Exploring strategies for fostering problem-solving skills in students in an Actuarial Science context using action research

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Elsa Gouws

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Abstract

This study explores strategies to foster problem-solving skills in students. Educational strategies, problem-solving strategies and strategies to improve creativity are introduced using a participatory action research (PAR) design. The research is located within the specific context of a qualitative interpretivist study. A PAR design is used to ensure that shortcomings with the approach can be identified and improvements can be implemented as the cycle is repeated.

The intervention strategy took the form of two cycles of three sessions each where students were exposed to problem-solving strategies as part of their Actuarial Science Honours course. The participants were Actuarial Science Honours students at the University of Pretoria. Data on how the students experienced the interventions and their ability to apply the strategies were collected using surveys and focus-group discussions. The researcher also observed and reflected on the behaviour of students in the sessions. The aim with analysing the data was to establish the effect that exposure to the strategies had on students' ability to develop problem-solving skills.

The findings of the study reveal that exposure to the strategies made students aware that problem-solving skills were important to acquire in the Actuarial Science field and for life in general. They gained insight into what aspects were required to foster the skills within themselves. Students started applying some of the strategies to improve their understanding of the underlying fundamentals of their subjects. They also started applying some of the strategies to improve their ability to solve problems in a structured and creative way. However, given the time constraints and pressures of their Honours year, they struggled to apply these strategies consistently, especially under test and examination conditions.

The conclusion, concurring with the literature, is that students should be exposed to problem-solving strategies on a regular basis to foster problem-solving skills. The more students practise solving problems, the more natural it would become for them to use the strategies. In an eective education system, what students need to learn, how it is taught, assessed and how all aspects are intertwined with the goal of meaningful learning by students must be aligned.

Keywords: Teaching strategies, learning strategies, problem solving, critical thinking, problem-solving strategies, problem-solving skills, critical thinking skills, education, action research, Actuarial Science education

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List of abbreviations

Abbreviation	Description
ACC	Actuarial Control Cycle
AOS	Analysis of Surplus
ASSA	Actuarial Society of South Africa
PAR	Participatory Action Research
PBL	Problem-based learning

1. Introduction

1.1 BACKGROUND

The Actuarial Society of South Africa (ASSA) defines the role and function of an actuary as follows (Actuarial Society of South Africa, 2017): "An actuary is a professional who applies analytical, statistical and mathematical skills to financial and business problems. They are able to provide realistic solutions to complex problems with a long term forward view." Gamedze (2011), one of ASSA's past presidents said the following: "It is therefore becoming critically important for us as professionals in general and actuaries in particular to challenge ourselves vigorously about the value we provide to society. In doing so, we shall find ourselves already on the road towards retaining and extending the relevance of our contribution, even in an environment of historically unprecedented change."

To enable actuarial students to achieve the capabilities required above, ASSA introduced a Normative Skills development programme in 2015 with the aim of improving students' normative skills, defined as a range of skills, including business management skills, that focus specifically on teaching strategic thinking and problem solving to students as they start their career (Gladwin, 2015). It has the ultimate aim to benefit future actuaries in being able to integrate theory and practice and to deliver the actuarial promise (Gladwin, 2014). However, the sooner students are exposed to these skills, the better due to their ability to gain a deeper knowledge about what they are learning, and to learn the application of the skills within the context in which they will have to apply it (Johnson, 2010; Shepherd, 2010; Snyder & Snyder, 2008).

I had discussions with some of my ex-colleagues from industry to determine how the University of Pretoria could improve the capabilities of its graduates from the Actuarial Science Honours Course. I wanted to ensure that actuarial students are developing the skills that they will need when they start practising as professionals. A common finding was that employers felt that young actuarial employees who came straight out of university had a sound theoretical understanding of the concepts but found it difficult to apply them in practice. Snyder and Snyder (2008) state that to have knowledge and information is not enough. To be effective at work (and in their personal lives), students must be able to solve

problems and make effective decisions. Students should be taught to think critically, as this would help them to solve problems better (Snyder & Snyder, 2008). Soden (1994) states that employers find the ability to apply knowledge effectively in the workplace to be a skill that many employees lack. Employees are expected to be flexible and adaptable when faced with non-standard tasks or scenarios at work and should be able to solve problems effectively (Lyn, Palandra, & Daykin, 2002; Soden, 1994).

In this study I investigate if the strategies suggested by the literature are effective to improve the students' critical thinking and problem-solving skills. Problem solving has been defined as the thinking that is required to solve a problem where the solution or solution method is not immediately obvious to the task performer (Soden, 1994). Barnett (1992) defines it as the integration of theory and practice and the knowledge of how to apply standard techniques. In addition, he states that it is the ability to develop strategies to deal with new situations not previously encountered and to which the profession's currently developed theories and techniques could not readily be applied. Problem-solving skills are considered to be lacking if people either do not have enough knowledge to find a solution, or do not have strategies to enable them to find a solution that is not immediately obvious to the task performer (Fogler, LeBlanc, & Rizzo, 1995; Soden, 1994).

Throughout my lecturing career, many actuarial students have expressed a concern regarding the extent of their problem-solving skills as defined above. Hence, the aim of this study is to determine if it is possible for students to acquire the skills that would enable them to become better at solving problems as well as identifying the best strategies to achieve this.

I consulted the literature on problem solving and problem-solving skills. I noticed that problem-solving skills were required in more than 80% of the job vacancies sent out by the Actuarial Society of South Africa during the period June 2016 to September 2016. This finding confirmed that problem solving was an important skill required by most employers of actuarial students. Gribble (March 2003) included critical evaluation and problem solving in the skillset required by a good actuary. I also found that the University of Pretoria's requirement for teaching included the need to teach not only discipline-specific knowledge, but also higher-order thinking skills such as problem solving, critical thinking and the ability of students to actively engage with ideas, reflecting on the learning and indeed applying the principles to new problems and situations (Guidelines for Teaching and Learning, Department for Education Innovation, University of Pretoria, 2009). So, not only are critical thinking and problem solving important skills for students to learn, but lecturers at the University of Pretoria are required to be teaching these skills to students.

Now that I had established what skills would benefit our students, I investigated what were the most effective ways of teaching and learning these skills, according to the literature. I found that most research agreed that strategies for teaching and learning could assist to foster problem-solving skills in students (Broadbear, 2003; Johnson, 2010; Shepherd, 2010; Snyder & Snyder, 2008). Furthermore, students need to be equipped with problem solving and critical thinking strategies that would enable them to solve problems (De Bono, 2010, 2015, 2017; Fogler et al., 1995; Soden, 1994). McPeck (1981) says that something becomes a skill if it is regularly practised. Hence, if problem-solving strategies are taught and teaching strategies are applied by lecturers and learning strategies are applied by students, it should lead to the development of problem-solving skills if practised and used regularly by both lecturers and students.

The attitude of the lecturer and the approach taken in the lecture hall, as well as the way in which assessments are done, could influence students to become predisposed to using the strategies and hence acquiring such skills sooner (McPeck, 1981; Shepherd, 2010; Snyder & Snyder, 2008). Da Silva (2016) says in her Presidential Address that the profession requires education strategies that deal with the "how" of learning rather than just the "what" when speaking to the challenges facing the education system at the time. Norman (1981, as quoted by Snyder & Snyder, 2008) said that we expect students to learn, but we seldom teach them anything about how to learn. Content is important, but the process of how students learn the material is just as important (Snyder & Snyder, 2008).

Shepherd (2010, p. 9) says the focus on actuarial education tends "to be on what actuaries need to know rather than what actuaries may need to do when they practise in the real world". Research has confirmed that lecturing and memorising do not lead to long-term knowledge or the ability to apply that knowledge in new circumstances (Scriven & Paul, 1987; Tempelaar, 2006). Education strategies that require students' higher-order thinking skills lead to a deeper understanding of the theory and hence easier application to real-life problems (Lyn et al., 2002; Shepherd, 2010; Snyder & Snyder, 2008). However, many teachers struggle to engage students in critical thinking activities (Tempelaar, 2006). Students seldom use critical thinking skills to solve complex problems (McPeck, 1981; Snyder & Snyder, 2008). I discuss some reasons for this and suggest some solutions to overcome these difficulties.

My research incorporates feedback from students on the impact that teaching these strategies had on them so that the process could be improved over time. I use an action research methodology. Action research is the process of identifying an area in need of improvement, implementing some practical changes and analysing the effects of these

changes in order to transform and develop the participants during the research process (Maree, 2010; Zuber-Skerritt, 1992). In an education context, it aims to bring forth a practical change by systematically implementing interventions and constantly reviewing the success of such interventions, adjusting and improving them where necessary (Creswell, 2007; Maree, 2010; Zuber-Skerritt, 1992). It has been used in a number of studies as a development strategy for both lecturers and students and to improve educational practices (Maree, 2010; Zuber-Skerritt, 1992).

1.2 RESEARCH OBJECTIVES

My research focuses on determining effective methods of introducing problem-solving strategies to Honours students at the University of Pretoria and the impact thereof on their ability to develop problem-solving skills. My approach involves teaching students strategies to improve their learning and understanding of the underlying theory as well as creative problem solving and critical thinking strategies to enable them to apply this knowledge in a range of unfamiliar circumstances. I also recommend certain teaching strategies to lecturers to assist students to develop these skills.

Based on the purpose of this study, I have formulated my primary research question as follows:

(a) How can exposure to applicable problem-solving strategies foster problem-solving skills in Actuarial Science students?

I also consider the following sub-questions:

(b) How does training in problem-solving strategies affect students' learning practices?

(c) How does training in problem-solving strategies affect the way students approach problems?

(d) Which problem-solving strategies did students experience to be the most helpful in developing their problem-solving skills?

1.3 IMPORTANCE AND BENEFITS OF THE STUDY

As explained above, if students can acquire critical thinking and problem-solving skills during the course of their studies, they should be better equipped to deal with problems that they

will encounter in the workplace. They should be able to make a valuable contribution to the workplace early in their career, and hence will be sought after by employers. If they can apply some of the principles of critical thinking and problem solving to learning the core knowledge of the subjects, as suggested by Soden (1994), their understanding of the core knowledge will be enhanced, benefitting them even while studying. This is because problem solving requires similar critical thinking techniques than for embedding new knowledge in the mind when studying (McPeck, 1981; Soden, 1994). Shepherd (2010) believes that one will not only directly address the development of the skills, but will raise the level of new actuaries' understanding of the technical aspects of their work and how they should be applied in practice at the same time.

1.4 DOCUMENT LAYOUT

In this document I share with the reader the development and progress of my research. This first chapter presents the problem to the reader by means of stating the background and the main research question and sub-questions to be answered, the proposed research methodology and the importance and benefits of the proposed research.

In Chapter 2, the literature on critical thinking and problem solving and on strategies of teaching, learning and applying critical thinking and problem-solving skills are explained. Some barriers to applying these strategies are also discussed.

Chapter 3 deals with the research methodology. My paradigmatic approach and research design are explained as well as my methods of data collection and analysis. It also covers the ethical considerations that are taken into account.

Chapter 4 contains an explanation of the interventions that were implemented to enhance the students' critical thinking and problem-solving skills as well as the feedback from students and the findings of my research based on content analyses and reflection.

This is followed by Chapter 5 which is the final chapter of this study. It contains the conclusions and further recommendations that follow from the findings. I answer the research questions in this chapter, mention some limitations of my study and give recommendations for future study in this field.

2. Literature review

2.1 INTRODUCTION

As discussed in the previous chapter and for the purpose of this study, the skills that I want to equip students with are problem-solving and critical thinking skills. I start with a definition and overview of problem-solving and critical thinking skills. I then discuss whether these skills can be taught and if so, when and how it should best be done. I touch on barriers to teaching these skills for lecturers and barriers to applying these skills for students. I end by explaining some strategies from the literature that can be used to foster these skills as well as considering the characteristics of good problem solvers.

2.2 PROBLEM-SOLVING AND CRITICAL THINKING SKILLS DEFINED

McPeck (1981) suggests that a person has the skill to solve problems if they are able to apply the careful and precise thinking needed to solve a problem. Critical thinking is required to solve problems optimally (Baron & Sternberg, 1987; McPeck, 1981; Snyder & Snyder, 2008). Critical thinking has been defined as using the mind in a disciplined way to analyse, synthesise and/or evaluate information gathered from observing, experiencing, reflecting, reasoning or communication, before you believe something or take action on something (Scriven & Paul, 1987). There is also a metacognitive element in critical thinking, namely the requirement to think about your thinking (Tempelaar, 2006).

Critical thinking can be further explained by considering each of the words separately. 'Critical' requires a certain scepticism and suspending before believing any information given until one has considered alternative hypotheses or possibilities. It involves the appropriate use of reflective scepticism that requires knowledge of the field in question so that appropriate questions could be asked to gain insight into the problem and to find a more satisfactory solution (McPeck, 1981).

'Thinking' does not merely require more thinking, but rather making finer discriminations with regard to what one is thinking about, for example: what is logical?, what is rational?,

how does the context affect my thinking? (McPeck, 1981). Improving problem-solving skills requires that students should gain insight into the nature of their thinking and that they be taught thinking techniques and strategies to assist them to solve problems (Snyder & Snyder, 2008; Soden, 1994). It is clear that effective problem solving cannot take place if the problem solver is not able to think critically about the problem.

For the purpose of this paper, I will use Barnett's definition of problem-solving skills as the ability to integrate theory and practice by being able to think critically about how to apply the theoretical concepts to practical problems or in unfamiliar scenarios (Barnett, 1992). Effective problem solving requires a deep understanding of the underlying concepts of the subject matter and how they link to each other. In addition, problem solvers need the ability to understand how to use their minds optimally and to have strategies in place for solving complex problems (Baron & Sternberg, 1987; Fogler et al., 1995; McPeck, 1981; Shepherd, 2010; Soden, 1994). To develop feasible solutions to non-familiar problems, you need knowledge to help you understand the problem as well as creativity to come up with a range of solutions (De Bono, 2015; Fogler et al., 1995).

Once someone has been trained in critical thinking techniques and problem-solving strategies, it is important that they use it often for these techniques and strategies to become skills (McPeck, 1981; Snyder & Snyder, 2008). 'You can lead a student to logic, but you can't make him use it' (Mc Peck, 1981, p. 14). Lecturers can assist to develop students' skills by frequently modelling to students the use of the techniques and strategies during lectures and practical sessions as well as encouraging students to use them whilst studying. Furthermore, it is important that lecturers should use assessments that require the use of the techniques (Baron & Sternberg, 1987; Shepherd, 2010; Snyder & Snyder, 2008; Soden, 1994). This will ensure that students end up studying the underlying concepts with the intention of being able to apply that knowledge to solve problems (Shepherd, 2010; Snyder & Snyder, 2008).

2.3 CAN PROBLEM-SOLVING AND CRITICAL THINKING SKILLS BE TAUGHT?

I investigated opinions on whether critical thinking and problem-solving skills can be taught and/or improved through effective teaching and learning. Snyder and Snyder (2008) state that people are not born with the ability to think critically. Some people may be naturally inquisitive, but they will require training to become systematically analytical, ethical, reflective and open-minded in their pursuit of knowledge. Soden (1994) reasons

that these skills can be taught as something could be a problem for one person but not for another, because the first person had experience ('practical training') in solving a similar problem in the past. The learning and reasoning from solving certain types of problem can be transferred to solve other similar types of problem (Fogler et al., 1995; Soden, 1994). To become good at solving problems, students need to practise thinking critically about problems, implementing solutions and evaluating solutions to problems (Broadbear, 2003; McPeck, 1981; Snyder & Snyder, 2008; Soden, 1994). Students need to be taught how to generate relevant questions about problems and must be given strategies to adopt a structured approach to solving problems (Fogler et al., 1995; McPeck, 1981; Soden, 1994).

Snyder and Snyder (2008) conclude that critical thinking is a learned skill that requires instruction and practice. They suggest that lecturers can enhance students' critical thinking skills by using appropriate education strategies of engaging students in the learning process, by focusing attention on the process of learning and not just the knowledge that needs to be obtained and by using appropriate assessment techniques that require students to think critically and solve problems.

McPeck (1981) believes that since it is a skill, it can be taught through drills and exercises. He states, however, that critical thinking involves both a propensity and a skill. Teachers need to teach 'how to' as well as 'to use', hence creating the propensity to use the skill. They need to provide both the capacity and the will to think critically. To this end, he states that the attitude of the teacher and the atmosphere in the lecture hall must influence students to become predisposed to use the skill (Kline, 1999; McPeck, 1981).

Broadbear (2003) presents four essential elements (see section 2.4.1) that lessons must contain that should promote critical thinking amongst students, hence concluding that the development of thinking skills can and should be done within all educational settings.

I conclude that critical thinking and problem-solving skills can be developed in students. I believe lecturers and students have a role to play in fostering these skills.

2.3.1 BARRIERS TO APPLYING THE TECHNIQUES

Snyder and Snyder (2008) suggest that the reason why teachers struggle to get students to think critically and why students struggle to use critical thinking skills to solve problems may be due to the methods of instruction used. Clement(1979, as cited in Snyder and Snyder, 2008) states that educators should be teaching students how to think, but instead they are

teaching them what to think. As mentioned in Section 1.1, we expect students to learn, but do not teach them enough about learning (Norman, 1981). Education strategies and assessment methods must ensure that students are required to demonstrate higher-order thinking skills. Snyder and Snyder (2008) identify the following barriers to integrating critical thinking in education:

- Teachers are often not trained in finding pragmatic and pedagogical methods of teaching critical thinking (Broadbear, 2003).
- Few instructional materials provide critical thinking resources such as open-ended questions or chapter-based critical thinking discussion questions (Scriven & Paul, 1987).
- Kang and Howren (2004, as cited in Snyder and Snyder, 2008) say that both teachers and students have preconceptions such as personal bias about the content, which prevents them to think critically about the content and to be fair, open-minded and inquisitive about it.
- If students are used to being passive learners and only had to memorise and recall information, they will be uncomfortable at first to engage in active learning situations where they have to apply critical thinking skills. Educators should be aware of their initial resistance and need to guide them to start using their minds in a different way (Broadbear, 2003; Browne & Keeley, 1990; Snyder & Snyder, 2008).
- Lastly, time constraints are barriers to ensuring critical thinking skills are developed in the classroom, because a great deal of content needs to be covered within a short period and it is easier to lecture and have objective tests than engaging the student in learning and having subjective assessments (Shepherd, 2010; Snyder & Snyder, 2008).

One solution for the barrier mentioned in the last bullet is to 'outsource' assessment to the students themselves in the form of peer assessments and self-assessments which, in itself, add value to improve understanding (Shepherd, 2010). Broadbear (2003) adds that students cannot apply the suggested criteria for assessing thinking and improving thinking without having a very clear understanding of the content and what constitutes good critical thinking.

When introducing the teaching of critical thinking in education, Broadbear (2003) admits that one might be sacrificing breadth of content coverage for depth of reasoning, but says that it is a trade worth making. When students are engaged in critical thinking about an

aspect of the work, they are still covering a great deal of content when applying their mind to that aspect.

Section 2.4 covers strategies for fostering problem-solving and critical thinking skills that could overcome most of the barriers.

2.3.2 SEPARATE COURSE OR PART OF THE CORE SUBJECTS?

There are differing opinions as to whether these techniques should or could be taught as a separate course or whether it should form part of the vocational training. Soden (1994) believes that the thinking processes involved in problem solving are best learnt if taught in the context in which they are going to be applied and not as a separate course. This preference is because the thinking processes required for solving problems are closely linked to the topic being taught. An important part of solving a problem is the ability to extract applicable knowledge from within the subject (and related subjects) and to use various techniques and thinking processes to create extra information that may be required to solve the problem (McPeck, 1981; Soden, 1994).

Another reason why Soden (1994) recommends that students should be taught thinking processes as part of their subject matter is that the same thinking processes for solving problems should be used to store new information or knowledge whilst learning. These techniques will enable students to have a structured approach to learning, hence embedding knowledge better and this will assist them to extract the knowledge more effectively when required to solve problems.

McPeck (1981) strongly agrees with Soden (1994) and states that a good understanding of the content and context of a subject is critical to be able to assess statements and arguments. This is an important requirement for solving problems. One has to understand the context of the problem and the practical consequences of certain solutions by taking into account the subject knowledge and information relevant to the problem (Fogler et al., 1995; McPeck, 1981). Fogler et al. (1995) state that both creativity and knowledge are required to solve problems because creativity without knowledge will lead to solutions that may not be feasible.

Broadbear (2003) recommends an approach that systematically develops these skills by making it a repetitive cycle throughout the course. He suggests that all lessons should contain the essential elements for fostering the critical thinking skills that are discussed in

section 2.4.1. Shepherd (2010) agrees that critical thinking and problem-solving skills are developed effectively when activities for fostering these skills are integrated within education and assessment tasks in the core discipline subjects. He states that subjects that focus on skills acquisition in isolation have been proven to be much less effective.

De Bono (2010), however, feels that subject matter content hinders the development of creative thinking, and that creative thinking strategies should be taught in isolation from content and subject-specific information. He warns that gathering too much information around a problem may destroy the chances of obtaining an original and creative solution because you will be exposed to all the existing assumptions that may limit your creativity. Tempelaar (2006) mentions that critical thinking skills can be transferred across knowledge domains and, as such, could be considered a separate module in certain courses. However, he states that it is more common that these active learning approaches that embed the critical thinking skills are adapted, not in the course content, but in the learning method. This involves case study methods and problem-based learning as pre-eminent tools.

McPeck (1981) states that it is unrealistic to think that it will be possible to appropriately apply critical thinking tools gained from artificial situations elsewhere. He is wary of disregarding content and knowledge that are required to measure the plausibility of ideas when having to solve real problems in a specific context.

I suggest we incorporate critical thinking and problem-solving strategies as part of the Actuarial Science Honours course but also to educate lecturers to incorporate at least some of the suggested educational strategies at all levels of the Actuarial Science undergraduate course.

2.4 STRATEGIES TO FOSTER PROBLEM-SOLVING AND CRITICAL THINKING SKILLS

Problem-solving and critical thinking skills can be improved by using various teaching and learning strategies as well as problem-solving strategies. In this study, I will focus on the following three aspects that should improve these skills:

- Educational strategies that enable students to gain a deep knowledge and understanding of the underlying concepts of the subject matter, which is imperative

for solving problems (Baron & Sternberg, 1987; Broadbear, 2003; McPeck, 1981; Shepherd, 2010; Snyder & Snyder, 2008; Soden, 1994).

- Problem-solving strategies on how to think critically about problems and how to systematically solve problems (Baron & Sternberg, 1987; Fogler et al., 1995; McPeck, 1981; Shepherd, 2010; Snyder & Snyder, 2008; Soden, 1994).
- Strategies to improve creativity, including the importance of mindset (De Bono, 2010, 2015, 2017; Fogler et al., 1995).

2.4.1 EDUCATIONAL STRATEGIES

The brain requires similar thinking techniques for storing information in an effective way than for retrieving that information when required for solving problems (Soden, 1994). The way in which information is learned and stored in the brain can inhibit or enhance problem solving. Learning and problem solving are interdependent mental activities (Soden, 1994). Students should approach learning with a critical thinking mindset to become better at solving problems. The literature suggests that if students are taught with the intention of developing critical thinking skills in them (effective teaching) and if students learn with the intention of developing those skills in themselves (effective learning) and if the education environment is such that it encourages the use of these skills (a thinking environment) then these skills will be fostered in students.

