & Saiz, C. (2011). Skills and dispositions of critical thinking: Are they sufficient? *Anales de Psicología*, *27*(1), 202–209. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2011-03317-024&lang=ja&site=ehost-live%5Cnacarracedo@usal.es

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic analysis: Striving to meet the trustworthiness criteria. *International Journal of Qualitative Methods*, *16*, 1–13. https://doi.org/10.1177/1609406917733847

Ohemeng-Appiah, F. (2014). *Teaching the Design Process in the Grade 9 Technology Class*. University of Kwazulu Natal.

Ordem, E. (2017). Developing Critical-Thinking Dispositions in a Listening/Speaking Class. *English Language Teaching*, *10*(1), 50–55. https://doi.org/10.5539/elt.v10n1p50

Ponterotto, J. G. (2005). Qualitative Research in Counseling Psychology: A Primer on Research Paradigms and Philosophical Science. *Journal of Counseling Psychology*, *52*(2), 126–136. https://doi.org/10.1037/0022-0167.52.2.126

Qing, Z., Ni, S., & Hong, T. (2010). Developing critical thinking disposition by task-based learning in chemistry experiment teaching. *Procedia - Social and Behavioral Sciences*, *2*(2), 4561–4570. https://doi.org/10.1016/j.sbspro.2010.03.731

Robinson, S. R. (2011). Teaching logic and teaching critical thinking: Revisiting McPeck. *Higher Education Research and Development*, *30*(3), 275–287. https://doi.org/10.1080/07294360.2010.500656

Schooner, P., Nordlöf, C., Klasander, C., & Hallström, J. (2017). Design, system , value : The role of problem-solving and critical thinking capabilities in technology education, as perceived by teachers. *Design and Technology Education: An International Journal*, *22*(3), 1–16.

Sefotho, M. M. (2018). *Philosophy in Education and Research*. Pretoria: Van Schaik.

Shin, N., Jonassen, D. H., & McGee, S. (2003). Predictors of well-structured and ill-structured problem solving in an astronomy simulation. *Journal of Research in Science Teaching*, *40*(1), 6–33. https://doi.org/10.1002/tea.10058

Stake, R. E. (1995). *The Art of Case Study Research*. Thousand Oaks: Sage Publications. https://doi.org/10.2307/329758

Taylor, P. C., & Medina, M. N. D. (2013). Educational research paradigms: From positivism to multiparadigmatic. *Journal of Meaning-Centred Education*, *1*, 1–16. Retrieved from https://www.researchgate.net/profile/Peter_Taylor11/publication/264196558_Educational_research_paradigms_From_positivism_to_multiparadigmatic/links/53d1c13d0cf228d363e8eccd/Educational-research-paradigms-From-positivism-to-multiparadigmatic.pdf

Tishman, S., & Andrade, A. (1996). *Thinking Dispositions: A review of current theories, practices, and issues.* Cambridge, MA. Project Zero, Harvard University.

Tishman, S., Jay, E., & Perkins, D. N. (1993). From Thinking Dispositions: Transmission to Enculturation. *Theory into Practice*, *32*(3), 147–153.

Van Gelder, T. (2005). Teaching critical thinking: some lessons from cognitive science. *College Teaching*, *53*(1), 41–46. Retrieved from https://www.reasoninglab.com/wp-content/uploads/2013/10/Tim-van-Gelder-Teaching-CT-Lessons-from-Cog-Sci.pdf

Vieira, R. M., Tenreiro-Vieira, C., & Martins, I. P. (2011). Critical thinking: Conceptual clarification and its importance in science education. *Science Education International*, *22*(1), 43–54.