2.4.1.1 EFFECTIVE TEACHING

It is worthwhile to consider what constitutes effective teaching. The Boyer Commission on Educating Undergraduates (1998, as cited in Shepherd, 2010) states that learning should be based on discovery whilst guided by mentoring. Learning should not focus on the transmission of information. From an educational perspective, the capabilities that are required from the qualified professional (in this case actuary) need to be identified and then the curriculum needs to be designed to ensure that these capabilities are acquired throughout the education period and/or working life wherever it is most appropriate (Shepherd, 2010). Shepherd (2010) feels that the curriculum often focuses too much on knowledge at the expense of other capabilities. Assessment is often inconsistent with the learning objectives stated, and that leads to a surface approach to learning by students. Table 2.1 by Ramsden (2003, p. 46) shows the difference between a deep approach to student learning versus a surface approach.

Table 2.1: Surface approach vs deep approach to learning

Surface approach	Deep approach
Intention is simply to complete the task requirements	Intention is to understand
Focus is on 'the symbols' (e.g. words, methods, formulae) uncritically	Focus is on the meaning of 'the symbols'
Focus is on parts of the task, often seen as unrelated	Relate previous knowledge to new knowledge
Memorise information for assessments	Relate knowledge from different subjects
Associate facts and concepts ineffectively	Relate theory to everyday experience
Fail to distinguish principles from examples	Relate and distinguish evidence and arguments
Treat task as an external imposition	Organise and structure content into a coherent whole

Source: Ramsden (2003)

Shepherd and Bellis (1994) state that universities often spend time on 'what' students must learn, but not enough time on 'how' it should be taught to ensure that knowledge can be applied in new situations and be remembered a long time after leaving university. Students need to understand the big picture before the detailed learning will make sense to them. The order of learning is important and could play a role to ensure deeper understanding (Lyn et al., 2002; Shepherd, 2010; Soden, 1994). They must be taught the core concepts first, and then link the other concepts to the structure of the core concepts (Soden, 1994).

It is helpful to create a structure for students so that they can 'save' the information in a structured way to enable them to extract the information easily when having to solve problems (Soden, 1994). It is important for lecturers to bring the lecture themes together so that students can build a big picture for themselves and learn to add onto existing knowledge. Soden (1994) suggests that lecturers should create an overview that covers the fundamental concepts that will be taught as well as the main relationships between concepts as the brain finds it easier to extract knowledge that was stored effectively in large concept structures with interrelated links between them. Lecturers should make students aware of the common features and distinguishing features of different concepts so that different concept structures could be linked where possible.

The student's approach to learning is influenced by a number of factors such as nature of assessment, workload, teacher's approach to teaching, how clear the learning objectives are and the interest of the student in the subject (Shepherd, 2010). In an effective education system, what students need to learn, how to teach it and how to assess it must be aligned with the goal of meaningful learning by students.(Shepherd, 2010). There should be a consistent aim for skills to be fostered and it should be transparent in learning objectives, course notes, assignments, lectures, group discussions and assessments (Broadbear, 2003; Shepherd, 2010).

Ennis (1993 as cited in Snyder and Snyder, 2008) states that assessments should emphasise thinking rather than facts. Subjective tools like essay questions and case studies force students to apply knowledge to new circumstances which is a better indication if they truly understand what they have been taught. To help students improve, it is important to review their answers, explaining better and worse answers, and to model a critical thinking process to them (Browne & Keeley, 1990).

Miller (1996, as cited in Johnson, 2010) states that there are three common views on teaching: teaching as transmission, teaching as transaction, and teaching as transformation. Teaching as transmission has the aim of transferring knowledge from point A (the teacher's head) to point B (the students' heads). The teacher is the one dispensing the knowledge and academic achievement is seen as the students' ability to demonstrate or replicate that body of knowledge back to the teacher when being assessed.

Teaching as transaction is the process of creating situations where students can interact with the material to be learned to construct knowledge – consistent with the Constructivism educational philosophy. Here the student becomes an active part in the knowledge gathering process and knowledge gets built up by connecting their past knowledge and experiences with new information (Shepherd, 2010). Experiences are thus created where students' old information can connect with new information to create meaningful knowledge that can be used to solve real-world problems (Johnson, 2010; Shepherd, 2010).

Teaching as transformation is teaching that creates conditions that have the ability to transform the learner on many levels (cognitive, emotional, social, intuitive, creative, spiritual and other). Holistic education is an educational philosophy that supports this transformative aim and learning is said to have occurred when learning experiences lead to a transformation of consciousness, resulting in a greater understanding of self, others and the environment. Johnson (2010) observed that the most powerful and sustained learning occurs when transactional and transformational approaches are used. Teachers who use

these methods ensure that the lecture hall becomes a place of inquiry where questions become just as important as answers.

Broadbear (2003) suggests the following four essential elements that lectures should contain to promote critical thinking and problem solving:

- Ill-structured problems: Lessons should contain plenty of examples of practical problems that either do not have a clear definition of the problem, or where there is not a clear answer and where experts might disagree on the best solution to the problem. This will promote reasoning and debate where judgement would need to be applied so that students learn that there may be better and worse answers and where they can assess the quality of each other's thinking and reasoning.

- Criteria for assessing thinking: Linking to the paragraph above, there need to be criteria to evaluate the thinking in order to improve the thinking. Some examples are to test the clarity, accuracy, relevance, significance, depth, breadth, logic and fairness displayed in each other's thinking (Paul and Elder (2001, as cited in Broadbear, 2003)).

- Student assessment of thinking: The general mindset of a student is 'what gets assessed, gets done' (Shepherd, 2010). The more students practise to meaningfully assess their own and other people's thinking, the more their thinking will improve. This will require of them to become comfortable, through practice, with receiving critical assessments that will help them grow, learn and improve their thinking (Broadbear, 2003). This element will only be meaningful if students give honest feedback on the strengths, weaknesses and suggestions for improvement on each other's work. They would need to be held accountable for the quality of their assessments to ensure they give constructive and useful feedback and that they apply their minds. The more continuous the assessment and feedback cycle and demonstrating better and worse answers, the more comfortable students will become at receiving constructive criticism regarding their thinking (Broadbear, 2003).

- Guidelines and demonstrations to help improve thinking: These four elements must continuously form part of lessons, courses and the whole curriculum. The development of thinking will be negatively affected if it only receives sporadic emphasis. To improve thinking, it cannot stop at the assessment of thinking. Guidelines must be given on how to improve thinking and students must review and resubmit their work after having seen stronger and weaker examples. Educators should continuously demonstrate good

thinking techniques and guide students through the process of critically thinking when solving problems (Snyder & Snyder, 2008).

Shepherd (2010) says that students who are required to write about, debate, explain, research and apply core concepts and principles of what they are studying will achieve a deeper understanding of what they are learning. Boud (1985, as cited in Shepherd, 2010) explains problem-based learning (PBL) as an approach for developing critical thinking and problem-solving skills in the learning process. The challenge is for the developers of the curriculum to find a range of problems that, combined, will ensure students are exposed to all fundamental knowledge, skills and values of the profession. The chosen problems become the curriculum as students have to actively research the problem and the relevant knowledge that would help them to provide and evaluate potential solutions.

Snyder and Snyder (2008) agree that problem-based learning activities promote critical thinking and problem-solving skills because they lead to active participation in the learning process and self-directed learning as students have to identify their own learning needs. Such activities encourage and develop teamwork, creative discussion, learning from peers and the integration of a variety of knowledge.

Students will need guidance to move from being passive learners to play an active role in their learning and development. Educators could model critical thinking techniques when solving problems in a discussion setting by asking questions to walk students through the process of thinking critically to solve problems.

The ideal is to engage students in an active learning environment that focuses on application of content, the process of learning and methods of assessment that emphasise thinking rather than facts (Snyder & Snyder, 2008). This confirms what Kline (1999) writes about creating thinking environments where students are encouraged to ask questions and use their minds optimally.

2.4.1.2 CREATING A THINKING ENVIRONMENT

Students must be encouraged to develop insight into the nature of their thinking when learning new concepts and when solving problems (Broadbear, 2003; Snyder & Snyder, 2008; Soden, 1994; Tempelaar, 2006). Certain conditions are conducive to thinking and lecturers should aim to make the place of education a ‘thinking environment’ (Kline, 1999). Kline (1999) states that a ’thinking environment’ is one where students are encouraged to

think for themselves because they realise that this will lead to increased knowledge and ultimately respect. Everyone in the lecture hall should be trained to give full attention to anyone who speaks and should listen with respect and interest whilst treating others as equals.

Kline (1999) suggests that the level of thinking is directly related to how well the audience is listening and how safe the environment is for thinking. There should be no ridiculing, laughing or signs of being irritated, but everyone should rather give their full attention and encouragement and even probe further so as to ensure that deep thinking takes place. One student's question may lead to an idea or question from another student, and so the learning expands more rapidly than in the traditional 'lecturer speaking to class' scenario (Fogler et al., 1995; Kline, 1999).

Lecturers should use questioning techniques to help students evaluate the clarity and accuracy, breadth and depth of their thinking (Browne & Keeley, 1990). It is important that they understand why they think the way they do and that they assess whether their thinking process is logical. They should give sufficient time for students to respond to questions as it takes time to process a question and formulate a response, especially when it requires critical thinking (Snyder & Snyder, 2008). Kline (1999) agrees that lecturers should not be too quick to provide solutions, but should encourage students to use their minds to find a well-reasoned solution on their own.

In a short survey that I requested from students, many mentioned that they are often shy to ask questions or to say what they think in class for fear of sounding ignorant or being ridiculed. It is important that thinking techniques are taught in a co-operative and non-judgemental environment where ideas are encouraged to be explored and developed rather than having fixed right and wrong answers (Broadbear, 2003; Soden, 1994).

Snyder and Snyder (2008) refer to Browne and Keeley (1990) who suggest students should be asked the right questions to help stimulate their critical thinking skills and suggest the following questions:

- What do you think about this?
- What is your knowledge based upon? What does it imply/presuppose?

- What explains it, connects to it, follows from it?
- Should/could it be viewed differently? Have you considered an alternative view?

Such questions help students to understand and improve their own thinking.

Lecturers should thoroughly explain the critical thinking criteria that they use when demonstrating to students how they solve practical business problems. They should model their problem-solving approach to students and provide as much information as possible when doing so (Broadbear, 2003; Kline, 1999; Snyder & Snyder, 2008). As was said in Section 2.4.1, students who used to be passive learners may find it difficult to engage in active learning environments that require of them to think critically (Browne & Keeley, 1990). Lecturers should guide them through the process until they get more comfortable to think through answers rather than just getting to the 'right answer' (Snyder & Snyder, 2008).

Lecturers can also assist by removing limiting assumptions that students have about themselves or about the problem by asking questions in a way that removes such assumptions, for example, 'Considering that finances are not a factor in this instance, what would your answer to the question be?', or 'If you knew that you are intelligent enough to solve this problem, how would you approach it?' (Kline, 1999). Lecturers should encourage students to ask questions to clarify statements made by lecturers that they do not understand. Lecturers must remember that they may have used automated thinking techniques that they may no longer be aware of using when making certain statements (Snyder & Snyder, 2008; Soden, 1994).

Shulman (1999) says that learning is increased if we offer our knowledge to be tested, examined, challenged and improved by our fellow learners. Assessment of thinking is required due to the metacognitive nature of critical thinking. Students learn more when they have to assess and be assessed on their own and their fellow students' thinking rather than just being assessed by the lecturer (Broadbear, 2003).

Finally, to ensure that a 'thinking environment' is created, the focus on improving thinking must continually form part of lessons, courses and the curriculum as a whole. It should be an approach to teaching included in every aspect of the educational strategy (Broadbear, 2003). This was discussed in detail under the previous heading.

2.4.1.3 EFFECTIVE LEARNING

When effective teaching practices are used and a 'thinking environment' is created, students should gain a deeper knowledge of what they are learning and understand how to apply it to solve practical problems. The following are some effective learning strategies that students could use to improve their understanding of the work and to assist them with developing problem-solving skills:

1. STRUCTURED LEARNING

Students should think critically about new knowledge before they blindly accept it as the truth (Baron & Sternberg, 1987; Broadbear, 2003; McPeck, 1981). Soden (1994) states that good problem solvers:

- Organise information into categories related to distinct concepts and know the relationships between different categories;
- Reorganise their concept structures as they acquire more information;
- Understand the fundamental principles in their subject.

Hence, good problem solvers are good at organising and categorising new information by considering the features of new knowledge compared to existing knowledge. This links to Ramsden (2003) who explains how deep learning and understanding take place (Table 2.1). Fogler et al. (1995) suggest the following structure for solving problems that I suggest students could use as a structure for learning to improve their understanding of where their new knowledge fits into the big picture. It is based on the McMaster 5-point strategy (Woods, 1985) and will again be discussed in Section 2.4.2 in the context of structured problem solving:

i) Define the problem

ii) Generate solutions

iii) Decide the course of action

iv) Implement the solution

v) Evaluate the solution.

This structure relates aptly to the Actuarial Control Cycle (ACC) in Figure 2.1 that Actuarial Science students are familiar with.

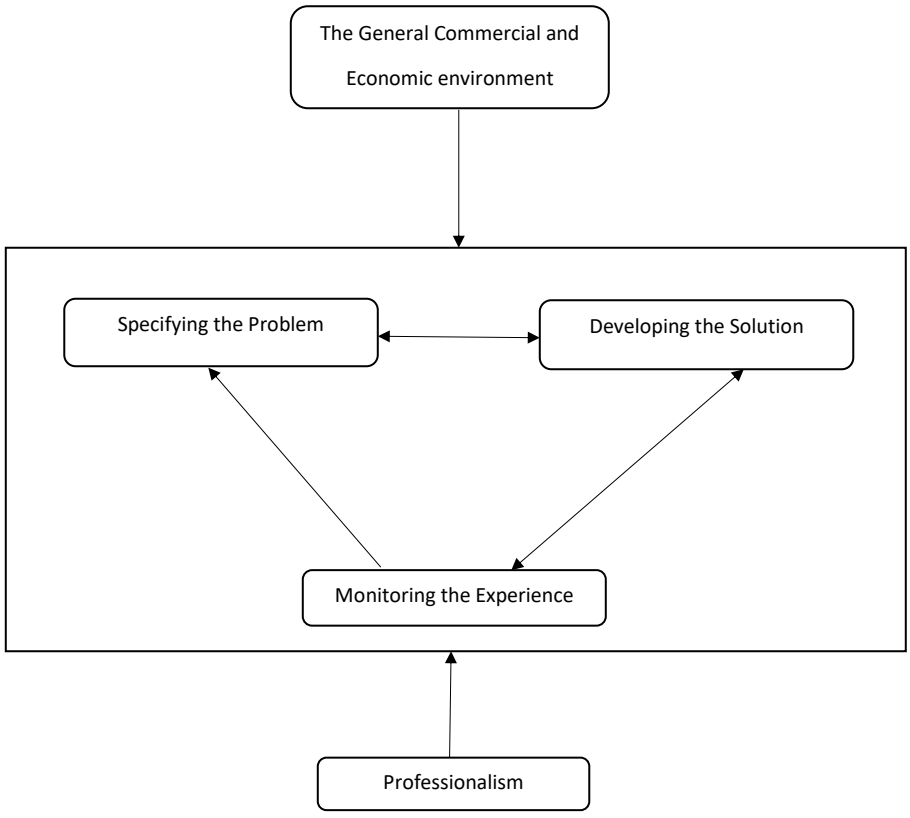


Figure 2.1: The Actuarial Control Cycle
Source: The Actuarial Education Company (2016)

Lyn et al. (2002) suggest that it would be a fitting structure to use to train actuaries in the broad application of actuarial concepts to practical business problems. This is because it gives students a framework for solving actuarial problems and how to evaluate and monitor the performance of the solution. It also ties back to Soden (1994) who suggests that students and lecturers should categorise new information into planning, implementing, monitoring and evaluating categories.

All the material covered in the Actuarial Science Honours course can be related to the structure in Figure 2.1. It will create a big picture for students and is a sensible structure

to store any new knowledge in. Lecturers and students could, however, use any sensible structure that links concepts together in a way that makes sense for them.

2. QUESTIONING AND CRITICAL THINKING

As explained in Section 2.4.1, questioning techniques by lecturers is an effective teaching practice that would guide students to think critically about what is being taught. Similarly, students must be encouraged to question themselves to improve their ability to think critically about new knowledge that they acquire (Broadbear, 2003; Kline, 1999; Snyder & Snyder, 2008). This helps them to establish whether to believe or act on any new knowledge. It also assists to establish where the new knowledge fits into the structures mentioned above and to identify the links between the structures (Baron & Sternberg, 1987; Shepherd, 2010; Soden, 1994). Questions activate the frontal lobes of the brain used for analytical and logical thinking hence, asking questions is an important strategy to use when learning and solving problems (Kline, 1999).

Students need to understand the purpose of everything that they are learning, not just getting to the right answer (Baron & Sternberg, 1987; Shepherd, 2010). Students need to find answers to the questions: 'Why am I doing this?'; 'How does this link back to my role as an actuary?'; 'How does this link back to previous weeks' knowledge and previous years' knowledge?', rather than just knowing what the outcome is supposed to be. Students learn more effectively if they have an aim of understanding what the author is trying to convey, rather than memorising facts for a short period in order to satisfy some external requirement like passing an exam (Ramsden, 1988). Educational research shows that better quality learning takes place if students can relate the new knowledge/information to existing knowledge or to an everyday experience that they already know and understand (Baron & Sternberg, 1987; McPeck, 1981; Ramsden, 2003; Shepherd, 2010; Soden, 1994).

Perkins in Baron and Sternberg (1987) suggests that to understand something, one must be able to answer the following four questions about it:

- What is the purpose of this?
- What is its structure?
- What examples are there to prove the object or statement?

- What arguments explain this and can be used to evaluate the object or statement?

The more deeply the learner explores these four questions, the deeper the understanding of the new knowledge will be.

Snyder and Snyder (2008) state that questioning techniques help students to analyse, synthesise and evaluate information rather than just memorising the information.

Students should be encouraged to discuss their thinking amongst each other and to review each other's thinking (Shepherd, 2010). This is good practice for their professional worklife where peer reviews are often encouraged or even required by regulation. By actively participating in class and by having to explain one's thinking to others will lead to a deeper understanding of what was learnt (Shepherd, 2010).

As mentioned above, lecturers and fellow students need to provide a safe 'thinking environment' for discussions and for asking and answering questions (Kline, 1999; Soden, 1994).

Once students have improved the way they file new knowledge into existing structures in their minds whilst making sure they have a deep understanding of what they are learning by using the critical thinking and questioning techniques mentioned above, it will be easier to apply the techniques mentioned below to extract the knowledge when needed to solve problems.

2.4.2 PROBLEM-SOLVING STRATEGIES

The brain functions optimally if a structured approach is taken to solving problems (Fogler et al., 1995; Soden, 1994). As explained above, effective teaching and learning take place if lecturers and students provide a structure for the brain to store new information in. Similarly, effective problem solving takes place if the brain uses a structure for solving problems (Fogler et al., 1995; Lyn et al., 2002; Snyder & Snyder, 2008; Soden, 1994). I consider the problem-solving strategies in the context of the preferred approach to solving problems, namely structured problem solving.

In a recent study, students who used a heuristic to solve problems fared better than students who did not take a structured approach to solving problems (Fogler et al., 1995). There are many heuristics that could be used. Snyder and Snyder (2008) suggest Facione's IDEALS technique to guide students through the critical thinking process to solve problems:

I - Identify the problem; D - Define the context; E - Enumerate the choices/plausible options; A - Analyse options to choose best course of action; L - List reasons explicitly for choice of action; S - Self-correct and consider if something was missed.

Another structure for solving problems as suggested by Fogler et al. (1995) is based on the McMaster 5-point strategy (Woods, 1985) and was mentioned in Section 2.4.1 in the context of structured learning. I decided it would be sensible to use the same structure when training students to take a structured approach when solving problems. The five steps to structured problem solving are explained below.

2.4.2.1 DEFINING THE PROBLEM

Charles Kettering said: "A problem well-stated is half-solved." The literature suggests the following strategies to define problems clearly:

a) Exploring the problem (Fogler et al., 1995)

When faced with a problem, one should gather as much information as possible about the problem to understand where the problem originated. A good starting point is to ask questions such as: What is the problem, what not? Where is the problem, where not? When was it a problem, when not? Who is affected by the problem, who not? One needs to think through possible causes for the distinction between is and is not. It helps to draw graphs and diagrams to get visual inputs too. It is important to discuss the problem with the people involved or affected by the problem as well as with the person who posed the problem statement in its current form.

Verbalising the problem statement helps to clarify in your mind what you are trying to do. It is important to check whether the reasoning and assumptions of the people who posed the problem statement are valid. It is important to challenge established thinking patterns and not to rely on other people's interpretation of the problem. After one has verified that all the information is correct by cross-checking and cross-referencing data, facts and figures and one has confirmed all findings, opinions and assumptions, then one can start exploring the problem as follows:

Consider the information gathered about the problem by using the techniques from the previous paragraph. Now recall or investigate theories and fundamentals applicable to this type of problem. Attempt to collect missing information or state your assumptions about missing information. Solve a simplified version of the problem to obtain a ballpark answer

that can serve as a reasonability check. Hypothesise what could be wrong with the current situation. Brainstorm to guess an answer, recalling past or related problems or experiences. Finally, taking into account all the information gathered from the steps above, define the real problem accurately.

b) Present state–desired state technique (Fogler et al., 1995)

This technique requires that one verbalises where you are (the present state) and where you want to get to (the desired state) so that an appropriate solution can be found. It is important that every concern in the present state should be addressed in the desired state. One needs to re-work the statements until they match. This technique ensures that one thinks carefully about what the real problem is by considering if the desired state solves the problem completely.

c) Duncker Diagrams (Fogler et al., 1995)

This technique helps to find solutions that meet the criteria set up by the present state/desired state statements. It also aims to find ways to solve a problem by making it fine not to reach the desired state. General solutions on the left side of the diagram illustrate how to move from the present state to achieve the desired state. General solutions on the right side of the diagram illustrate how to make the current state better and hence be fine not to achieve the desired state. There are two steps involved in each pathway; first the functional solutions need to be determined and then specific solutions.

Functional solutions explain what to do to move from the present state to either achieve or not achieve the desired state. It does not take into account the feasibility of these solutions. After generating a number of functional solutions, specific solutions need to be generated for each functional solution. Specific solutions explain how to implement the functional solutions. Often the most difficult skill is to choose the appropriate desired state.

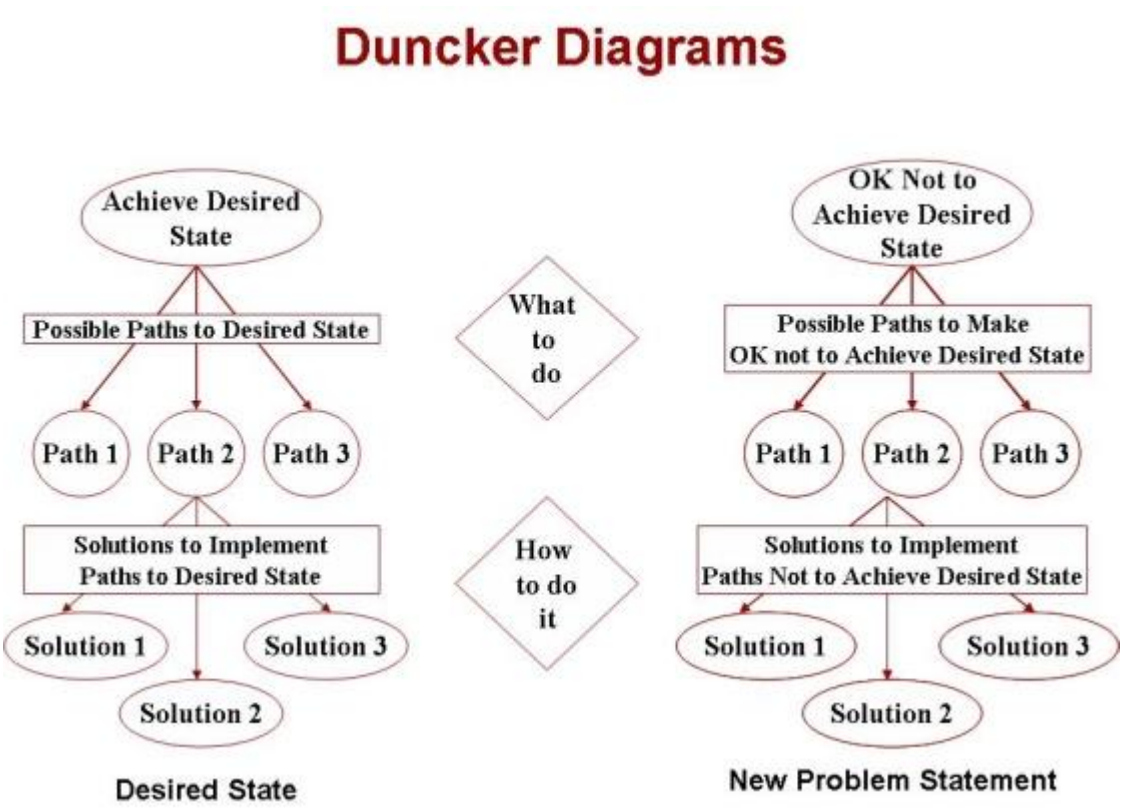


Figure 2.2: Duncker Diagram
Source: Fogler et al. (1995)

e) Statement/Re-statement techniques (Fogler et al., 1995)

This technique suggests that the problem should be re-stated in different forms several times to arrive at the most accurate problem statement. The following six ways to re-state the problem and generate questions about the problem were suggested by Parnes in Fogler et al. (1995):

i) Vary emphasis on different words and phrases in the problem statement.

ii) Replace words with phrases that have the same meaning or with the definitions of the words. This helps one to consider what defines or affects each part of the problem statement.

iii) Make an opposite statement (change positives to negatives and vice versa). This helps one to think out new ideas and to consider factors affecting the problem from another angle.

iv) Change or add terms, e.g. every to some, always to sometimes, this year to always, sometimes to never and vice versa.

v) Replace persuasive words in the problem statement such as 'obviously,' 'clearly,' and 'certainly' with the argument it is supposed to be replacing.

vi) Express words in the form of an equation or picture, and vice versa.

Once a person has improved the skill of defining problems accurately by using the techniques mentioned in this section, they should spend time on the strategies mentioned below to increase the number of potential solutions generated for problems.

2.4.2.2 GENERATING SOLUTIONS

There are often preconceived ideas or mental barriers that stand in the way of generating creative solutions to problems. One needs to first identify and remove such barriers and focus on obtaining the right mindset to ensure the strategies for generating creative solutions to problems will be effective (Fogler et al., 1995). Goman in Fogler et al. (1995) says that people experience mental blocks when trying to solve problems as a result of one or more of the following reasons:

They have a negative attitude and feel overwhelmed by the problem. They have a fear of failure or fear of taking risks. Some people believe they are not creative enough to come up with solutions. This can become a self-fulfilling prophecy.

Sometimes people define the problem too narrowly or do not define it clearly. They are trying to fix the symptoms rather than the real problem. People often assume there is only one right answer. Another reason is that people stick with the first solution that comes to mind or a solution that almost works, but really does not. People also get distracted by irrelevant information or they become too anxious to finish. Prolonged concentration is required to solve problems, so there should not be distractions that prevent this. Some people have intellectual blocks as a result of not knowing the theory or fundamentals surrounding the problem well enough. Others have expressive blocks where they have difficulty communicating their ideas to others and this can block their progress and ability to solve problems.

The following strategies have been suggested to remove such mental blocks (Fogler et al., 1995):

Change your thinking and attitude by listing the positive outcomes and aspects of the problem. Believe that there is not only the danger of failure but an opportunity for success

in every problem. Ask yourself what is the worst possible outcome and how you would deal with that. Encourage your creativity by asking 'what if' questions and creating metaphors and analogies. Try different ways of expressing creativity by using your imagination, feelings and sense of humour.

There is a direct correlation between the time people spend 'playing' with a problem and the diversity of solutions generated. People should give themselves enough time to work on problems and not stick with the first solution that comes to mind. Effective problem solvers make sure they understand the facts and fundamentals surrounding the problem by asking questions. They break the problem into sub-problems and start at a point they understand. They use the fundamental concepts underlying the problem as building blocks. They use problem-solving heuristics. They persevere when stuck.

Once the mental barriers have been removed, the following strategies can be used to generate more solutions to problems (Fogler et al., 1995):

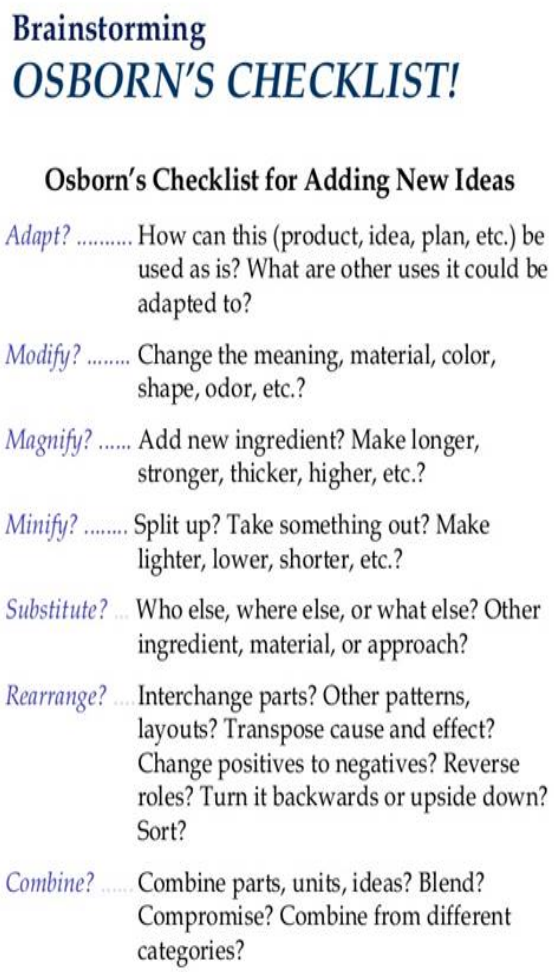
a) Brainstorming

This technique involves an unstructured free association of ideas in a group to generate solutions to problems. It should initially include wild or unusual solutions without regard to their feasibility. The theory is that people build on each other's ideas or suggestions, leading to a much wider range of solutions being generated. Individuals could change this to 'brainwriting' and force themselves to come up with as much ideas as possible without getting too technical about whether the ideas are viable or feasible. The first step is to generate as many potential solutions as possible.

Vertical thinking techniques such as Osborn's checklist below build on the ideas already generated or it can look at the different parts of the problem in an effort to generate ideas.

b) Osborn's checklist

Osborn in Fogler et al. (1995) suggests that you should consider the following seven questions to help you come up with more potential solutions:



Brainstorming

OSBORN'S CHECKLIST!

Osborn's Checklist for Adding New Ideas

Adapt? ..... How can this (product, idea, plan, etc.) be used as is? What are other uses it could be adapted to?

Modify? ..... Change the meaning, material, color, shape, odor, etc.?

Magnify? ..... Add new ingredient? Make longer, stronger, thicker, higher, etc.?

Minify? ..... Split up? Take something out? Make lighter, lower, shorter, etc.?

Substitute? ... Who else, where else, or what else? Other ingredient, material, or approach?

Rearrange? .... Interchange parts? Other patterns, layouts? Transpose cause and effect? Change positives to negatives? Reverse roles? Turn it backwards or upside down? Sort?

Combine? ..... Combine parts, units, ideas? Blend? Compromise? Combine from different categories?

Figure 2.3: Osborn's checklist
Source: Fogler et al. (1995)

c) Random stimulation (De Bono, 2010)

This technique requires that a person uses a random thought or word from a dictionary to stimulate a new flow of ideas. Similar to brainstorming, this is effective because this word, which is out of context, will stimulate a new train of thought in the problem solver and help to increase ideas to solve problems.

d) Futuring

This technique focuses on generating solutions that are currently not feasible but could be in the future. Ask yourself what are the characteristics of the ideal solution. What would make a major difference to the way we do business? One needs to visualise the ideal state and work on devising ways to attain it.

e) Analogy and cross-fertilisation

This technique suggests that ideas, rules, laws, facts and solutions from one discipline can be transferred to another discipline. Use your knowledge from one field of expertise to help you solve problems in other situations. It works as follows: State the problem; generate analogies (this problem is like trying to ...); solve the analogy; and transfer the solution to the problem at hand.

f) Incubation

This requires that one stops to actively work on the problem and let one's subconscious continue the work. The brain does a mental scan of its billions of neurons and searches for novel or innovative connections to make to help you solve the problem.

The strategies mentioned in this section should assist people to come up with a range of possible solutions to problems by encouraging them to think wider and deeper and to transfer solutions across disciplines. Some of these solutions might not be feasible upon closer inspection. An important part of the problem-solving process is to choose viable solutions and the best possible solution from those generated.

2.4.2.3 DECIDE THE COURSE OF ACTION

In deciding the best course of action to solve the problem, the questioning and critical thinking techniques mentioned in Section 2.4.1 are useful once again (Broadbear, 2003; Browne & Keeley, 1990; Soden, 1994). One needs to take a logical approach and analyse each alternative to reach a decision. It is important to try to identify the consequences of each potential solution and determine preventative actions to improve the solution. One needs to consider the advantages and disadvantages of each option. Consider carefully what each potential solution implies and what the impact would be on all parties involved. One needs to consider ethical factors and viability. It is also important to consider the financial impact of each solution – the cost versus benefit approach (Fogler et al., 1995).

2.4.2.4 IMPLEMENT THE SOLUTION

The literature on the implementation of the solution was focused on strategies of project management and teamwork. I left this out in the interest of time and to keep my focus on those steps of the problem-solving structure that would benefit students the most.

2.4.2.5 EVALUATE THE SOLUTION

It is important to complete the problem-solving structure by evaluating if the problem has really been solved. One needs to take a step back to reflect on the process and to determine if it has led to the best solution. What could be learnt from the process? What could be changed to improve it in future? It is important to understand that evaluation should take place continuously – from the start – to help develop a solution by evaluating each possible solution and throwing some out at that point in time or altering some to improve them. The end goal is to evaluate the solution we have implemented, to make sure it completely solves the problem, is ethical, and is safe to people and to the environment (Fogler et al., 1995).

A structured approach to problem solving is widely accepted as the most effective strategy to solve problems (Fogler et al., 1995; Snyder & Snyder, 2008). We have considered the literature on strategies to educate for fostering problem-solving skills and on strategies of effective problem solving. We now consider the literature on strategies to improve creativity, which is an important aspect to improve problem-solving skills (De Bono, 2010, 2015, 2017; Fogler et al., 1995).

2.4.3 STRATEGIES TO IMPROVE CREATIVITY

Einstein as quoted by Fogler et al. (1995) said: 'The mere formulation of a problem is far more often essential than its solution, which may be merely a matter of mathematical or experimental skill. To raise new questions, new possibilities, to regard old problems from a new angle requires creative imagination and marks real advances in science.' Soden (1994) writes that thinking, knowledge and creativity are required to solve problems. Franken (1994, p. 396) defines creativity as the ability to 'generate or recognize ideas, alternatives, or possibilities that may be useful in solving problems, communicating with others, and entertaining ourselves and others.'

2.4.3.1 THE IMPORTANCE OF MINDSET

The mindset and attitude of the problem solver are important in differentiating effective problem solvers from ineffective ones (Fogler et al., 1995). Extensive research has been carried out on the differences between effective problem solvers and others. These authors suggest that the following characteristics differentiate effective problem solvers from ineffective ones:

- The attitude with which they approach the problem
- How aggressive/active they are in the problem-solving process
- Their concern to be accurate
- The techniques or strategies that they use to get to a solution.

Good problem solvers believe that the problem can be solved and they do not give up easily (Fogler et al., 1995). They are not scared to take calculated risks. They think creatively to come up with many potential solutions to the problem.

The actions taken by good problem solvers are that they re-read the problem several times (where relevant). They re-describe the problem to themselves and others and ask questions to create a clear picture in their mind of the problem and draw sketches and write equations where appropriate. They do not jump to conclusions quickly.

Good problem solvers' concern for accuracy leads to them checking and re-checking their solutions. They try to anticipate the consequences of their proposed solutions and do not implement the first solution that comes to mind.

The procedures used by good problem solvers entail taking a structured approach to solving problems, for example breaking the problem into sub-problems, then starting from a point they understand, using a few fundamental or key concepts as building blocks, persevering when they get stuck, using formulae and graphs to gain more information about the problem and lastly, monitoring their progress and success (Fogler et al., 1995).

Moulton and Lowe in Shepherd (2010) link well to the above when describing the personal abilities required by engineers. They must be willing to face and learn from errors and listen openly to feedback. They must understand their personal strengths and limitations. They need to be confident to take calculated risks and take on new projects. It is important that they are able to remain calm under pressure. They should have the ability to defer judgement

and not jump in too quickly to solve a problem. A willingness to persevere when things go wrong is important. They must take responsibility for projects and be willing to make hard decisions. Having a sense of humour helps and they must be able to keep work in perspective.

Fogler et al. (1995) suggest the following techniques to improve one's creativity:

Pose new questions to yourself every day and try to find unique solutions. Keep abreast of your field and learn about fields outside of your specialty. Be open and receptive to new ideas. Take a new route to work every day. Encourage debate and contrarian thinking and practise problem finding as well as problem solving.

2.4.3.2 DE BONO'S STRATEGIES TO IMPROVE CREATIVITY

Edward de Bono developed the lateral thinking techniques of random stimulation (discussed in 2.4.2.2) and Other People's Views described below to help generate ideas during brainstorming (De Bono, 2010). Lateral thinking provides a different angle to look at a problem to get 'unstuck'. He has written numerous books on improving creativity (De Bono, 2010, 2015, 2017). Some of his techniques to improve creative thinking when solving problems are as follows:

a) Other People's Views (OPV)

OPV requires one to think about the viewpoint of all people affected by a problem to help define problems accurately. It also forces one to consider the impact on all parties to help generate solutions and to find the optimal solution.

b) Pluses, Minuses and Interesting facts (PMI)

De Bono suggests that one should consider the pluses (P), minuses (M) and interesting facts (I) about any problem statement or about any potential solution to stimulate creative thinking about them.

c) NO vs PO

He also recommends changing NO to PO statements. For any widely accepted belief that something cannot be done, for example NO way this can be done, change the sentence to become PO way this can be done. This forces one to think about how to make it possible. What do you need to do or put in place to change the statement from NO to PO?

d) The six thinking hats

De Bono suggests one puts on each of the six hats in Figure 2.4 to help you think creatively when faced with a challenge:

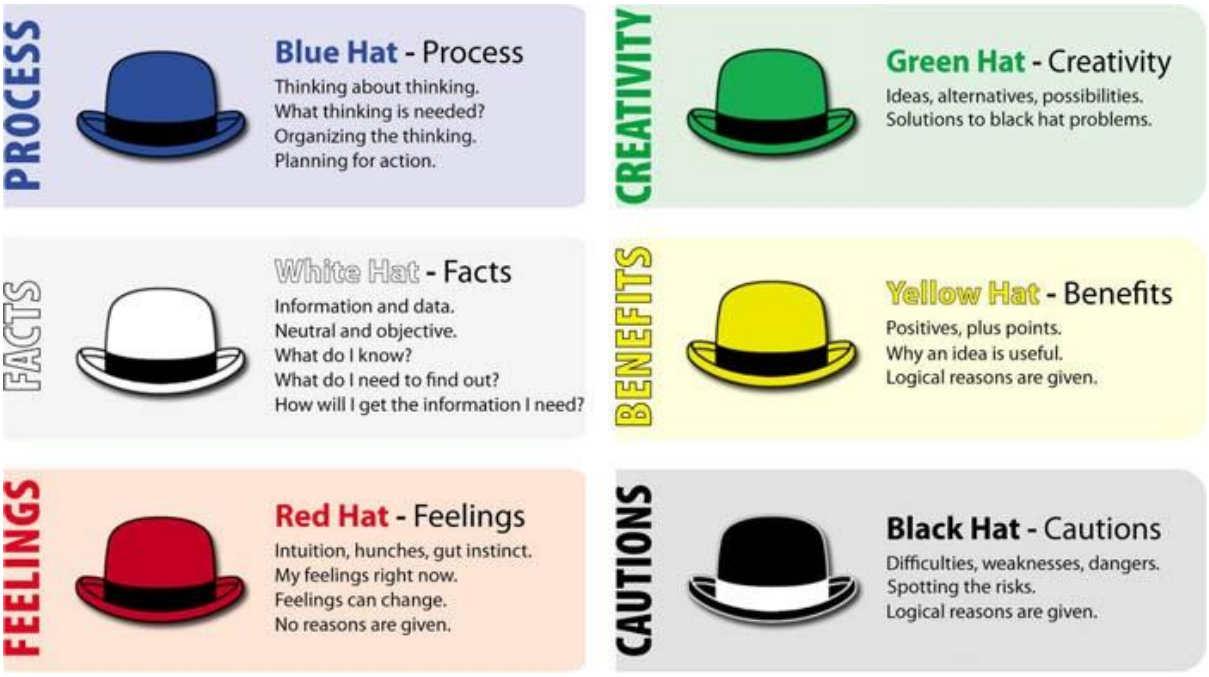


Figure 2.4: The six thinking hats
Source: De Bono (2017)

Franken (1994) states that creativity enables a person to view things in new ways or from a different perspective. One must be able to generate new possibilities or alternatives. Being truly creative is not only about the number of alternatives that people generate but the uniqueness of those alternatives.

2.5 CONCLUSION

Chapter 2 focused on critical thinking and problem-solving skills and strategies for fostering these skills in an education context. It described a structured approach to solving problems and strategies to improve creativity that should assist to develop these skills in people. Based on the literature overview presented, I introduced students to the literature and applied some

of the suggested strategies. I gathered feedback from students to assess the effect that this approach had on them to see if it supported the literature, or if it could lead to new insights. The details of the research methodology followed are explained in Chapter 3.

3. Methodology

3.1 INTRODUCTION

I used a participatory action research methodology to address the research question. This methodology adopts a collaborative approach between participants and the researcher and it aims to find a practical solution to a practical problem experienced by participants (Maree, 2010). The aim is to improve practice and requires a detailed problem analysis and a strategic plan to solve the problem. The impact of the implemented plan should be evaluated and the results reflected on. This may lead to a new problem or problems being identified and hence a new cycle of planning, acting, observing and reflecting (Stringer, 2008; Zuber-Skerritt, 1992).

Action research is a term that includes various paradigmatic approaches and data collection strategies. In this chapter I expand on the paradigmatic approach I used in this study as well as the data collection and data analysis methods that I employed. I explain how my sample was selected and what my intentions were with the interventions for each cycle of interaction. I explain how I have ensured reliability and validity of the data, the limitations and the ethical considerations concerning this research study.

3.2 PARADIGMATIC APPROACH

In the 19th and 20th centuries, the research paradigms were objectivism, rationalism and positivism where research results were proven to be true by establishing scientific laws that were supposedly an objective truth that would hold in all circumstances (Maree, 2010). At the turn of the 20th century, research undertaken in the field of physics revealed complex relationships within diverse observations and this led to the relativity theory that implied that human observations were relative to the individual's or group's frames of reference. Scientists began to realise that the universe is too complex to be understood and predicted by deductive reasoning alone. Researchers were also surprised by the social sciences' ability to predict human behaviour by approaches referred to as naturalistic, subjective, interpretivist and constructivist (Maree, 2010). Maree (2010) groups these research approaches under an umbrella term of qualitative research and this includes a range of research methodologies, including action research.

This research study is located within the qualitative research approach as defined above and in particular within the interpretivist paradigm. An interpretivist paradigm aims to offer a perspective on a situation and to give insight into the way a specific group of people understand and deal with the situation (Maree, 2010). This paradigm is appropriate for this study because it involves the gathering of rich and descriptive data to develop a better understanding of what works and what can be improved when making changes in an education context. This paradigm focuses on how individuals and groups view and understand the world and observes participants in the specific environment of interest to conclude whether an intervention is successful or not. This research approach acknowledges that the world is made up of people with different assumptions, plans, attitudes, beliefs and values, and attempts to see how people have come to believe their reality by asking them about it (Maree, 2010; Zuber-Skerritt, 1992).

The findings of the research might not be generalisable, but they provide greater clarity on how people in this context experienced the interventions and hence aid in a greater understanding of which practices could be more effective than others when having to establish them in a similar context (Zuber-Skerritt, 1992).

3.3 RESEARCH DESIGN

In this study I made use of Participatory Action Research as my research methodology. In participatory action research there is emphasis on equal collaboration between the researcher and the research participants who are an integral part of the design (Creswell, 2007). The participants together with the researcher should focus on creating practical changes through the research process. I was actively involved in the research process and discussed the reasons for and benefits of the interventions with the participants. I discussed the process with them, trained them in the strategies and sought their feedback to inform the next cycle's interventions.

Action research has been effective in the field of education to improve both teaching and student learning (Maree, 2010; Stringer, 2008; Zuber-Skerritt, 1992). It recognises that practice and research are like two sides of a coin and that the one should constantly inform the other (Maree, 2010; Zuber-Skerritt, 1992).

Action research is generally cyclical in terms of identifying a problem, coming up with a range of possible solutions, implementing some of the possible solutions, evaluating the outcome of the solutions, then going back to improving the solutions or trying different solutions,

whilst continuously reflecting as researcher and getting feedback from participants on the effectiveness of the implemented solutions (Creswell, 2007; Maree, 2010; Stringer, 2008).

'The basic assumption of action research is that people can learn and create knowledge (Zuber-Skerrit, 1992, p. 11):

1. based on their concrete experience;
2. through observing and reflecting on that experience;
3. by forming abstract concepts and generalisations; and
4. by testing the implications of these concepts in new situations, which will lead to new concrete experience and hence to the beginning of a new cycle.'