Yang, Y. T. C., & Chou, H. A. (2008). Beyond critical thinking skills: Investigating the relationship between critical thinking skills and dispositions through different online instructional strategies. *British Journal of Educational Technology*, *39*(4), 666–684. https://doi.org/10.1111/j.1467-8535.2007.00767.x

Yin, R. K. (1994). *Case Study Research Design and Methods*. Thousand Oaks: Sage Publications. Retrieved from http://www.madeira-edu.pt/LinkClick.aspx?fileticket=Fgm4GJWVTRs%3D&tabid=3004

Zabit, M. N. (2010). Problem-Based Learning On Students Critical Thinking Skills In Teaching Business Education In Malaysia: A Literature Review. *American Journal of Business Education (AJBE)*, *3*(6), 19–32. https://doi.org/10.19030/ajbe.v3i6.436

Zhang, L. F. (2003). Contributions of thinking styles to critical Thinking Dispositions. *The Journal of Psychology*, *137*(6), 517–544. Retrieved from https://hub.hku.hk/bitstream/10722/53492/1/88592.pdf?accept=1

APPENDICES

APPENDIX A: INSTRUMENTS

A1: Interview Questions

Semi-structured interview

*Critical thinking (CT) is a higher-order thinking skill that involves activities like analysis, synthesis, interpretation and evaluation. CT has two components namely **cognitive skills** and **affective dispositions**. For this interview, we will only focus on the second component, namely the **dispositions**. A disposition is the internal motivation or willingness to act or do something in a certain manner.*

In this interview I will ask questions on 7 dispositions. I will first explain each disposition before asking the questions related to that specific disposition.

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1. Inquisitiveness

Inquisitiveness is the inclination to be intellectually curious and to have a hunger for new knowledge, even if at that moment it is not clear how the knowledge is relevant. It is also an eagerness to be and stay well-informed. The opposite of being inquisitive is being indifferent and uninterested.

1.1 How do you foster and encourage inquisitiveness in your technology classroom?

1.2 Does your classroom environment encourage learners to be intellectually curious? Please explain how.

1.3 How do you keep learners interested in a topic while teaching?

1.4 How do you encourage learners to not only consider the given textbook and class notes but further investigate and research topics, concepts and objects?

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2. Analyticity

Analyticity is understood as the quality of being analytic with a willingness to apply reasoning and use evidence to solve problems. It is also the habit of foreseeing potential effects of choices, actions and ideas and acting on it. Inattentiveness is considered the opposite of analyticity.

2.1 How do you foster and encourage analyticity in your technology classroom?

2.2 How do you encourage learners to engage in reasoning when they are solving problems?

2.3 What strategies do you use to encourage learners to provide evidence when solving problems?

2.4 How do you assist learners in anticipating potential difficulties during the design process?

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3. Systematicity

Systematicity is understood as the orderly, focused and diligent manner in which relevant information is sought out and arguments are presented. The opposite of systematicity is haphazardness.

3.1 How do you foster and encourage systematicity in your technology classroom?

3.2 How do you encourage organised, focussed and diligent inquiry in your classroom?

3.3 How do you teach leaners to organise and focus their own arguments?

3.4 How do you ensure that your own classroom practice is systematic?

---

4. Truth seeking

Truth seeking is understood as an eagerness to ask questions and consider alternative opinions in the pursuit of reaching an honest and objective truth even if it does not support your own beliefs. Intellectual dishonesty is considered the opposite of being truth-seeking.

4.1 How do you foster and encourage a truth-seeking spirit in your technology classroom?

4.2 How do you encourage your learners to ask questions?

4.3 How do you encourage your learners to consider alternatives (different options, opinions and views)?

4.4 How do you encourage your learners to critically evaluate information, objects, statements and conclusions?

4.5 What opportunities are there for learners to search for knowledge?

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5. Open-mindedness

Open-mindedness is understood as the willingness to tolerate and respect divergent views and the habit of being sensitive to one's own biases. The opposite of being open-minded is being intolerant.

5.1 How do you foster and encourage open-mindedness in your technology classroom?

5.2 Our personal biases sometimes hinder us to be critical. How do you make learners aware of their own biases?

5.3 How do you teach your learners to be sensitive toward different opinions and views than their own?

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6. CT Self-confidence

CT self-confidence is understood as the inclination to trust in one's own reasoning process and judgements when responding to and solving problems. It is further considered as being confident in one's reflective thinking abilities in order to make decisions. The mistrust of reason is considered the opposite of self-confidence.