The action research cycle can be visually demonstrated in Figure 3.1.

Zuber-Skerritt (1992) suggests that action research is an effective way to improve learning and teaching practices in higher education. She states that many teachers want to improve their teaching, but often try methods such as attending staff development sessions, consulting the literature in the field or getting help from an educational adviser. She thinks that this is similar to the surface approach taken by students when learning something new by forcing someone else's truth into their heads. A more appropriate approach would be to take a 'deep learning' method, namely learning by discovery, experiential learning and doing problem solving to get to the best answer for their unique circumstances. Such active and creative learning experiences can lead to improved knowledge in the field should teachers document these learnings in an action research thesis.

However, the nature of the research design raises some ethical dilemmas because of the bias of the researcher towards the data collected. There could also be contamination of research data because of multiple factors that operate in the context in which the interventions are done. The researcher could become too involved or emotionally attached to the participants and lose objectivity (Maree, 2010). On the other hand, some researchers may find it difficult to earn the trust of participants for them to feel comfortable to allow the researcher insight into their perceptions and experiences. There is also the challenge of making sure that all voices are heard because no community can be regarded as a homogeneous entity. Lastly, it is challenging to assess the quality of the outcome and whether a sustainable change has been facilitated (Maree, 2010).

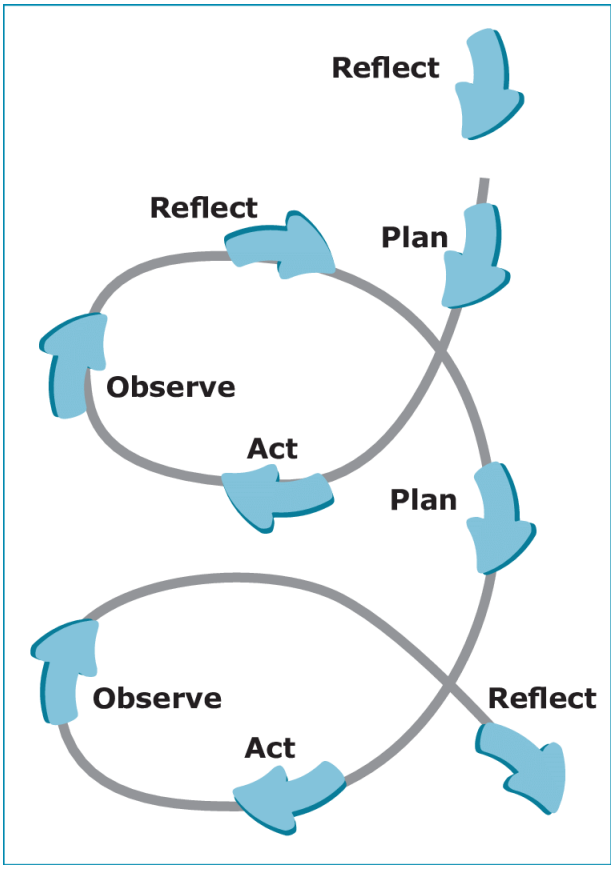


Figure 3.1: Action research cycle
Source: www.researchgate.net

The main benefits of action research are that it improves practice, it improves the understanding of practice by its practitioners and/or it improves the situation in which the practice takes place (Zuber-Skerritt, 1992). Practitioners benefit from the self-development and the development of their research capacity and the organisations benefit from the continuous cycle of development and change (Maree, 2010; Stringer, 2008).

Another advantage of action research is that it is generally cost-effective in terms of time because rich information can be gathered through short sessions with participants. The relationship between participants and researchers often improves during the process of action research since both are working towards a common goal of improving practice that will benefit both parties (Maree, 2010). It generates rich contextual data, which helps to understand the participants' own experiences, challenges, opportunities and points of view. This information

can be used to facilitate ways to address the challenges and put plans into action to solve practical problems (Maree, 2010; Stringer, 2008; Zuber-Skerritt, 1992).

For this study, the practical problem was identified as the lack of problem-solving skills that students are equipped with when leaving university and entering the workplace. It is important to understand the context as well as possible solutions to the problem when undertaking an action research methodology (Maree, 2010). The researcher, in this case myself, understood the workplace context after practicing as an actuary in the private sector for 11 years, and also understood the university context after being a lecturer for five years. This helped to successfully undertake an action research approach because I acted as a mediator to help participants understand the reasoning behind the interventions and I could make a fair assessment of the effectiveness of the interventions by considering their ability to solve real-life problems.

Table 3.1 shows the interventions during each cycle of the participatory action research process. It shows the data collection method that was used during each cycle and the observations following from the analysis of the data. It then shows the reflections and relevant findings after each cycle, which led to the changes in the next cycle.

Table 3.1: Participatory Action Research Design

	Cycle 1 (2017) (Pilot)	Cycle 2 (2018)
Session 1: Plan	The pilot project intended to engage participants in three sessions of two hours each to obtain feedback that would improve the next cycle. The purpose of the first session was to introduce participants to the reasons for the research study, why I believe problem-solving skills are important to develop and the principles for developing these skills. I planned to give an overview of some strategies that should enable participants to acquire problem-solving skills and learning skills that should enhance their knowledge and understanding of the work. This should improve their ability to apply the knowledge to practical problems. The pilot project facilitated feedback from participants to improve the interventions in the next cycle.	The feedback from the pilot project suggested that these sessions should be held earlier in the year so that participants obtain the knowledge sooner to be able to apply it earlier. Hence, I planned the sessions to be one month apart in this cycle. I also planned for a session with lecturers of the participants to brief them on the principles that my research was based on to encourage them to adjust their teaching methods accordingly. As part of the action research design, I planned to get feedback from participants again to see if the improved interventions were successful.

Table 3.1: Participatory Action Research Design

	Cycle 1 (2017) (Pilot)	Cycle 2 (2018)
Session 1: Act	The first session was held in January 2017 and covered the introduction as planned above. It was a two-hour contact session in the form of an interactive lecture with participants. I used the start of the session to explain exactly what the research entailed and to gain informed consent from participants. I ended the session with a practical example, but due to time constraints, we could not cover it in sufficient depth.	The first session was held in January 2018 and covered the introduction similar to the first session of 2017. It was a two-hour contact session in the form of an interactive lesson with participants. I explained the nature of my research and acquired informed consent from participants similar to 2017. One change from the first lecture in the previous cycle was that I did a past exam question to practise generating questions, helping them to formulate the problem better. We also used a problem-solving structure to generate solutions. This was an improvement from 2017 when we did not have enough time to do a practical, actuarial example of the principles at the end of Session 1.

Table 3.1: Participatory Action Research Design

	Cycle 1 (2017) (Pilot)	Cycle 2 (2018)
Session 1: Observe	The data were collected in the form of an anonymous written survey that was done at the start of the second session. Participants wrote down their responses to the on-screen questions on paper. The aim was to check with students whether the first lecture had an impact on their understanding of the work and their approach to learning.	Similar to 2017, the data were collected in the form of an anonymous written survey done at the start of the second session. They wrote their responses to the on-screen questions on paper. The questions were similar to the previous cycle. I modified the questions slightly to improve clarity and to gain more information from participants.
Session 1: Reflect	Participants appeared to be interested in what I was saying and they contributed actively. I needed more time with the practical example at the end of Session 1. According to the feedback, most of the participants have started to use some of the methods that were discussed in Session 1.	Participants contributed actively to the session. The majority of participants found the first session helpful and have started to use some of the methods that were discussed in Session 1. They have started to ask more questions to themselves and others and have started to use structures like mind maps or the Actuarial Control Cycle while studying.

Table 3.1: Participatory Action Research Design

	Cycle 1 (2017) (Pilot)	Cycle 2 (2018)
Session 2: Plan	The purpose of the second session was to introduce strategies to help students define problems accurately as well as strategies to generate more solutions to problems.	The purpose of this session was similar to the second session in the first cycle. The problem-solving lectures were held one month apart in this cycle, rather than two months apart as in the previous cycle. This was because participant feedback in 2017 indicated that they wanted to receive the knowledge earlier in the year. I also planned to make use of more actuarial examples in Session 2 than in 2017.
Session 2: Act	The second session was held in March 2017 (around two months after the first session). It was a two-hour contact session in the form of an interactive lecture with participants. Five strategies to define problems better were explained with examples to illustrate how to apply these strategies. Seven strategies to generate solutions to problems were explained with examples of how to apply these strategies.	The second session was held in February 2018 (around one month after the first session). It was a two-hour contact session in the form of an interactive lecture with participants. The same strategies of 2017 were explained but I spent more time on the strategies that students found to be more useful from the feedback given in 2017. I added a few examples in an actuarial context to make it easier for students to understand how they will apply the strategies in their context.

Table 3.1: Participatory Action Research Design

	Cycle 1 (2017) (Pilot)	Cycle 2 (2018)
Session 2: Observe	The data were collected using an online survey tool containing 10 questions. The aim was to establish whether the participants were using the strategies that were taught in the second session and which strategies were being used more than others. One of the questions tested whether participants found the volume of work covered in the sessions appropriate.	The data were collected using the same online survey tool as in 2017 containing 10 questions with the same aim as in 2017.
Session 2: Reflect	I would have liked to do more practical examples that have specific bearing on their actuarial studies. I will focus on practical application in an actuarial context for the third session in this cycle. I think it could be useful to bring some group work into the last session to ensure that students get enough practical experience of the strategies and also benefit from the group wisdom.	The participants were engaged and participative and I think they enjoyed the practical examples, especially those within an actuarial context. The second session contained a large amount of information to absorb. A third session is needed to practise these strategies and I will focus on practising examples in an actuarial context, the same as in 2017.
Session 3: Plan	The purpose of this session was to practise the strategies given in the first two lectures so that participants understood how and when to use the strategies more effectively in an actuarial context.	The purpose of this session was to practise the strategies given in the first two lectures so that participants understood how and when to use the strategies more effectively in an actuarial context, similar to 2017.

Table 3.1: Participatory Action Research Design

	Cycle 1 (2017) (Pilot)	Cycle 2 (2018)
Session 3: Act	The third session was held in May 2017 (around two months after the second session). It was a two-hour contact session in the form of an interactive, practical application class with participants grouped into four groups of six students each.	The third session was held in March 2018 (around one month after the second session). It was a two-hour contact session in the form of an interactive, practical application class with participants grouped into four groups of five students each.
Session 3: Observe	The data were collected in the form of a group discussion between an independent education specialist employed at the university and the participants willing to attend. The discussion of 50 minutes took place in May 2017 and was recorded and analysed afterwards to identify themes. The aim was to establish whether participants found the problem-solving lectures useful and to determine which of the strategies they were using. I also wanted to establish what could be improved for the next cycle.	The data were collected in the form of a group discussion between an independent education specialist employed at the university and the participants willing to attend. The discussion of 50 minutes took place in March 2018 and was recorded and analysed afterwards to identify themes. The aim was the same as for 2017.

Table 3.1: Participatory Action Research Design

	Cycle 1 (2017) (Pilot)	Cycle 2 (2018)
Session 3: Reflect	Lecturers should receive a briefing on the principles that I had discussed with participants because a different approach to teaching would be required, not only to learning. Participants seemed to find a structured approach to learning and problem solving useful. Participants requested the sessions to be held earlier in the year. I will schedule the sessions one month apart for the next cycle. Participants gave a good description of the techniques that they were using as a result of the interventions.	Participants requested a problem-solving toolkit to be placed on ClickUP to remind them of the techniques to practise and use. I arranged for a summary to be put on ClickUP. Participants found the practical third session helpful but still needed continuous practice throughout the quarter to embed the strategies.

3.4 SELECTION OF PARTICIPANTS

For the study, the participants were Actuarial Science Honours students at the University of Pretoria. I selected this population purposefully because I had been teaching Honours students at the University of Pretoria and I became aware of the need for problem-solving skills in these students. I decided to teach problem-solving strategies as part of the Actuarial Science Honours course (within one of the first semester subjects) to ensure that students acquire problem-solving skills within the field of expertise where they will have to apply the skills, thus supporting McPeck (1981) and Soden (1994).

For the first cycle, I did a pilot project with the 2017 Actuarial Science Honours students (37 students were registered for the Honours course). The students could choose whether to attend the problem-solving lectures or not. I requested the students' feedback after each lecture to help improve the strategies. Thirty students attended the first session, 28 students the second session, and 24 students the third session.

The improved strategies were then implemented within the same first-semester subject of the 2018 Actuarial Science Honours students (41 students were registered for the Honours course). Attending the problem-solving lectures was voluntary once again. Thirty students attended the first session, 26 students the second session, and 20 students the third session.

I reflected on the effectiveness of each of the lectures and requested feedback from students as to their experience of the effectiveness after each of the lectures to enable me to report on the final results. The number of participants in every session and the number of participants who gave feedback provided sufficient information so that reasonable conclusions could be drawn. I investigated the decline in the number of students attending each session to attempt to explain the pattern.

3.5 DATA COLLECTION

I made use of qualitative data collection methods because I wanted to gain insight into how effective the participants experienced the interventions to be. In addition, I wanted to give them an opportunity to help improving the methods or processes used. My research stretched over two years which I refer to as two cycles. Within each cycle, I used cycles of planning, acting, observing, reflecting to establish the impact of the interventions in each session within that cycle and to improve the next session and cycle (as described in Table 3.1 in Section 3.3).

The first feedback requested from participants was in the form of written feedback (anonymous) at the start of the second session to establish whether the first session had an impact on their behaviour and/or study methods. The questions that were asked can be seen in Table 3.2. Each question was discussed with the class to make sure they understood the purpose of the question. The questions were slightly adjusted over the two cycles to improve clarity and understanding.

Twenty-seven participants gave feedback on Session 1 in Cycle 1 and 26 participants gave feedback on Session 1 in Cycle 2.

Table 3.2: Questions for feedback on Session 1

Cycle 1	Cycle 2
1. Has the previous lecture created an awareness of the skills required for better problem solving?	1. Did the previous lecture create an awareness of the techniques required for better problem solving?
2. Do you understand the big picture of your subject? What have you done/are you planning to do to understand the big picture?	2. Do you understand the big picture of your subject? If yes, explain. If not, why not?
3. Have you been asking more questions?	3. Have you been asking more questions?
4. How have you adjusted your study methods?	4. How have you adjusted your study methods?
5. How have you used the Actuarial Control Cycle as problem-solving tool?	5. Have you found the Actuarial Control Cycle useful?
6. Any other comments/ideas/suggestions?	6. Any other comments/ideas/suggestions?

The feedback requested from participants to establish the success of the interventions after the second session was in the form of electronic feedback through an anonymous online survey tool. The questions that were asked can be seen in Table 3.3. The purpose with the questions was to establish whether students had been using the techniques that were taught in both sessions.

Fourteen participants completed the survey in Cycle 1 and 23 participants completed the survey in Cycle 2.

Table 3.3: Questions for feedback on Session 2

Cycle 1 and Cycle 2
1) The lectures on problem solving provided me with useful techniques to help me define problems/understand test questions better. (Strongly agree to strongly disagree – 4 point scale)
2) Have you been able to apply some of the techniques that were explained in the problem-solving lectures to define problems/understand test questions better? (Yes/No)
3) If yes, which techniques have you applied (name or explain the technique/s). If no, why not?
4) The problem-solving lectures provided me with useful techniques to help me to generate more solutions to problems/questions? (Strongly agree to strongly disagree – 4 point scale)
5) Have you been able to apply some of the techniques that were explained in the problem-solving lectures to generate solutions? (Yes/No)
6) If yes, which techniques have you applied (name or explain the technique/s). If no, why not?
7) I valued the practical actuarial examples that demonstrated the techniques in the problem-solving lectures. (Strongly agree to strongly disagree – 4 point scale)
8) I valued the non-actuarial examples that demonstrated the techniques in the problem-solving lectures. (Strongly agree to strongly disagree – 4 point scale)
9) The volume of content of the problem-solving lectures were: (Too little, Just enough, Too much)
10) Do you have any other comments/ideas/suggestions/needs for the final problem-solving lecture?

Lastly, I requested focus-group discussion feedback from the participants that was facilitated by an independent education specialist employed at the university. It was in the form of a semi-structured group interview because such interviews cater for making use of pre-determined questions to be answered by the participants, but also give flexibility to the facilitator to add additional comments or questions. This type of interview is appropriate because it allows for probing and clarifying issues related to the interventions to gain a deep understanding of the impact and suggested improvements. The pre-determined questions and suggested probes can be seen in Table 3.4. The purpose of the questions was to establish whether students found the sessions useful and which particular techniques they found the most helpful. I also wanted to ensure that they understood what was required from them to improve their own problem-solving skills.

Eleven participants attended the focus-group discussion in Cycle 1 and 14 participants attended the focus-group discussion in Cycle 2.

Table 3.4: Questions and probes for focus-group discussion feedback

Question	Cycle 1 and Cycle 2
1	Do you believe that problem-solving skills is an important skill to have? **Probes:** Why? How often do you think you'll use this skill? Do you think it's a skill that can be developed, or do you think some people just have it and others not?
2	Have you adjusted the way you study? **Probes:** Do you ask more questions to yourself and/or others? Do you understand the big picture and where everything that you are learning fits in? Do you use a more structured approach to learning? Are you using the Actuarial control cycle (ACC) as framework to 'link' chapters to or do you use mind maps or something similar?
3	What do you think can help you to improve your problem-solving skills? Can you remember some techniques mentioned in the lectures? **Probes:** Facilitator was made aware of terms such as questioning, understanding the theory, deep learning, a structured approach to solving problems, understanding the big picture, linking concepts to existing knowledge, frame of mind.
4	What techniques have you used to help you to define problems better? **Probes:** Facilitator was made aware of techniques such as questioning to clarify what the real problem is, distinguishing between assumption versus fact, present state/desired state approach, Duncker diagram method, statement/re-statement technique. Was it useful to have the toolbox on ClickUP to refer back to for ideas and to remember what was taught?
5	What techniques have you used to help you generate more solutions? **Probes:** Facilitator was made aware of techniques such as brainstorming, considering impact on all stakeholders, questioning potential consequences of any solution to come up with more solutions, considering the positives, negatives and interesting facts about problems and solutions, Osborne's checklist, random stimulation, using the Actuarial control cycle, using diagrams/graphs/formulae to stimulate the brain, letting the problem incubate
6	Are there any techniques that you felt were not very useful to you? **Probes:** Why? Do you think it should be left out in future or do you think someone else found it useful?
7	Did the lecturer make it practical enough? **Probes:** Do you understand how to apply some of the techniques now? How helpful was the last lecture with that? And the examples of the other lectures?
8	Do you have any suggestions to improve the effectiveness of the lectures?

I believe using multiple methods to collect feedback ensured that I received different and honest views and perspectives. The cycle of reflection and feedback was repeated and strategies were refined and improved as a result of this.

3.6 DATA ANALYSIS

I used content analysis to analyse the data in this study as it was the most appropriate method of analysis to be used. Content analysis is a systematic approach to the analysis of qualitative data. It is the process of looking at data from different perspectives and angles to identify themes that will assist the researcher to understand and interpret the data and construct meaning (Maree, 2010).

For the written feedback on the first session in each cycle, I counted the number of positive versus negative responses to each question. I then considered the reasons given for the positive or negative responses to each question, grouped the reasons into themes and counted the number of responses for each theme. For the open-ended question at the end, I grouped the responses into themes.

For the electronic feedback after the second session in each cycle, I counted the number of responses in each category. I counted the number of students mentioning particular techniques or explaining the techniques to establish which techniques were being used the most. For the open-ended question at the end, I grouped the responses into themes.

Finally, the focus-group interviews after the third session were recorded on a voice recorder for each cycle. I listened to the interviews a few times. The reason for this was to make sense of the information before I started my transcriptions. I then made my transcriptions and once this was done, I read through the data and identified themes and grouped responses accordingly.

These phases of data analyses were done after each session and this made it possible for me to adjust the following sessions and cycles to demonstrate to participants that they have been heard and that I valued their contributions and used their recommendations where practical and sensible.

I present the findings from the feedback in Chapter 4.

3.7 RELIABILITY AND VALIDITY OF DATA

'Validity in qualitative research means the extent to which the data is plausible, credible and trustworthy; and thus can be defended when challenged. Reliability and validity remain appropriate concepts for attaining rigor in qualitative research' (Bashir, Afzal, and Azeem, 2008, p. 35). It is important to consider procedures such as consistency checks and credibility checks to ensure the trustworthiness of the data analysis, findings and conclusions (Maree, 2010).

During the course of this study I used numerous data collection methods such as written anonymous feedback, electronic anonymous feedback and focus-group semi-structured interviews by an independent facilitator to verify my findings. All of these methods of data collection were used to enhance the trustworthiness and reliability of the data and to gain a clear understanding of the impact that the interventions had on the participants. Using multiple data sources also served as a check for consistency in the findings (Maree, 2010).

The concept of crystallisation is proposed by Richardson (2000) in Maree (2010) for qualitative research studies. The aim is to probe for a deeper understanding of a complex phenomenon, rather than to search for causal relationships (Maree, 2010). The reality obtained from using multiple data sources and several investigators ('the crystallised reality') is credible in so far as those reading the data and analysis will be able to see the same patterns emerging, and this adds to the trustworthiness of the research.

Credibility in qualitative research is to ensure that the research is reliable and valid (Bashir, Afzal, & Azeem, 2008; Maree, 2010). This often requires quality rather than quantity in a qualitative research design. In this study, three sessions were held in each cycle. Written and electronic surveys were used as data collection methods for the initial sessions and these were supported by a semi-structured interview (focus-group discussion) after the final session to enhance the data collected through the surveys. Credibility was ensured by getting continuous feedback throughout each cycle to establish common themes throughout.

3.8 ETHICAL CONSIDERATIONS

Any research involving individuals or institutions must consider ethical decision-making (Ethics guide, Faculty of Natural and Agricultural Sciences, University of Pretoria, 2016). Ethics involves dealing with decisions to be taken during the research project based on rightful and wrongful actions or potential consequences of actions. For this research

project, numerous ethical considerations had to be taken into account. Ethical clearance had to be obtained from the Research Ethics committee of the Faculty of Natural and Agricultural Sciences at the University of Pretoria. Informed consent had to be given by the participants. I had to ensure confidentiality and anonymity when reporting my findings.

Firstly, I applied for ethical clearance from the Faculty of Natural and Agricultural Sciences Research Ethics committee. I obtained restrospective ethical clearance by the committee in May 2018 (Addendum A).

At the start of the first session in each cycle, I explained to participants what my research aimed to achieve and what would be required of them. I assured them of the confidentiality and anonymity of their participation and feedback during this research project. I gained the informed consent of participants after explaining the process as well as the importance of their participation in the proposed research project. A copy of the consent letter to the participants is attached as Addendum B.

A description of the participants' possible discomfort and risks to be expected during the research had to be discussed and explained, as well as the potential benefits that participants could receive when taking part in this research project. The participants were informed that they could take part in the research project on a voluntary basis, meaning that they had a choice as to whether they wanted to attend the sessions and also whether they wanted to give feedback or not. Participants were informed that they would be requested to give feedback during and after completion of the course to comment on the usefulness or otherwise of the interventions aimed at improving their problem-solving skills. They were assured that all information obtained during the course of the study would be strictly confidential.

Participants were told about some of the benefits of participating in the study:

- They would make a contribution towards establishing how problem-solving and critical thinking strategies could be taught to students in the most effective way.
- They would have the opportunity to reflect on their own learning, problem-solving and critical thinking skills and most probably experience some improvement in those areas over the period.

When dealing with the confidentiality and anonymity of the participants, it was necessary to ensure that the participants were given the opportunity to remain anonymous. All data

were kept and treated with confidentiality to protect the participants from any harm. I was not employed by the university at the time of applying the interventions, which may have provided comfort to the students because I was not involved with their marks and hence, students who attended the problem-solving lectures would not be treated different to students who chose not to attend these lectures.

Permission for possible publication of the research findings was also negotiated with the participants. In the case of Participative Action Research, it would be of great importance for the final research findings to be published to inform and benefit the university, educators and future students.

I also committed myself to the principle of trust. I did this by building good relationships with my participants and by conducting myself with integrity towards my participants by keeping my promises and demonstrating courtesy and respect to all my participants at all times.

3.9 CONCLUSION

This chapter explained the research methodology that was used to collect the data necessary to answer my research question. In this chapter, I presented my research design and research paradigm that demonstrated that this was an in-depth study to understand the participants' perceptions of the effectiveness of the interventions. The participants were actively involved in the study. I also presented my data collection methods and processes used in the collection of data as well as how my participants were selected.

In this chapter the trustworthiness of the study and ethical considerations were addressed. A detailed description of the interventions in each cycle and an in-depth analysis and interpretation of the data collected are presented in Chapter 4.

4. Interventions and findings

4.1 INTRODUCTION

As outlined in Chapter 3, the methodology for this study is based on a participative action research design. The intervention strategy took the form of sessions with students to expose them to problem-solving strategies as part of their Actuarial Science Honours course.

The data obtained through paper surveys, online surveys and focus-group interviews were analysed for each cycle separately as explained in Chapter 3. I also analysed the data across the cycles to identify similarities and differences and to look for key patterns in the data to determine if they support the theory that was presented in Chapter 2.

I present the results per cycle in this chapter and the combined results in the last section. In presenting the results, the following research questions that guided the study will be considered:

- How can exposure to applicable problem-solving strategies foster problem-solving skills in Actuarial Science students?
- How does training in problem-solving strategies affect students' learning practices?
- How does training in problem-solving strategies affect the way students approach problems?
- Which problem-solving strategies did students experience to be the most helpful in developing their problem-solving skills?

I now give a detailed account of the interventions, feedback from students and my reflections on the effectiveness of the interventions.

4.2 CYCLE 1

I break down the interventions and findings for Cycle 1 per session and then give a summary for Cycle 1 in Section 4.2.4.

4.2.1 SESSION 1

Date: Wednesday, 25 January 2017.

Place: Lecture hall Mathematics 1-14 at the University of Pretoria.

Participants: There were 30 students present of the 37 registered for the Honours course.

Context: The students were welcomed back to the university for their Honours year on Monday, 23 January 2017. They had their first lecture on Tuesday, 24 January, which covered 'What is the Actuarial Risk Management subject all about?' and 'Professionalism'. On 25 January, their first two-hour session on problem-solving strategies was conducted. I decided to have the first lecture of 2017 as early as possible in the semester in order to explain to students the aim of the problem-solving interventions and to give them tools to improve their learning, problem-solving and critical thinking skills from early on.

I discuss each session under the headings of the actions required by the action research cycle, as introduced in Chapter 3 in Figure 3.1 and specific to this research in Table 3.1.

4.2.1.1 PLAN

I used the first session to define problem-solving skills and to explain to students why I believe they needed these skills. I also introduced them to some principles and strategies to improve their study methods and their understanding of the subject. These principles and strategies should also help them to develop and improve problem-solving and critical thinking skills. This should improve their ability to apply the knowledge to practical problems. I now give a detailed account of the actions I took to meet this aim.

4.2.1.2 ACTIONS

I defined problem-solving skills as the skills required to 'integrate theory and practice' (Barnett, 1992). It is the ability to apply the technical and theoretical principles that students have learnt up to now to solve practical problems using knowledge, thinking techniques and creativity (Soden, 1994). I gave many examples of why everyone needed to solve problems in their lives, but also that it was a competency requirement in 80% of the vacancies advertised by employers of actuarial students in the year 2016. Employers often commented that employees found it difficult to apply their knowledge effectively and practically to solve workplace problems (Soden, 1994). I gave examples of how people have managed to develop these skills in themselves. It starts by understanding the underlying

fundamentals around a problem and the reasoning behind the approach to be taken to solve the problem and to store this information in the mind in an efficient way. Then you will be able to use these skills to solve similar problems in future (Broadbear, 2003; Shepherd, 2010; Snyder & Snyder, 2008; Soden, 1994).

Students needed to equip themselves with: a) a deep knowledge of the subject; b) problem-solving techniques; and c) creativity to enable themselves to become good problem solvers (De Bono, 2015; Fogler et al., 1995; Shepherd, 2010; Soden, 1994; Ramsden, 2003). I discuss each of these aspects in more detail below.

(a) **Obtaining a deep knowledge of the subject:** Students should ensure that they understand the fundamental concepts of the subject by using methods such as **asking relevant questions** and by taking a **structured approach** to learning. I explained the importance of asking questions whilst studying. Questions activate the brain to start thinking (Kline, 1999). Questions help students to understand better if the lecturers make certain statements in class that are not immediately obvious to the students. This helps students to learn from the automated thinking techniques that the lecturers may have used to get to the statement, which they may no longer be aware of using (Snyder & Snyder, 2008). They should ask questions to lecturers, fellow students and themselves to establish whether they can accept any new information as 'truth'. Such questions should help students to relate new knowledge to existing knowledge and to everyday experiences, which, in turn, leads to a deeper understanding. They should consider all the evidence and arguments obtained from their questions before accepting anything as truth (Broadbear, 2003; McPeck, 1981). Questions also help to establish where any new information should be 'filed' within existing structures in the brain.

This brought me to the importance of structured learning. I discussed the importance of 'saving' new information into structures and linking them to existing structures. The way in which information is learned and stored in the memory could inhibit or enhance one's problem-solving ability (Soden, 1994). The thinking procedures required for problem solving will be applied most effectively if students have stored the information in an organised way whilst learning. I demonstrated the impact of structured learning by dividing the class into two groups. The one group had a list of names to remember and the other group had a diagram of those names to remember (Addendum C). The average number of names remembered was 13 out of 20 for the

group who had to remember them in a list form and 19 out of 20 for those who had to remember them in a structured format. This demonstrated to them that the brain remembers things better if they were presented and saved in a structured form.

I further illustrated the usefulness of structures by referring to a supermarket that stores products according to identifying features, hence products with the same features are found in the same isle to make it easier for people to find. Similarly, the brain locates concepts easier when needed to solve problems if the learner linked the identifying features of new concepts to those of existing concepts (Soden, 1994).

I suggested that they could use the Actuarial Control Cycle (ACC) as a structure to link their new learning to (Lyn et al., 2002). We did an exercise to group the chapters of their Actuarial Risk Management subject into the categories of the ACC. I emphasised that some chapters belonged in more than one category and that it remained important for them to understand the interrelationships of the concepts that they will be learning in the year as well as the concepts that they have learnt in their undergraduate studies.

Soden (1994) suggested that one should follow the same thinking techniques when learning new information than when solving problems. I encouraged students to ask questions to themselves when learning a new concept to check if there is a similar concept in their memory. If they can identify similarities with and differences to existing concepts, then they can 'link' the new concept to an existing concept, thereby creating more links between everything that they know to be true already. The meaning of concepts is then derived from their relationships with other concepts (Soden, 1994). The key lies in asking relevant questions. The depth of one's understanding could be described as the number of meaningful links with other concepts one has created.

I explained that students needed to establish the big picture and **broad principles** of the subject since that would help them to create a framework to hook new knowledge on, which would help to obtain a deeper understanding (Shepherd, 2010). I suggested that a good starting point would be to page through the subject notes and read through the headings and summaries of each chapter. In addition, the first chapter of their notes gave a good overview of what would be covered in the subject.

To summarise, students should ask **relevant questions** when learning something new before accepting anything as the truth. They should take a **structured approach** to learning so that information is stored by linking new information to existing information. They must understand the **broad principles** of the subject and understand how everything that they are learning fits into the big picture.

(b) **Using problem-solving techniques:** I explained to the class that studying (or acquiring new learning) requires certain thinking techniques, as exlained above. Solving problems requires similar thinking techniques. Hence, studying and problem-solving are interdependent mental activities (Soden, 1994). I explained the importance of **asking questions whilst solving problems** as well as taking a **structured approach when solving problems**.

I informed the class that psychologists have identified the following techniques that contribute to efficient thinking when faced with problems (Fogler et al., 1995):

- Find a **starting point** that allows you to move forward.
- **Ask questions** about the problem (What? Why? When? Where? How?).
- Try to **generate alternative courses of action** and do not just stick with the first solution that comes to mind.
- Identify **potential consequences** of the proposed courses of action.
- Consider the **advantages and disadvantages** of the proposed courses of action.
- Recall **similar problems** and actions and try to **generalise** it to the current problem.
- **Check** the solutions against the facts. Check that solutions solve the real problem, and that they are not just treating the symptoms.

All of the points above can be generated by asking questions. Asking these questions helps one to think critically about every problem that you have to solve. The key to solving problems lies in learning to **generate questions** about the problem to transform your existing knowledge into problem-solving tools. Asking questions will help you to describe problems accurately, classify problems appropriately, identify problems of a similar type that one has solved before and to generalise appropriately to increase the number of potential solutions. I made them aware of how similar the process of questioning is when solving problems to the process of questioning when learning new concepts. The questioning whilst learning new concepts helps to file the new learning appropriately in a structure. The questioning whilst problem solving helps to determine from which structure to extract the learning required for solving the problem.

Good problem solvers organise their learning into structures and know the relationships between different categories. They reorganise their concept structures as they acquire

more information (Soden, 1994). The difference between expert problem solvers and novices is that experts store knowledge in larger concept structures and have created more links between the structures.

I introduced a **problem-solving structure** to them. It closely resembles the Actuarial Control Cycle and I made it clear that the ACC could be used as a structure for filing new learning, as discussed under a) above, but also in this instance as a problem-solving tool (Lyn et al., 2002). The structure is shown in Figure 4.1:

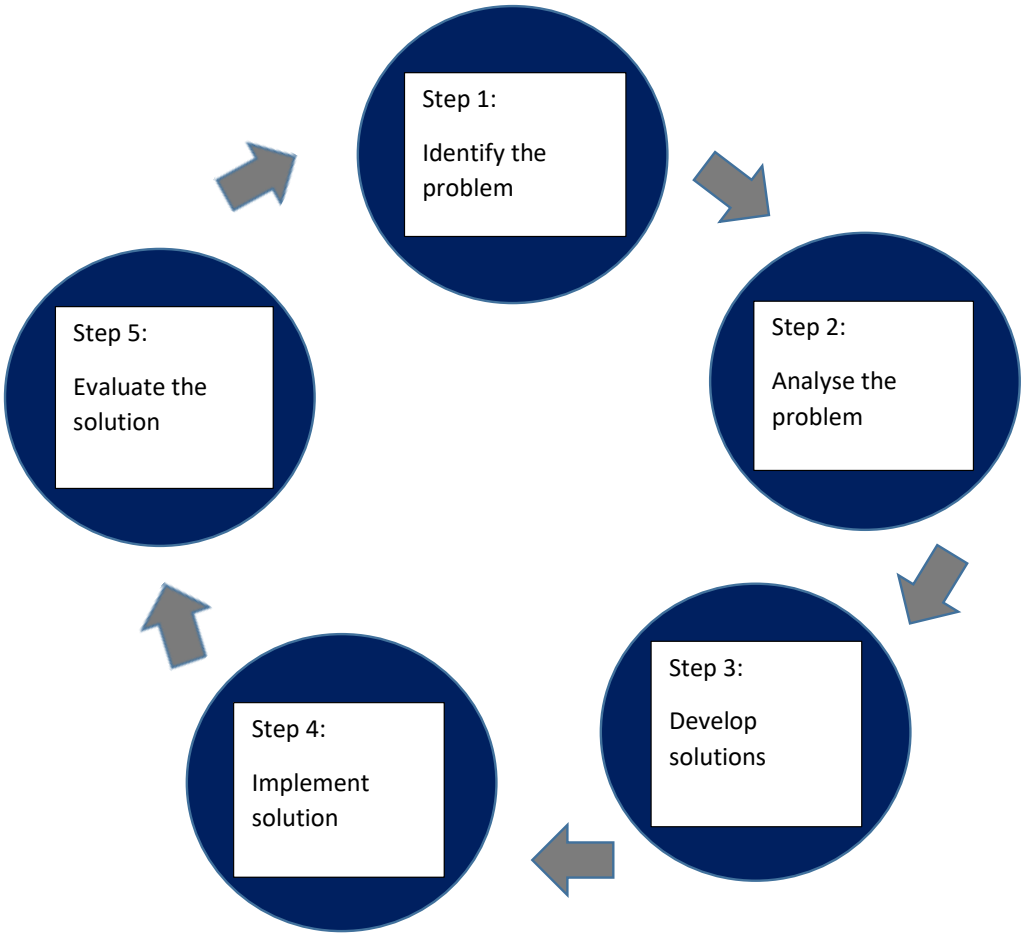


Figure 4.1: A problem-solving structure
Source: http://broadcast.lds.org

I explained how the bulleted questions above could be linked into this structure to help identify and analyse the problem, develop solutions, decide which solution to implement and to evaluate the solution.

Finally, I explained to students that problem-solving techniques are **modelled** to them by lecturers and other experts and that they should learn from them (Snyder & Snyder, 2008). I arranged a short discussion with lecturers to make them aware that they should demonstrate and model critical thinking and problem-solving strategies to students to guide them to develop these skills in themselves (Shepherd, 2010; Snyder & Snyder, 2008). Students should be encouraged to ask questions to learn from the thinking that lecturers use in class to solve problems.

The problem-solving techniques I focused on could be summarised as **asking questions** about problems to activate critical thinking, using a **structured approach** to solve problems and **learning from experts** who model critical thinking and problem-solving strategies.

(c) **Developing creativity:** I used the 9-dot problem (Addendum D) to demonstrate that creativity is often required to solve problems as well as the need to think outside the box. Students should not keep everything they have learnt in separate boxes. Being creative is sometimes just bringing concepts together that other people keep in separate boxes. I encouraged students to not place restrictions on themselves when trying to solve problems. I mentioned some characteristics of effective problem solvers versus ineffective ones to demonstrate the tenacity required to become a good problem solver (Fogler et al., 1995). These include having a positive attitude and believing that the problem can be solved. They need to be willing to spend time on the problem and not give up too quickly. Lastly, they can develop their creativity by reading wider than their field of interest and learn from other fields to help build their creativity.

4.2.1.3 OBSERVATIONS AND REFLECTIONS

The students appeared to be engaged and enjoyed the practical examples that demonstrated the effectiveness of the techniques. I realised that I needed to arrange a session with lecturers to make them aware that they needed to identify the core concepts of the subject and to explain these to students in a structured way. If possible, they needed to demonstrate how new knowledge linked to existing knowledge and to explain it with enough practical examples to ensure that students obtained 'deep learning' from it (Shepherd, 2010; Snyder & Snyder, 2008; Soden, 1994). I realised that the key to successfully

embedding these techniques to become skills lay in reinforcing these principles during lectures (asking questions, structured teaching, modelling problem-solving techniques and encouraging creativity) and for students to practise it throughout the semester on application-type questions (Broadbear, 2003; Shepherd, 2010; Snyder & Snyder, 2008).

I requested feedback from students in the form of a powerpoint questionnaire containing six questions at the start of the second lecture. I asked for their feedback in writing (anonymous) to gain an understanding of how well the message was received. This was about two months after the first lecture. I wanted to establish which of the strategies they had been using since the first lecture and what aspects of problem solving and critical thinking they still struggled with so that I could focus on that for the final lecture. A total of 27 students completed the questionnaire. I set out the feedback that was received below. I first list the question and then a summary of the students' responses. For some questions students gave multiple answers, hence they would be included in more than one category. This means that the total will not add up to 27 for some questions.

1: Has the previous lecture created an awareness of the skills required for better problem solving?

Twenty-six students (96%) responded positively and one negatively (4%) (Figure 4.2).

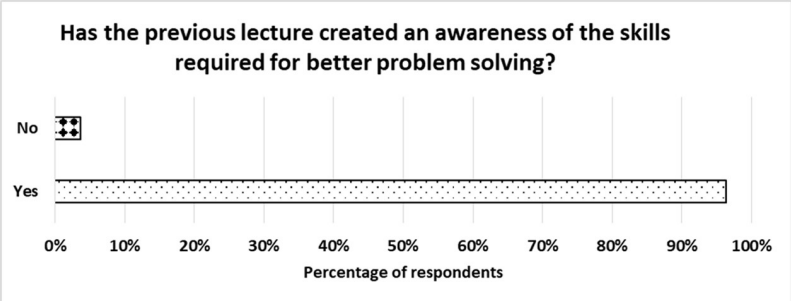


Figure 4.2: Survey 1 Q1

2: Do you understand the big picture of your subject? What have you done/are you planning to do to understand the big picture?

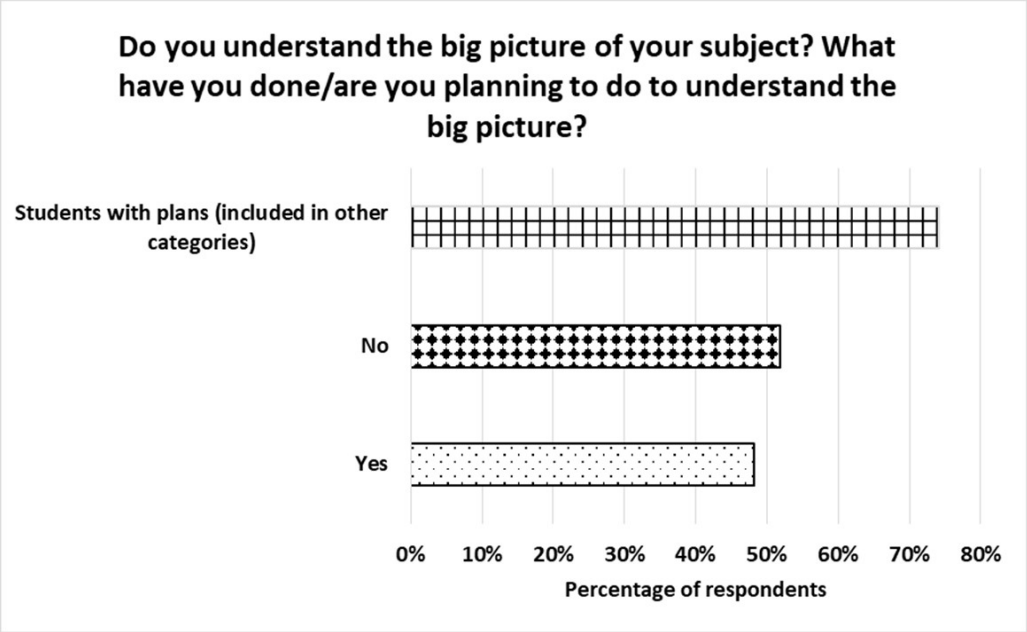


Figure 4.3: Survey 1 Q2

Thirteen students (48%) felt that they had a reasonable idea of what the subject (or at least the part that had been covered in lectures) was all about and how it all fitted together. Two comments from students that demonstrate the general feedback were: 'I have looked at the summary and have a reasonable idea of how the chapters fit together' and 'I am starting to get an idea of where we are headed to with the subject. I intent to categorise the chapters into main categories.' (Original spelling maintained throughout.)

One student commented as follows: 'Yes. I am planning to get a big picture by using the ACC in a mind map form to see how everything fits together. Furthermore I attempt to see how each chapter would be applicable in practice.'

Another wrote: 'Sort of. I try to link chapters together and not put things in boxes/chapters anymore. I plan to keep updated with current afairs as well to help.'

Fourteen students (52%) said that they did not have a good idea of what the subject was all about, but most were aiming to get there by working hard to get through the content once. Some were reading wider and most were attempting to find out how everything links together. One student wrote the following: 'Not yet; all the puzzle pieces have not been laid out yet. Use summaries via mind maps to capture essential info from material.'

Another student wrote: 'Not really. I have no idea how it all will come together in the end, however I believe I need to get a firm grasp of all the principles and a thorough understanding of all the theory.'

Two other comments to demonstrate the general feedback were: 'No I'm struggling to grasp all the theory. I plan to get through all the theory as soon as possible to get the big picture before I start studying' and 'So far it is far more work than anticipated.'

Précis: The majority of students (74%) indicated that they knew it was important for them to understand the big picture and that they had a plan to improve their understanding of it (Figure 4.3).

3: Have you been asking more questions?

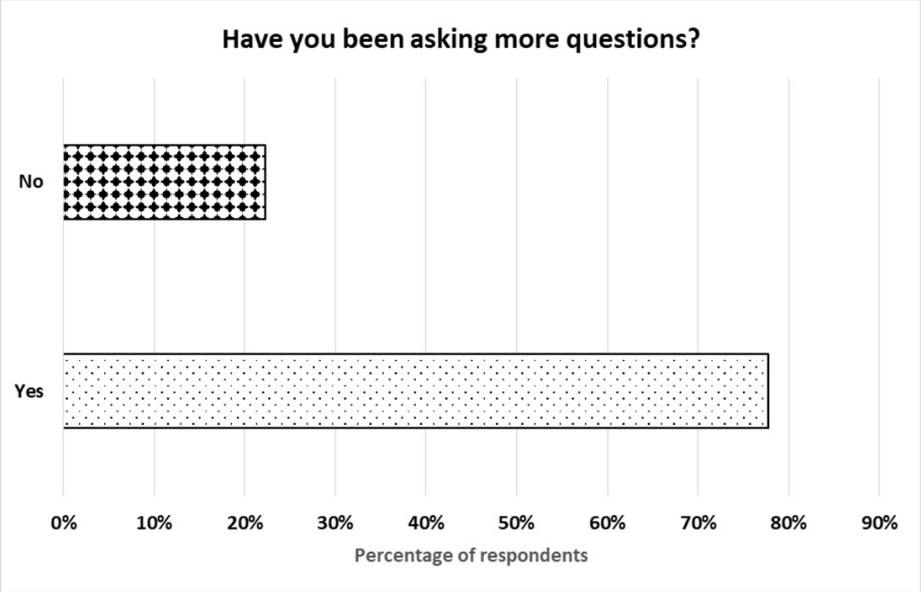


Figure 4.4: Survey 1 Q3

Twenty-one students (78%) indicated that they had been asking more questions in general (Figure 4.4). Twelve of them indicated that they had been asking questions to themselves whilst studying and six mentioned that they asked their friends if they did not understand certain aspects. Some comments were as follows:

'Yes. I have been questioning my own knowledge quite a bit. I have also been trying to ask the lecturers more questions to try and understand the work better.'