6.1 How do you foster and encourage self-confidence in your technology classroom?

6.2 How do you encourage learners to practice and develop their own reasoning processes?

6.3 What opportunities are there for learners to be reflective?

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7. Maturity of judgement

Maturity of judgement is understood as the habit of making sensible choices by being judicious about the making, suspending and revising of your own decisions. It is an awareness that problems are ill-structured and have multiple solutions. The opposite of maturity of judgement is cognitive immaturity.

7.1 How do you foster and encourage maturity of judgment in your technology classroom?

7.2 How do you ensure that learners apply good judgement when they are making or changing their decisions, designs and models?

7.3 What strategies do you use to encourage learners to generate multiple solutions?

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8. How would you rank the 7 dispositions in terms of importance in the technology classroom? Please rank the dispositions from most important to least important.

A2: Observation Schedule

Observation schedule

	Time occurred during lesson											
CT Disposition	5	10	15	20	25	30	35	40	45	50	55	60
Inquisitiveness												
Systematicity												
Analyticity												
Truth-seeking												
Open-mindedness												
CT self-confidence												
Maturity of judgement												

I - Fostered as part of investigating phase

D - Fostered as part of designing phase

M - Fostered as part of making phase

E - Fostered as part of evaluating phase

C - Fostered as part of communicating phase

T - Fostered as part of general technology theory

As - Assessment
Di - Discussions
En - Environment
Ex - Examples
Fe - Feedback
Mo - Modelling
Qu - Questioning
Re - Resources

APPENDIX B: CODE BOOK

Code	Name	Description
1.I	Inquisitiveness	Instances where intellectual curiosity or an eagerness to learn and be well informed was fostered. [Opposite = Indifference/uninterested].
2.A	Analyticity	Instances where reason had to be applied or evidence provided. Guidance provided to anticipate consequences. [Opposite = inattentiveness].
3.S	Systematicity	Instances where order, focus and diligence were encouraged specifically when information is sought out and arguments are presented. [Opposite = haphazardness].
4.T	Truth-seeking	Instances where the consideration of alternatives was motivated and an eagerness to ask questions cultivated. [Opposite = intellectual dishonesty].
5.O	Open-mindedness	Instance where an understanding, tolerance and respect for divergent views were fostered and sensitivity towards own biases were motivated. [Opposite = Intolerant].
6.C	CT self-confidence	Instances where a trust in a person's own reasoning process was nurtured. [Opposite = mistrust of reason].
7.J	Maturity of judgment	Instances where the quality of being judicious about the making, suspending and revising of decisions where cultivated. [Opposite = cognitive immaturity].
As	Assessments	Instances where assessments were referred to with regards to the assessment brief, instructions, requirements, outline, stated problem and the rubric.
Di	Discussions	Instances where a discussion would take place between two parties [the teacher and the learner(s)] or where the teacher talks about a concept or idea to provide further explanation.

En	Classroom environment	Instances where the atmosphere in the classroom encourage a positive disposition towards CT, learners were already disposed to act in a certain manner, together with the lesson structure and class rules.
Ex	Examples	Instances where any physical, electronic or mental example was used.
Fe	Feedback	Instances where teacher reacts to and provides constructive criticisms to learners informally [during class and while working] or formally 0after the completion of an assessment].
Mo	Modelling	Instances where teachers demonstrated the disposition themselves.
Qu	Questioning	Instances where the teacher would ask strategic or leading questions or where questions from learners were answered promptly and praised.
Re	Resources	Instances where any physical or electronic resources was used.
Br	Brief	Assessment instructions, more specifically the PAT instructions for the design project.
Pr	Problem	The stated problem in the PAT or related design activity.
Ev	Evaluate	The evaluation phase during the design process.
Co	Communicate	The communication phase during the design process.
In	Investigate	The investigation phase during the design process.
De	Design	The design phase during the design process.
Ma	Make	The make phase during the design process.
So	Solution	Reference to the solution to the stated problem in the PAT or related design activity.