'Yes. I am questioning anything in the notes that I do not understand. I mostly talk to my friends and lecturers to try and better understand those parts.'

'Yes. I have been asking more questions, both to myself and lecturers to gain an understanding of the work in a work environment context.'

'More than I ever have but I still feel I could ask more - get a bit shy sometimes to ask.'

Twelve students said that they had been asking the lecturers questions, either in class or via e-mail after class, but nine said that they were too shy to ask questions in class or found the lecturers too intimidating. Some comments were as follows:

'If I don't understand something I usually Google it or ask my friends. I am too shy to ask questions in class.'

'No, I feel like some lecturers are intimidating and not really open to answering questions. Questioning myself.'

'Yes and No; some lecturers do not give proper opportunities for question time.'

'I have been questioning myself while going through the notes and while studying. I do not feel comfortable to ask questions in class, because some of the lecturers reaction to questions imply that they think your question is stupid.'

'No. I feel Honours teaches you to get answers to your own questions.'

Précis: It appeared that an awareness of the importance of asking questions had been created by the first lecture. Lecturers should be informed to encourage questions from students and to create a safe environment where they can interact and learn from the lecturer's thinking techniques.

4: How have you adjusted your study methods?

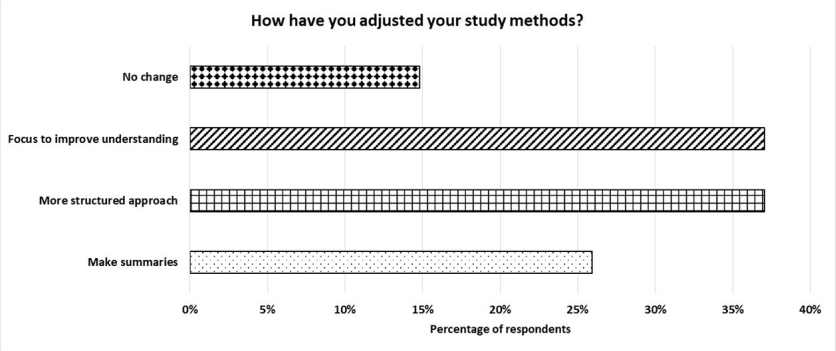


Figure 4.5: Survey 1 Q4

Seven students (26%) had changed their study methods by making summaries. Ten students (37%) had started to take a more structured approach by either using mind maps or considering the big picture or ACC when studying. Three of these students said they were trying to better understand what they were learning and how it would be applied in practice. Seven of them mentioned that they were doing more past questions to understand the work better. Some comments were as follows:

'I have started to voice record summaries and explain the work to myself and I listen to it in the car. It helps to think where it fits in, in the bigger picture. [Linking work to things I already know helps a lot].'

'More structure e.g. pre-read notes first and develop glossary. Then recap notes and make chapter summaries and also answer the questions in each chapter. Also record myself reading the summaries so I can have "audio" study methods too.'

'Not studying everything to know it off by heart anymore ("parrot work"). I try to understand it more that I can apply it better.'

'I revise a lot more and try to fit every chapter to the ACC. I mix up the work I do to keep it interesting - I practice questions, revise old chapters, summarise new ones, read the news.'

Four students (15%) wrote that they had not changed their study methods. Their comments were as follows:

'No adjustment. I struggle to adopt new techniques, so I rather stay with my tried and tested method of studying.'

'I haven't changed my study methods. I just learn the notes.'

'No, my study methods are quite rigid, and worked in the past.'

'No, I always use mind maps to study and it works well for me.'

Précis: The majority of students (85%) had taken a more structured approach to studying and became aware that they needed to understand what they were learning rather than just learning to remember it for a test (Figure 4.5).

5: How have you used the Actuarial Control Cycle (ACC) as problem-solving tool?

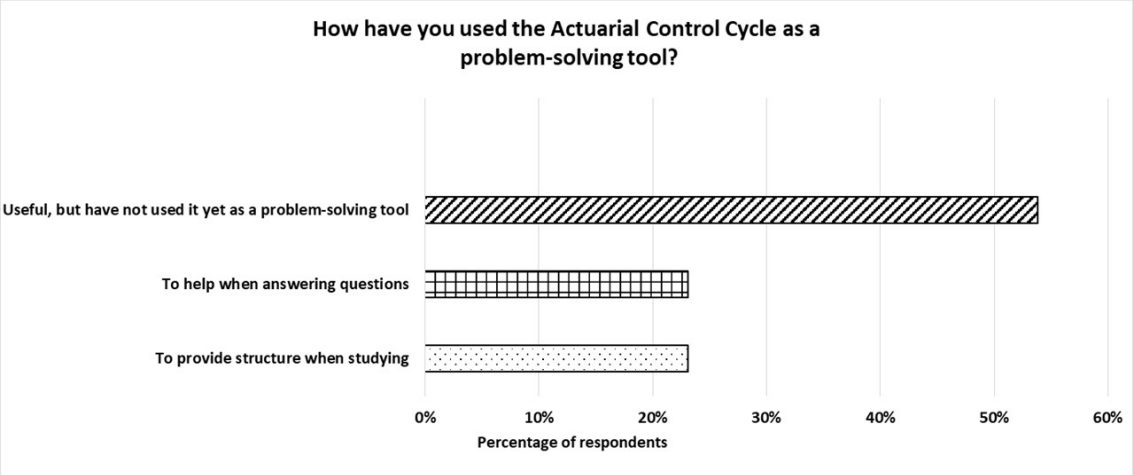


Figure 4.6: Survey 1 Q5

Six students (23%) said that they were using it while studying and for understanding where the chapters fitted in, but not specifically when answering questions or solving problems. Six students indicated that they had used the ACC to help them answer questions or assignments

and to help them understand what the question was asking. Two of these students made the following comments:

'I approach all questions in terms of the ACC to think of possible answers for the questions.'

'I have used it in answering questions - if I know where in the cycle I am then I'm more likely to remember the chapters/ideas I have put into that part of the cycle.'

Fourteen students (54%) said that they were not using the ACC as a problem-solving tool. Some comments were as follows:

'No, I don't have enough time in tests to try and think through the ACC and where the problem fits in.'

'I do not use it in tests because I get caught up with other ideas and don't directly think about the ACC.'

'I have not been using it previously, although I think I will try to start using it more and more in the future.'

Précis: More than half of the students had **not** used the ACC as a problem-solving tool. They needed to be taught how to use it through some practical examples. A large group of students had used the ACC as a tool to help them create structure while studying and when answering questions (Figure 4.6).

6: Any other comments/ideas/suggestions?

Fourteen students commented on this question. The students commented on their Honours classes in general and did not give specific feedback on the problem-solving lectures, but the feedback is still useful to help the university to foster the skills we want them to gain. Eight students requested that they needed to do more questions to know how to apply the theory in practice. They suggested that discussion classes could be a practical way to help train them into the thinking required to solve the more complex problems that they sometimes face in tests and exams. Some of their comments were as follows:

'I would prefer to have more interactive classes. Maybe a discussion class once a week to just understand and recap content for that week. I feel I need more exposure to understand the week's content.'

'It helps a lot to have class discussions (without stress) where you can learn from each other's train of thought.'

'It would be better if lecturers did more questions in class (old/previous questions) to teach/show us how we should ANSWER them and how we should read into questions. I don't really know how the Assignments will help us to prepare for CA1. It takes a really long time to complete.'

'More application/techniques to answer certain questions of the chapters.'

Three students requested that the difficult concepts needed to be explained better and that they felt more time was sometimes needed to embed the difficult concepts.

Précis: Lecturers needed to ensure that students understood the core concepts as well as the difficult concepts of each part of the work. They needed to create an environment where students felt safe to ask questions. Students needed many practical examples and practical problem solving had to be demonstrated to them. The students suggested a discussion class in this subject.

4.2.2 SESSION 2

Date: Thursday, 16 March 2017.

Place: Lecture hall Botany 2-23 at the University of Pretoria.

Participants: There were 28 students present.

Context: These students had nearly completed the first quarter of their Honours year and had written a class test the week before. They had written three class tests in total and four assignments at that point.

4.2.2.1 PLAN

I intended to cover strategies that would help students to define problems accurately as well as strategies to help them to develop multiple solutions to problems. Below, I give a detailed account of the strategies that were discussed.

4.2.2.2 ACTIONS

The following strategies to help students **define problems accurately** were explained:

1. **Exploring a problem in depth** (Fogler et al., 1995): I read the example of 'the dead fish problem' to the students: Stan, the engineer, was told to design a new waste treatment plant to reduce the toxic waste from the chemical plant since an increasing number of fish were dying downstream from the plant. This would have cost the company over a million dollars. Stan, by following the steps below to define the problem accurately, realised that the actual problem was not the concentrations of toxic chemicals combined with the low levels of the river that caused the fish to die, but that there was a fungus that was causing fish to die upstream and downstream from the plant. I then took them through the process that Stan followed by introducing the following strategies to define problems accurately:

   When faced with a problem, one should **gather** as much **information** as possible about the problem to understand where the problem originated. A good starting point is to **ask questions** such as: What is the problem, what not? Where is the problem, where not? When was it a problem, when not? Who is affected by the problem, who not? One needs to think through possible causes for the distinction between is and is not. It helps to draw graphs and diagrams to get visual inputs too. It is important to discuss the problem with the people involved or affected by the problem as well as with the person who posed the problem statement in its current form. It is wise to speak to knowledgeable people in the company, but also to non-experts. I also mentioned the example of the doorman who found a solution to put lifts on the outside of buildings. This was after he overheard the engineers and architects talk about the difficulties and costs to add another lift inside the hotel after clients of the hotel were complaining that they were waiting too long for the lifts.

   Verbalising the problem statement helps to clarify in your mind what you are trying to do. It is important to check the reasoning and assumptions of people who have posed the problem statement to check whether their reasons and assumptions are valid. I encouraged the students to challenge established thinking patterns and not to rely on other people's interpretation of the problem. After one has verified that all the information is correct by cross-checking and cross-referencing data, facts and figures and has confirmed all findings, opinions and assumptions, then one can start exploring the problem as follows:

   Consider the information gathered about the problem by using the techniques from the previous paragraph. Now recall or **investigate theories and fundamentals** applicable to this type of problem. Attempt to collect missing information or state your assumptions about missing information. Solve a simplified version of the problem

to obtain a ballpark answer that can serve as a reasonability check. Hypothesise what could be wrong with the current situation. Brainstorm to guess an answer, recalling past or related problems or experiences. Finally, taking into account all the information gathered from the steps above, define the real problem accurately.

2. **Present state/Desired state technique** (Fogler et al., 1995): This technique requires that one verbalises where you are (the present state) and where you want to get to (the desired state) so that an appropriate path can be found. It is important that every concern in the present state should be addressed in the desired state. One needs to re-work your statements until they match. I explained this method using the aircraft example from World War II. Many of the aircrafts were shot down while engaging in bombing missions over Germany. Many of the aircrafts that made it back were riddled with bullet and projectile holes. The damaged areas were similar on each plane. The instructions given to solve the perceived problem were: 'Reinforce the damaged areas with thicker armor plating.' One needs to re-work the statements until they match, as follows:

Table 4.1: Present state/Desired state Example 1

	Present state	Desired state
1)	Many bullets penetrating the aircraft	Fewer bullets penetrating the aircraft
2)	Many bullets penetrating the aircraft	Fewer planes being shot down
3)	Many bullets penetrating the aircraft in critical and non-critical areas	Fewer bullets penetrating critical areas

There is not a match in 1) because there are planes that are surviving that still have bullet holes. There is not a one-to-one mapping of all the needs in the present state addressed and resolved in the desired state. The states in 2) are better matched, but the distinction between present state and desired state is not clear enough. It may take only a single bullet hitting a critical area to bring down a plane. Statement 3) is a match and the distinction is sharp, which could lead to a variety of solutions such as reinforcing critical areas or moving critical components to more protected locations.

We did a practical example to check whether the present state and desired states match in the following question: 'A life insurance company sells without-profits non-linked whole life

policies. A recent survey has shown that the surrender values offered by the company are lower than those offered by other companies. A customer service manager has suggested that the company should increase surrender values to increase sales and avoid bad publicity. Discuss this suggestion.'

We discussed the customer service manager's suggestion and realised that the present state is not clearly defined in the question. We are not certain whether we are losing out on sales or if there has been bad publicity, so we have to state our assumptions on this. Assuming either or both of these present states are true, we actively debated whether increasing surrender values would solve the problem, that is, does the desired state address all of the problems in the present state. A whole life product protects against death, hence the savings element may be less important to clients who understood what they were buying. Increasing surrender values may mean that one would need to lower death benefits, the main aim of the contract, so we concluded that the suggested desired state was not a match. We created the following present state, desired state table:

Table 4.2: Present state/Desired state Example 2

	Present state	Desired state
1)	Surrender values lower than those of competitors leading to lower sales or bad publicity	Increase surrender values to increase sales
2)	Surrender values lower than those of competitors (leading to lower sales or bad publicity - assumption)	Ensure fair surrender values; Educate on impact of higher surrender values on product pricing

3. **Duncker diagram technique** (Fogler et al., 1995): I gave an example of a teacher who is uncertain as to whether she wants to return to teaching after a few months' leave of absence. Her options are to either quit teaching or make it fine not to quit (to illustrate the two options in the Duncker Diagram). Functional solutions for the 'quit' option would be to either 'find a new job' or to 'retire'. Functional solutions for the 'make it fine not to quit' option would be to ensure that she creates 'more leisure time' or to 'lower her stress levels'. Specific solutions for the 'quit' option would be to 'consider office manager or substitute teacher' as alternative employment. For the 'make it fine not to quit' option, she could consider: 'teach every other term, or teach half days' and for lower stress levels to 'teach a different grade, change schools, have a stronger say in choosing teaching materials (which was causing her stress in her current job)'.

I also demonstrated the technique using an actuarial example of the risk of not selling enough of your product. The options are to either make sure you 'sell enough' by 'keeping price low and ensuring marketing efforts are appropriate' or 'make it fine not to sell enough' by 'pricing appropriately for each risk and by underwriting as accurately as possible', mentioning that there might be practical limitations to such an approach.

4. **Statement/re-statement technique** (Fogler et al., 1995): As explained in 2.4.2.1, this technique requires that the problem be re-stated in different forms several times to try and arrive at the broadest possible problem statement. I demonstrated the technique using the following past semester test question: The company's Analysis of Surplus (AOS) has shown large morbidity experience losses over the past year. I first explained to them what an AOS is to ensure that they understood the context of the question. We then discussed the following six ways to re-state the problem and generate questions about the problem:

   a) Vary emphasis: THE COMPANY – what about other companies or the industry as a whole?

      AOS – how certain are we that the AOS is correct? – have we done any other checks to verify?

      LARGE – how large was it previously? – what is the trend?

      MORBIDITY losses – what is included in this figure? How can we break it up to get more information? What affects morbidity? Type of claim, claim amounts, claim inception rates, claim termination rates, the profile of clients, etc. Which of these parts was the largest contributor to the losses?

   b) Replace words with phrases that have the same meaning or with the definitions of the words – The company's (place that sells insurance products) analysis of surplus (profits arising in the year) has shown large (huge) morbidity experience (disability-related claims experience) losses over the past year (period under investigation). This helps one to consider what defines or affects each part of the problem statement.

   c) Make an opposite statement (change positives to negatives and vice versa) – How can the company make large morbidity profits over a year? Charge too much, be very prudent, claims experience better than expected, etc... . This helps you to think out new ideas and to consider factors affecting the problem from another angle.

d) Change or add terms, for example every to some, always to sometimes, this year to always, sometimes to never, etc. The company SOMETIMES makes morbidity losses – is that okay? But not ALWAYS?

e) Replace persuasive words to help check implicit assumptions, for example obviously – The AOS has obviously shown large losses – is it correct? How would our product be designed if it would obviously show losses?

f) Express words in the form of an equation or picture or vice versa – Formula for AOS losses = Actual morbidity experience minus expected morbidity experience. Break the formula down into: Actual morbidity experience = Actual claim inception rate * Actual claim amounts * Actual claims payment period. Expected morbidity experience = Expected claim inception rate * Expected claim amounts * Expected claims payment period. This breaks down the problem into its components to see if any specific component caused the problem.

The following strategies to help students **generate more solutions to problems** were explained:

1. **Removing mental blocks** (Fogler et al., 1995): I explained to students that people often experience mental blocks when trying to solve problems as a result of one of the following reasons: defining the problem too narrowly or not defining it clearly; trying to fix the symptoms rather than the real problem; assuming there is only one right answer; getting hooked on the first solution that comes to mind or a solution that almost works, but really does not. People also get distracted by irrelevant information or become too anxious to finish. Prolonged concentration is required to solve problems, so there should not be distractions that prevent this. One should take time to generate ideas, not be scared of taking risks and not judge ideas when in the process of generating as many ideas as possible. Some people have intellectual blocks as a result of not knowing the theory or fundamentals surrounding the problem well enough. Others have expressive blocks where they have difficulty communicating their ideas to others and this can block their progress and ability to solve problems.

   I discussed the following 'blockbusting' techniques with them: There is a direct correlation between the time people spend 'playing' with a problem and the diversity of solutions generated. Students should practise problem solving by giving themselves enough time to work on problems and to think through problems without the time

pressure of an exam situation. They should force themselves to think outside the box using some of the techniques discussed in the lecture. It is important to maintain a positive attitude about their abilities to solve problems. They should focus on the opportunity for success in every problem, not the danger of failure.

People should aim to improve their creativity to help them remove mental blocks. I suggested the following techniques: Pose new questions to yourself every day and try to find unique solutions. Keep abreast of your field and learn about fields outside of your specialty. Be open and receptive to new ideas. Take a new route to the university every day. Try recording your notes and listening to them while you drive.

Edward de Bono is seen by many as the father of creativity and he has written numerous books on improving creativity (De Bono, 2010, 2015, 2017). I mentioned some of his techniques to the students:

PMI: Think about the Pluses(P), the Minuses(M) and the Interesting things(I) about any statement, including problem statements.

OPV (other people's views): Take into account all the stakeholders when generating ideas to solve problems. We did a practical example to demonstrate this about a government that was considering to phase in a new pension scheme. The question required them to discuss the possible impact of this proposal on the different stakeholders if it was implemented. Students came up with the following stakeholders, and we discussed how each of them would be affected by the proposed change: State, Employers, Employees, Citizens of the country, Insurers, Asset managers, Trustees, Regulator, Tax authorities.

NO vs PO statements: Say there is a widely accepted belief that NO insurance products can be sold using cellular phones only. Then change the sentence to become PO insurance products can be sold using cellular phones only. This forces one to think about how to make it possible. What should the insurance product look like that could be sold by using only cellular phones? What do we need to do or put in place to change the statement from NO to PO?

The six thinking hats: De Bono suggests one should put on each of these hats to help you think through those particular aspects of any problem statement: White (facts and figures); Red (emotions and feelings); Black (cautious and careful - what could go wrong?); Yellow (speculative-positive - what could go right?); Green (creative - the sky is the limit); Blue (organise the thinking - bringing together the inputs from the other five hats).

2. **Brainstorming**: I explained to students that this technique involved an unstructured free association of ideas to generate solutions to problems. It should initially include wild or unusual solutions without regard to their feasibility. The theory is that people build on each other's ideas or suggestions, leading to a much wider range of solutions being generated. I explained that for this reason group studying is also effective. I encouraged students to attempt past exam questions together and brainstorm the answers to see how many solutions they can come up with compared to when they come up with solutions on their own.

   We practised the technique on a past exam question where a South African insurance company wanted to start selling affordable motor insurance for low-value cars in African countries. The cars had to meet specific criteria to qualify for the product, including passing a national roadworthy test in the country concerned. Products would be sold through various distribution channels, including low-level trained brokers, churches and other organisations, with 5% commission paid on each premium received. Students had to brainstorm the key risks for the insurance company of introducing the product.

   They came up with the following risks: sales volumes too high; sales volumes too low; risks in an African country being different to risks in South Africa, for example driving conditions could be different; drivers could get license at younger/older age; roads could be in better/worse condition; pricing would be difficult because you may not fully understand the risk; there could be corruption with road-worthy tests; distribution risk of mis-selling because they are using low-level trained brokers; expense risk because the company will not know how to allow for expenses correctly; political risk (in most African countries); natural hazards, for example cyclones or earthquakes could be different than in South Africa and difficult to allow for in pricing. Students agreed that the number of risks that they would have been able to come up with on their own would have been much lower than when we used the technique of brainstorming in a group.

3. **Osborn's checklist for adding new ideas**(Fogler et al., 1995): As explained in Section 2.4.2.2, Osborn suggests that one should consider seven questions to help you come up with more potential solutions. I demonstrated Osborn's checklist by referring to the past exam question above of the South African insurance company wanting to start selling affordable motor insurance for low-value cars in African countries. This time the students had to find mitigations for the risks mentioned in 2 above.

Adapt (What do we need to adapt to sell the product as is?): Students came up with: reinsurance, pricing appropriately, thorough market research and good marketing, making sure it meets a need, make sure you understand the risks and have plans in place to reduce the risks.

Modify (How should we modify the product to make it work?): Students suggested that the roadworthy test should be done at specified contacts of the insurer to ensure consistency; minimum level of training for the sales force.

Magnify (How can we make the product better, stronger, add new ingredient?): Add no-claims bonus; bring in telematics to measure driver ability – perhaps not viable in a low-income market. To reduce political risk, diversify into many different countries.

Minify (How can we split up the product, what can we take out, make easier, simpler?): Keep the price low; perhaps exclude natural disasters from cover.

Substitute (Who else, what else, what can we substitute, what other approach can we consider?): Involve the government in the process to try to reduce political risk.

Rearrange (How can we turn things upside down, change positives to negatives?): Provide insurance for bicycles, or cover for specific natural disasters in the specific country. Do something revolutionary.

Combine (How can we combine parts, ideas, units, different categories?): Make this insurance part of the benefits provided by employers for their employees. Combine with other existing cover.

4. **Random stimulation**: This technique requires a person to use a random thought or word from a dictionary to stimulate a new flow of ideas. Similar to brainstorming, this is effective because this word that is out of context will stimulate a new train of thought in the problem solver. I read the example of a toxic holding tank that needed to be made safe and then the random word that they used was 'Airplane'. This gave them the idea to put a fence around the tank, but also to protect the tank from above ... if an airplane were to crash into the tank.

   I then applied the airplane 'random stimulation' example to our past exam question in point 2 above to generate more ideas, for example that the insurer should consider whether they wanted to insure other vehicles such as airplanes, or just cars. I also used the random word 'monkey' to generate ideas about how monkeys could affect the insurance they offer. Monkeys live in forests; how is the natural environment in the African country different to South Africa? What risks are there in the natural

environment that are different to the risks in South Africa, for example earthquakes or storms? Perhaps the roads have been damaged by monkeys. Are the driving conditions different to those in South Africa? Monkeys could be damaging cars. Are the cars in a similar condition than in South Africa? This illustrated the point that plenty of new ideas could be generated by adding a random word to your thinking.

5. **Futuring**: This technique focuses on generating solutions that are currently not feasible but could be in the future. What are the characteristics of the ideal solution? I used the example of improving the higher education system by envisioning a virtual classroom with a lecturer that is a hologram of the most authoritative, dynamic professor in that field, speaking to students on each relevant topic. One needs to visualise the ideal state and work on devising ways to attain it. Think about what would need to happen to completely change the way we do business?

6. **Analogy and cross-fertilisation**: This technique suggests that ideas, rules, laws, facts and solutions from one discipline can be transferred to another discipline. Use your knowledge from one field of expertise to help you solve problems in other situations. It works as follows: State the problem; generate analogies (this problem is like trying to ...); solve the analogy; and transfer the solution to the problem at hand.

7. **Incubation**: This requires that one stops to actively work on the problem and let your subconscious continue the work. The brain does a mental scan of its billions of neurons and searches for novel or innovative connections to make to help you solve the problem. I suggested that students should sometimes read the questions of past exam papers the night before, then only do it the next day. It gives their minds time to get to work on the problem while they sleep.

4.2.2.3 OBSERVATIONS AND REFLECTIONS

Upon reflection, I realised that this session contained a substantial amount of information for students to absorb. I needed to reinforce and practise the techniques in the final session for it to be most useful to students. I decided to focus on the techniques that they found most valuable or useful, both for defining the problem and for generating solutions. I requested this information from students in a survey before the next session. I thought it would be useful to bring in some group work in the final session to ensure that students get enough practical experience of the techniques and also benefit from the group wisdom. I realised that it was unlikely that students would use all of the techniques explained in the session. I considered whether I wanted to reduce the number of techniques to present going forward.

As can be seen from the feedback below, students indicated that they benefited from being exposed to a wide range of techniques. Different students found different techniques useful to them. This led me to believe that the overview of all of the techniques as presented in this session was useful and catered for a greater variety of preferences of the students. The students were engaging and participative and I thought they enjoyed the practical examples, especially those of an actuarial nature. I was not sure if they enjoyed the non-actuarial examples, so I tested that with them in the survey. I perceived them to be not as attentive when I discussed non-actuarial examples than when I discussed actuarial examples.

I requested feedback from students in the form of an online questionnaire containing 10 questions. Twenty-one students completed the first question, but only fourteen students out of 27 that were in the session completed the full survey. I would have liked a higher percentage to have completed the full survey. There are limitations with the free version of the survey engine regarding the option to remind students to complete the survey. I sent out e-mail reminders to students to encourage them to complete the questionnaire. The results of seven questions/statements of the survey are shown in graphical form for ease of interpretation. The results of the three open-ended questions are discussed below the relevant graphs.

1: The lectures on problem solving provided me with useful techniques to help me define problems/understand test questions better

Sixteen out of twenty-one students (76%) felt that the techniques could be useful to them to define problems better or understand test questions better (Figure 4.7).

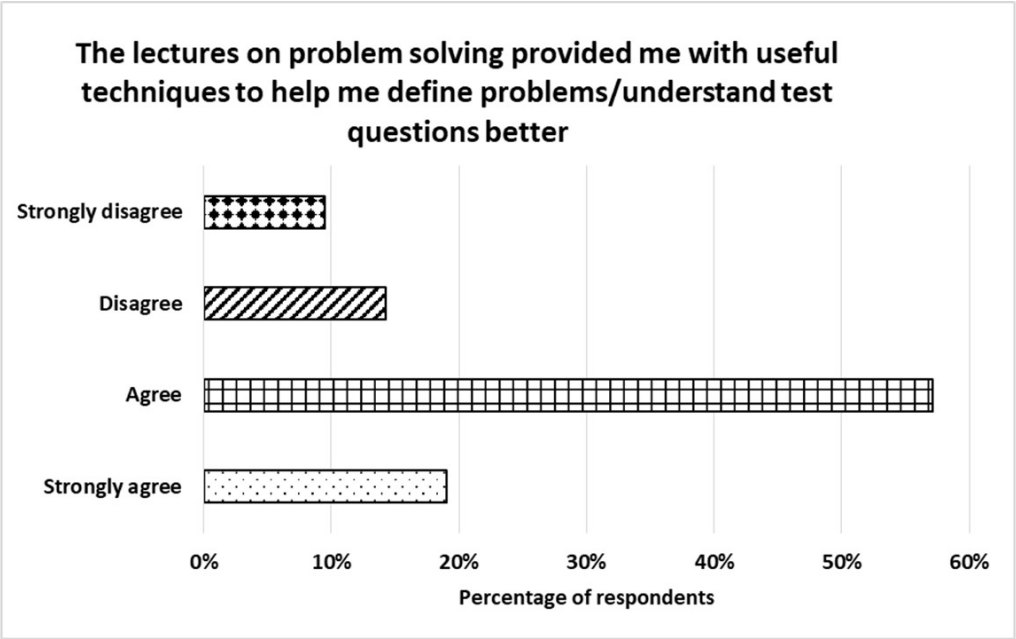


Figure 4.7: Survey 2 Q1

2: Have you been able to apply some of the techniques that were explained in the problem-solving lectures to define problems/understand test questions better?

Eight out of fourteen students (57%) were using some of the techniques to define problems or understand test questions better (Figure 4.8).

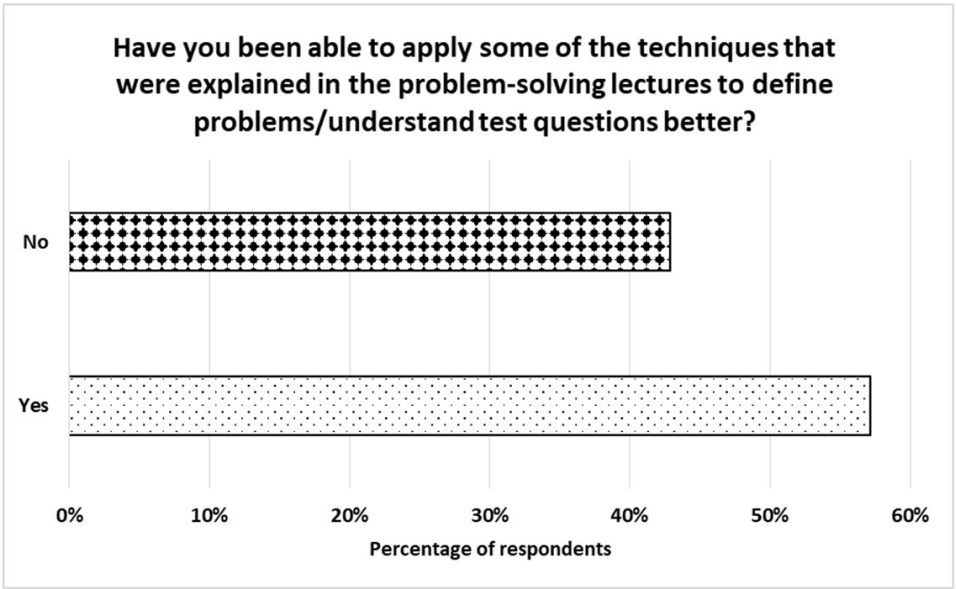


Figure 4.8: Survey 2 Q2

3: **This question referred to Question 2 and was as follows:** ***If yes, which techniques have you applied (name/explain the technique/s)? If no, why not?***

Ten students (71%) answered this question. The students used the following techniques to **define problems**:

Three students referred to paying attention to each word in the question to get a better understanding of exactly what the problem was and to use as much information as possible from the question in their answers.

Two other students mentioned that they used the method of categorising and making associations with existing knowledge to improve recalling of information.

One student mentioned the Actuarial Control Cycle and one student said mind maps.

Three students who responded negatively said that they were still unsure of how to apply the techniques that were taught, especially under time pressure.

4: The problem-solving lectures provided me with useful techniques to help me generate more solutions to problems/questions.

Eleven students (79%) who took the survey felt that the techniques could be useful to them to generate more solutions to problems or questions (Figure 4.9).

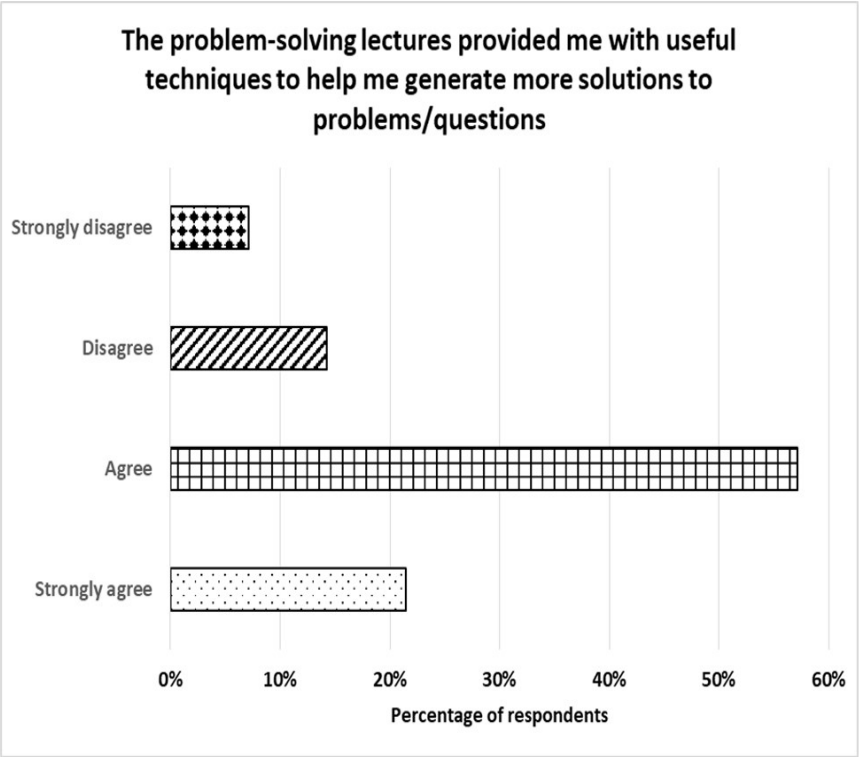


Figure 4.9: Survey 2 Q4

5: Have you been able to apply some of the techniques that were explained in the problem-solving lectures to generate solutions?

Seven students (50%) were using some of the techniques for generating solutions (Figure 4.10).

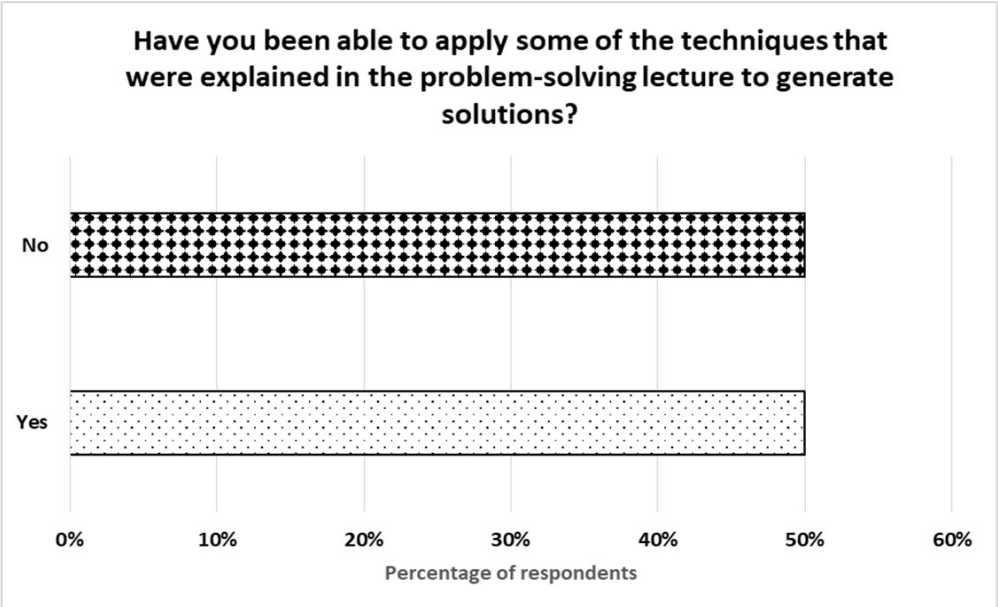


Figure 4.10: Survey 2 Q5

6: **This question referred to Question 5 and was as follows:** ***If yes, which techniques have you applied (name/explain the technique/s)? If no, why not?***

Nine students (64%) answered this question. The students used the following techniques to **generate solutions**:

Three students referred to using the information given in the question to help generate ideas.

Two other students mentioned that they used the method of random stimulation to help them generate ideas.

One student mentioned mind maps, one student said it helped to link concepts together and another used the method of finding other scenarios that the question might be applicable to as a reference point (I categorised it as analogy/cross-fertilisation).

The student who responded negatively said that he could not remember them when there were time restrictions.

7: I valued the practical actuarial examples that demonstrated the techniques in the problem-solving lectures.

Twelve students (86%) valued the actuarial examples used in the lectures and only 2 students (14%) disagreed with the statement (Figure 4.11).

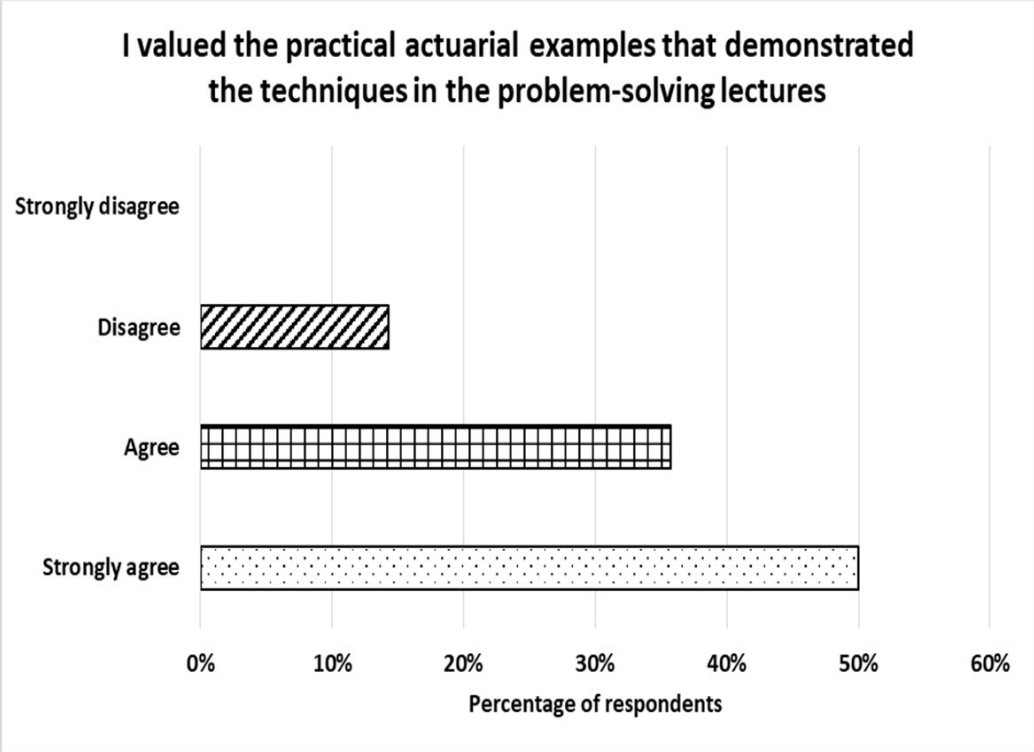


Figure 4.11: Survey 2 Q7

8: I valued the non-actuarial examples that demonstrated the techniques in the problem-solving lectures.

Ten students (71%) valued the non-actuarial examples used in the lectures and 4 students (28%) disagreed with the statement (Figure 4.12). Although a greater proportion of students valued the actuarial examples used in the lectures, there were a sufficient proportion of students who also valued the non-actuarial examples, so I decided to keep some non-actuarial examples in the lectures going forward, but to have more actuarial examples than non-actuarial ones.

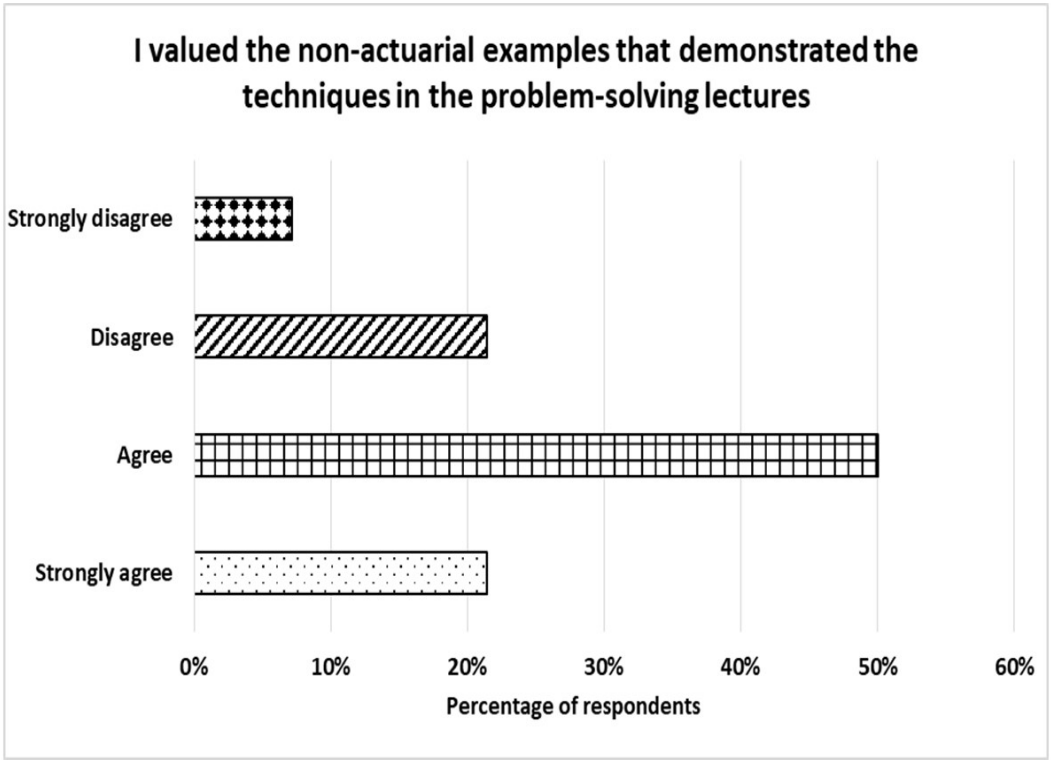


Figure 4.12: Survey 2 Q8

9: The volume of content of the problem-solving lectures was: too little, just enough, too much.

Six students (43%) said the volume of content in the lectures was 'just right', but seven students (50%) felt it was too much (Figure 4.13). Only one student said it was too little. I decided to focus on the practical application of the techniques from the previous lectures in the final lecture to ensure students had the opportunity to adequately process and apply the content.

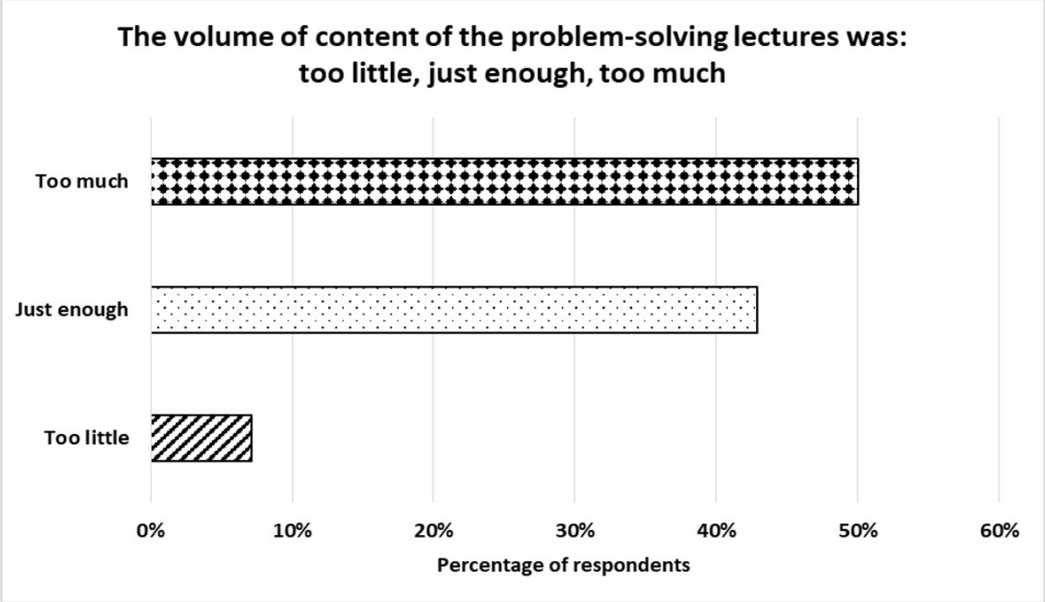


Figure 4.13: Survey 2 Q9

10: Do you have any other comments/ideas/suggestions/needs for the final problem-solving lecture?

Three students answered this open question and made the following comments:

'I am struggling to come up with solutions in the time allocated for the question. I would appreciate it if we could maybe look at techniques that could accelerate the thinking process.'

'Perhaps some more information on how to deal with anxiety whilst applying these techniques.'

'Please give us more time (make the lecture longer?) because we are receiving very valuable information but we go through it too fast to make notes or to memorise everything as we hear it ... .'

Précis: The students needed practice in the practical application of the techniques for it to become a natural thought process to follow when solving problems. The third lecture should focus on this, but students needed to practise applying the techniques throughout the quarter for it to become a skill.

4.2.3 SESSION 3

Date: Thursday, 4 May 2017.

Place: Lecture hall Botany 2-23 at the University of Pretoria.

Participants: There were 24 students present.

Context: These students had covered about 75% of their Actuarial Risk Management course material. They had written four class tests and a semester test and were nearly halfway through their Honours year.

4.2.3.1 PLAN

I used the final session to give students a short overview of what they were taught in the previous lectures. The main aim with the session was to let students practise the techniques to be able to use the techniques effectively in an actuarial context. I needed them to learn from their own thinking as well as from each other's thinking.

4.2.3.2 ACTIONS

Before I started with a recap from previous lectures, I introduced students to one more thinking technique suggested by Perkins (as cited by Baron & Sternberg, 1987), namely that to understand something, one must be able to answer the following four questions about it:

i) What is its purpose? Why would I need to know this or have this product or why would I require these checks and balances?

ii) What is its structure? Try to establish why it has the particular structure that it has.

iii) What models exist to prove this product? How is this product similar to anything else that I know or understand?

iv) What arguments explain and evaluate the product? For example, what are the advantages and disadvantages of it?

Perkins believes if you evaluate everything like this before you believe some claim, then it will lead to a deeper understanding and an ability to persuade, clarify, integrate with existing knowledge and inform your knowledge about everything.

I then did an example in class to demonstrate how I used some of the techniques. The students actively participated to help define the problem and to come up with possible solutions using the techniques that I suggested. After completing the example, I divided the class into three groups (eight students in each group) and allocated a different question to each of the three groups (one covering Life insurance, one covering Short-term insurance and one covering Pensions). The questions and model solutions that were discussed can be viewed in Addendum E. Each group had to discuss each of the three questions as a group. I gave them 10–15 minutes to discuss each question and then they gave feedback to the class for the next 10–15 minutes. The group feedback and discussion of each question were started by the group who was allocated the specific question. Afterwards, the other groups could freely add to the discussion if they felt an important point or points needed to be made. I suggested some appropriate techniques to use for each question (with a slight variation of techniques between the different questions). I reminded them to be aware of their thinking while they were discussing the questions. While they were giving feedback, I asked them why certain ideas came up in their minds? Was it a technique that helped them, or what sparked the idea?

The techniques that I suggested that they should focus on for the different questions were as follows:

Example question: Actuarial control cycle, Questioning, Purpose and structure

Question 1 (Life insurance): Purpose, Questioning, Other people's views (Stakeholders), PMI (Plus, minus, interesting facts)

Question 2 (Short-term insurance): Purpose, Questioning, Osborn's checklist, Random stimulation, Stakeholders and for part (ii) Present state–desired state and/or Duncker diagram

Question 3 (Pensions): Statement/re-statement, Purpose and structure, Questioning, Stakeholders, Present state–desired state.

4.2.3.3 OBSERVATIONS AND REFLECTIONS

I tried to keep to 30 minutes per question, but we ran out of time for the last question. I realised that the final lecture should ideally be increased by 30 minutes. It was difficult for some students to know why a certain idea came up in their minds. It was difficult for them to analyse their thinking and/or to verbalise it. I needed to spend more time practising this

in the initial lectures or otherwise should make students aware to practise thinking about their thinking throughout the semester.

The students appeared to participate actively in their groups. They referred to the proposed techniques in attempting the questions and used them to solve the problems. I could see how the group dynamics enhanced the level of answers given – the brainstorming effect.

I obtained the final feedback from students who attended the problem-solving sessions through a focus-group discussion. I used an independent education specialist, Dr Ina Louw, as the facilitator. She worked at the Department of Education Innovation at the University of Pretoria at the time (hereafter, the facilitator) and had a keen interest in improving education methods.

After checking the availability of the facilitator, I requested students to indicate their availability on the dates that suited the facilitator through an online application called a Doodle Poll. I then sent out a meeting request for the time that suited most students. I sent an e-mail to all the students the day before the meeting to remind them of the importance of this meeting, urging them to attend. The meeting was held on Monday, 15 May 2017 at 12:30 in Mathematics 1-12 (Mathematics Building, University of Pretoria). It lasted for an hour. Eleven students attended this session: 6 female students and 5 male students.

The questions posed by the facilitator and the summarised feedback from the students are given below. The facilitator started by explaining that the questions related to the techniques that students were taught during the problem-solving lectures to improve their problem-solving abilities.

1: Do you believe that problem solving is an important skill to have?

All students agreed that it was an important skill to have. One student gave the following reasons: 'Yes, I do think it's very important, especially in our field. I've done a bit of part-time work and I've seen practically that the main demand of actuaries in the workplace is to solve problems. Also, our field is very diverse. You don't get prepared for everything that you will be doing. You might study Pensions and work in Life insurance. You will need a set of problem-solving skills that's more important than pure theoretical knowledge.'

When being prompted by the facilitator about how often they think they will be using the skill, one student said that she would use the skill on a daily basis; if not for workplace problems, then to apply the skills to her own personal circumstances.

The facilitator questioned students about whether they believed that people could be taught the skill or if some people were born with the ability to solve problems and others not. Five students commented that they believed that both statements were true to a degree: some people have a natural ability to solve problems, but they have seen that the training in the techniques and learning from the 'natural' problem solvers in the group had improved their own abilities. One of these students said it was difficult to learn the skill in a short space of time, but by learning certain techniques, they could now carry on with the process of acquiring this new skill.

Précis: Students agreed that it was an important skill to have, especially in the line of work that they would be doing. Students believed that problem solving was a skill that could be learnt by practising the techniques.

2: Have you adjusted the way you study?

Six students indicated to the facilitator that they had adjusted the way they study by asking more questions. One of them stated that she asked more questions and was more inquisitive. She also read broader to improve her creativity and to broaden her mind, which helped her to answer questions that required broad thinking.

Three students stated that they read through the whole syllabus as quickly as possible to understand the bigger picture and to start attempting questions that would lead to a deeper understanding of the work.

One student pointed out that it was important to have these lectures at the beginning of the year so that they could adjust the way they studied from early in the year. All students agreed with this comment and indicated to the facilitator that the interventions assisted them to answer question papers better.

Four students agreed with the student who said the following: '...essentially she questioned our study methods directly by showing us examples of half of the class doing a list, and half of the class summarizing, and showing how effective summarizing is. She got most of us thinking: "maybe I should try this", "maybe I should change that" for this subject. The way we've been doing it over the past few years may not be effective for this module. We would have been panicking if we hadn't re-considered the way we study, or tried something new early on and not super late.'

One student further commented about the class example mentioned above by saying: 'This showed to me that linking whatever you're learning to stuff that you already know, helps

to remember it better.' The example helped her to see that categorising new information and understanding the relationships between facts that you are learning help you to store information better in your mind. Two students confirmed that this was helpful for them too.

Six students indicated that they were using more of their senses when studying by recording their summaries (or the chapter summaries) and listening to these recordings while driving or doing other things.

Précis: Students had adjusted the way they study and stated that the techniques assisted them to answer test questions better.

3: What do you think (or what can you remember from the lectures) is required to improve this skill of solving problems?

Five students agreed that the skill would improve with practice and repetition. One of these students said: 'From my experience, you actually have to practice using the toolbox, because each question needs different sets of solving skills or tools, so you can't get it if you just try it on certain type of problems, or certain questions. So you have to try it on a lot of different questions, different problems, and apply the toolbox, then that would really help your problem-solving skills.'

Four students mentioned that they learnt a lot from the group environment and their skill improved by seeing how other people applied the skills because they approached problems in a different way.

Seven students suggested that it would help them if they could receive feedback on how well they were applying the skills in a controlled environment similar to a test environment. Four of these students suggested that the lecturer could give feedback after tests to evaluate what students did well and what could be improved in relation to problem solving.

The facilitator prompted students as to what was the most important factor to improve the skill; being clever versus a 'can-do' attitude. Four students agreed that both statements were true to a degree but they felt that attitude was the most important factor. One student commented the following: 'I agree with what they said, it's a lot about the attitude, since we said you can learn these skills. Obviously you need to have some brains. But it's quite possible to learn these skills, and if you don't have can-do attitude it's easy to have blocks and get stuck.'

Précis: Students realised that they would have to practise the skills in order to improve them. Many of them learned and improved their skills by observing other people solving problems. They stated that they would benefit from being evaluated and getting feedback on how well they were applying the skills. They understood that their frame of mind was important and that a 'can-do' attitude was required to solve problems.

4/5: Which techniques have you used to help you define problems better or to generate more solutions? (I have combined the findings of these two questions because they overlap. The students said many of the techniques that helped them to better define problems also helped them to generate more solutions.)

Seven students agreed that identifying the key words in the question helped them to understand the environment and context of the problem to define the problem better. This helped them to understand all the factors they needed to address if they wanted to solve the problem and hence to generate a wider range of solutions. Three students added that the techniques of using each word in a question, emphasising different words and reflecting on what they could link to each word or considering the opposite of the word, helped them to generate solutions to test and past exam questions. I grouped this under the techniques of 'Statement/re-statement' for defining problems and 'Osborn's checklist' for generating solutions.

One student said: '... especially when I get stuck, I think about the toolbox she gave us, for example what are the positives and negatives?; and, if I increase this/decrease this, what is the effect of that? And that just helps you generate so many more points which for this subject is really important.' Four other students agreed with this statement and used similar techniques of considering pros and cons, consequences, characteristics and definitions given in the question to generate points. I grouped this under the technique of 'Structured problem-solving'.

After being prompted about whether they used the technique of making links to similar situations, one student said that they needed to do many past examination questions to be able to use this technique. They could then consider what was different/similar between questions, and it would help them to build up a repository of ideas. One student said he used the links between chapters to help generate more solutions. Another student said she tried to think more broadly to generate ideas. The linking of similar ideas and solutions was again grouped under 'Structured problem-solving'.

A few students said they considered the stakeholders and that they generated solutions by identifying all the stakeholders and considering the impact on each.

The following techniques were only mentioned by one student each, so they may not be widely used, but were taken note of by some students:

-the technique of taking a random word to enhance your creative thinking to get more ideas related to the question. The facilitator commented that some more students nodded their heads.

-the technique of incubation. The student said: 'I continue with the test. Let my subconscious get to work on the problem.'

The facilitator prompted as to whether they used the Actuarial Control Cycle (ACC) to help them generate solutions.

One student suggested that they were probably using the ACC subconsciously without realising it or thinking about it. Another student found it only relevant for longer questions or questions that covered more topics or the bigger picture. She found it hard to use if the question was very narrow/specific.

The facilitator commented that about half of the students said they had used the technique of drawing a picture/graph or used a formula to get unstuck after she prompted them about this technique.

Précis: Students had mainly been using the statement/re-statement technique and Osborn's checklist as well as taking a structured approach to solving problems.

6: Are there any techniques that you feel were not very useful to you?

All of the students agreed that they applied the specific techniques that they found useful but were not using techniques that they did not found useful. However, they believed that different techniques could be useful to different students. Different techniques might also be required for different types of question, hence they concluded that a variety of techniques from which they could choose should be taught.

7: Did the lecturer make the sessions practical enough?

Four students commented that the lecturer applied the theory to examples and past exam questions, especially in the last lecture. The facilitator got consensus from all the students that the interventions helped them to answer question papers better.

The facilitator wanted to establish if there was a link between the questions in examinations and actual problems in the workplace, and most students agreed that there was a link.

One student said the following: 'One thing she did really well was that it started off more theoretical because you have to understand the tool first before you can apply it. And then by the second and third session we were doing those past exam questions and applying it and that gave it a practical element. And whenever she gave a technique, she'd quote an example. So if I didn't understand the technique, then the example helped me to understand how you use it.'

Three students said that they were not sure how to apply the techniques to the class assignments, which are practical workplace problems that they needed to do on their own or in groups outside of the lecture times. They did not use the techniques when they had to build a model, evaluate or make assumptions about some practical workplace problems that were given in these assignments. One student suggested that this could be because some students had difficulties with Excel or SAS.

One student said the following: 'I think she tried to make it as practical as she could have. The subject is so diverse and covers so many things .... It would have been difficult to go into detail about problem solving on each specific aspect of the course or in general. In terms of a general overview of problem solving, it was practical.'

Précis: Students were able to apply the techniques to test and exam questions, but not to assignments and practical workplace problems, especially those involving the use of models.

8: Any suggestions for improvements?

Two students said they learnt a lot from the lectures, but that the lecturer went through everything too fast and therefore they could not remember all the techniques. It felt like an information overload and two hours were not enough time for each lecture. These two students and another student suggested that it would have helped to get a summary of all the techniques so that they could go and practise the techniques at home.

Three students suggested having a block lecture at the start of the semester, perhaps during orientation week. Five students suggested to rather have more regular lectures throughout the semester, teaching fewer techniques per lecture, and practising the techniques during each lecture so as to get a good understanding of each technique and how it could be applied. This would ensure that students obtained enough background knowledge throughout the semester

to make meaningful contributions towards solving these practical problems. One of these students said the following about the suggestion above: 'Another advantage of doing it that way, is instead of just picking one tool out of the toolbox that you feel applies to you, you are forced to evaluate to see how each one actually does work for you ... It's good to be forced to use different methods on different questions to practise it in.'

Two students requested to do more examples of assignment-type problems where students do not have to generate a certain number of points rather than solving a workplace-type problem. A further suggestion of making lectures more practical regarding students struggling with assignments was for the lecturer to get insight from other lecturers on specific topics that students were struggling with such as problems with modelling, reserving and branch the examples out into those areas.

As mentioned above, some students expressed a need that the lecturer should test and evaluate their problem-solving ability in a test environment so as to improve their ability to apply the techniques in such an environment.

Précis: Students made some good suggestions that should be considered to improve the effectiveness of future problem-solving lectures.

4.2.4 CYCLE 1 SUMMARY

In summary, I had learnt the following from Cycle 1 that I tried to improve in Cycle 2:

Lecturers needed to be made aware of the important role they play in fostering problem-solving skills in students. They needed to establish education strategies that would ensure deep learning by students. They also had to model problem-solving skills to students as often as possible. They should create a safe environment for students to ask questions and learn. I planned to set up a session with lecturers in Cycle 2 to share my learnings with them and to encourage them to use some of the education strategies to ensure deep learning in their classes.

Students requested for the sessions to be held earlier in the year. This would ensure that they have enough time to implement changes to make a significant difference in their problem-solving skills development from early on in the year. I scheduled the sessions one month apart for Cycle 2 instead of two months apart as in Cycle 1.

Students expressed that they felt information overloaded after the sessions in Cycle 1. I needed to consider if some of the techniques could be left out. Students commented that it

would help them if I generated a summary of the techniques that they could refer back to when practising at home. I planned to provide them with a 'problem-solving toolbox' that contained a summary of all the techniques that were demonstrated in class.

Students suggested that it would be helpful if lecturers could provide a debriefing session after assignments and tests to discuss common difficulties that students had or mistakes that students made and to demonstrate effective thinking and problem-solving techniques for the particular assignment/test. I planned to discuss this idea with lecturers in the lecturer information session at the start of Cycle 2.

4.3 CYCLE 2

I scheduled a session with all Honours lecturers at the start of 2018 to discuss my learnings from Cycle 1 and to introduce some of the education strategies from the literature with them. This one-hour interactive session was held on 31 January 2018 at the University of Pretoria in the Mathematics Building Room 1-14. Eight of the ten lecturers who taught the Honours students in 2018 were present. The following points were discussed:

Students needed to feel comfortable in the lecture environment to ask questions and to engage. A safe environment is key (Kline, 1999). Lecturers needed to encourage their bravery to ask questions. Students commented that asking questions would expose their lack of knowledge and understanding. Lecturers needed to use such opportunities to provide constructive criticism and to encourage further debate.

Students needed to be exposed to business problems as this would make them more receptive to the knowledge required to solve those problems (Shepherd, 2010). Lecturers should not simply give students the answers as they needed to find them by themselves and lecturers should support them in understanding, analysing and solving problems. Spending time on past exam questions and discussing solutions are some of the best ways of learning. The aim should never be for students to memorise content to be regurgitated in an exam. Situations should be created where students can interact with the work to construct meaningful knowledge that could be used to solve real-world problems (Johnson, 2010; Shepherd, 2010). Students who are required to write about, debate, explain, research and apply core concepts and principles of what they are studying will achieve a deeper understanding of what they are learning (Shepherd, 2010). Lecturers were encouraged to use such approaches when teaching students.

Students suggested that it would be beneficial to their understanding of how to apply theory to practical problems and for the development of their problem-solving skills if they could receive feedback from lecturers after tests and assignments as to what students did well and what could be improved. Lecturers should often demonstrate their suggested approach to solving problems so that students could learn from their approaches. There was a suggestion to incorporate interactive discussion classes into the schedule. These could be used to train students into the thinking that is required to solve complex problems. Students needed to be made aware of what constitutes sound thinking and how to evaluate their own and other's thinking (Broadbear, 2003).

After the meeting, I sent out a document to all lecturers that provided a summary of what we had discussed in the meeting as well as additional information on effective teaching strategies. This document is attached in Addendum F.

I break down the interventions and findings for Cycle 2 per session and then give a summary for Cycle 2 in section 4.3.4.

4.3.1 SESSION 1

Date: Wednesday, 24 January 2018.

Place: Lecture hall Botany 2-23 at the University of Pretoria.

Participants: 30 students attended the first session out of 41 students registered for the Honours course.

Context: The students were welcomed back to University for their Honours year on Monday, 22 January 2018. Similar to 2017, they had their first lecture on Tuesday, 2 January, which covered 'What is the Actuarial Risk Management subject all about?' and 'Professionalism'. On 24 January, their first two-hour session on problem-solving strategies was conducted. As in 2017, I presented the first lecture of 2018 as early as possible in the semester to explain to students the aim of the problem-solving interventions and to give them tools to improve their learning, problem-solving and critical thinking skills from early on.

4.3.1.1 PLAN

My plan for this session was the same as for the first session in Cycle 1. The feedback from students from Cycle 1 indicated that the first session was successful in teaching students the

definition and basic principles of problem-solving skills and to help them realise that these skills were important to develop. As in 2017, I wanted to use the first session to introduce the principles and strategies to improve their study methods and their understanding of the subject. This should help them to develop and improve problem-solving and critical thinking skills. The only improvement I planned for this session compared to 2017 was to leave sufficient time to complete a practical example at the end of the lecture. This would ensure that students gained a better understanding of how to apply the theory in practice. I now give a detailed account of the practical example I gave to meet this aim.

4.3.1.2 ACTIONS

I presented the same lecture as in Cycle 1 and ended off with the following practical example:

Class question: You are planning to set up your own insurance company. Briefly discuss the factors and risks that you should take into account. [20 marks]

I chose this question because it is very wide and it requires students to create a structure for themselves to make sure they cover all aspects of an insurance company.

The suggested solution is given in Addendum G. I guided students to determine a structure to use when answering the question. The suggested structure was to think about the life cycle of a policy from design to being sold, administered and becoming a claim. I encouraged them to think about the questions they could ask themselves to help them consider all the internal and external factors that affect an insurance company. I gave them 5 minutes to think about the solution and to discuss it in small groups. We then had an interactive discussion for 10 minutes. I used this time to make students aware of the thought processes that they followed in getting to their suggested answers so that they could learn from each other's methods. I made them aware of how their thought processes improved when providing a structure to the brain because it helps to create focused thinking.

4.3.1.3 OBSERVATIONS AND REFLECTIONS

The students were participative and appeared to reflect on what was said. They enjoyed the practical examples that helped them to understand how to use the techniques, but commented that they needed more practice of the techniques.

As in Cycle 1, I asked for their feedback in writing (anonymous) to gain an understanding of how well the message was received. This was just three weeks after the first lecture. I wanted

to establish whether the first session had an impact on their behaviour and/or study methods and which of the strategies they had been using since the first lecture. I realised that the results needed to be interpreted with care when comparing with those for Cycle 1, because the students had less time to start applying the techniques and to get a clear understanding of the big picture of the subject.

I requested feedback from the students in the form of a Powerpoint questionnaire containing six questions at the start of the second lecture, as in 2017. The questions were slightly adjusted to improve clarity and understanding. Each question was discussed with the class to make sure they understood the purpose of the question. A total of 27 students completed the questionnaire. I set out the feedback that was received below. I first list the question and then a summary of the students' responses. For some questions, students gave multiple answers, hence they would be included in more than one category. This means that the total will not add up to 27 students for some questions.

1: Has the previous lecture created an awareness of the techniques required for better problem solving?

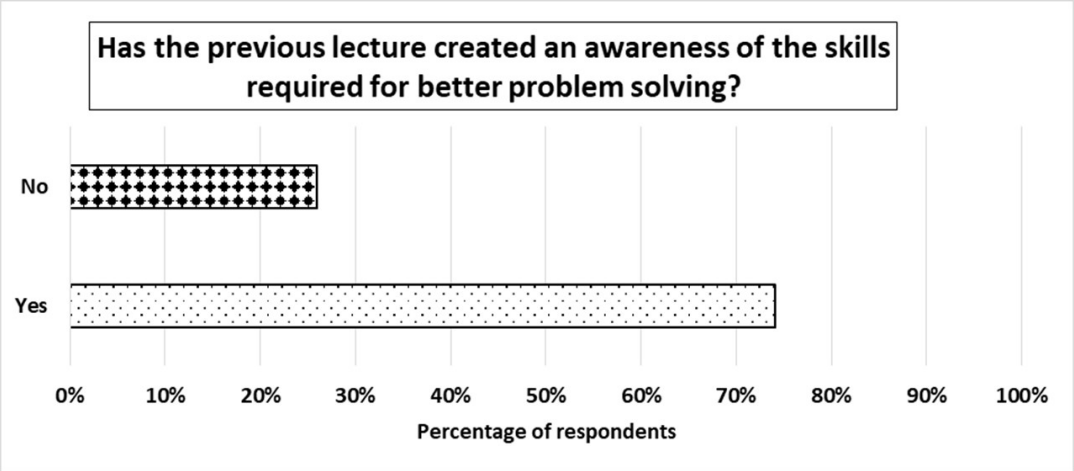


Figure 4.14: Cycle 2 Survey 1 Q1

Twenty students (74%) responded positively and seven (26%) negatively (Figure 4.14). As for Cycle 1, the majority of students had a greater awareness of the skills they needed to acquire to improve their problem-solving skills.

2: Do you understand the big picture of your subject? If yes, explain. If not, why not?

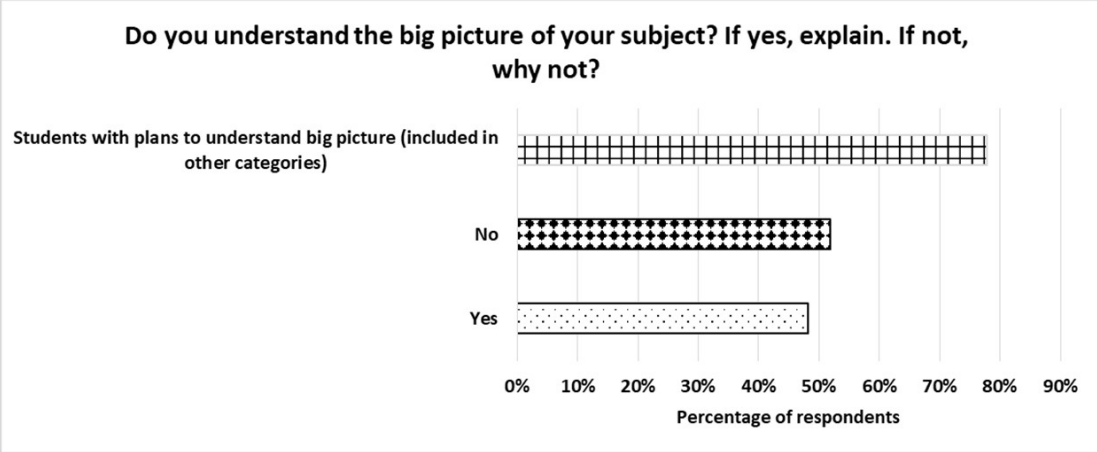


Figure 4.15: Cycle 2 Survey 1 Q2

Thirteen students (48%) responded positively. Some comments from students were:

'Summarising the first 15 chapters we have dealt with, I could get a feel for the bigger picture' and 'Asked myself question of why it's important in my role as an actuary to do this subject; read through the headings of each chapter.'

Two students commented on the interconnectedness of the work: 'It's very interconnected, as different chapters refer to other chapters and previous work.'

Another wrote: 'Yes, someone said everything is based on ACC, so this helped. On my wall I have a big mindmap.'

Fourteen students (52%) said that they did not have a good idea of what the subject was all about, but most were aiming to get there by getting to grips with the content. One student wrote the following: 'Not completely yet. But 2 pages with all the chapter headings (index) helps a lot. I keep it with me the whole time.'

Another student wrote: 'No, I am a bit confused and unsettled on the questioning, but I will get there.'

Précis: Twenty-one students (78%) indicated that they had a plan to improve their understanding of the big picture whether or not they currently understood it (Figure 4.15).

3: Have you been asking more questions?

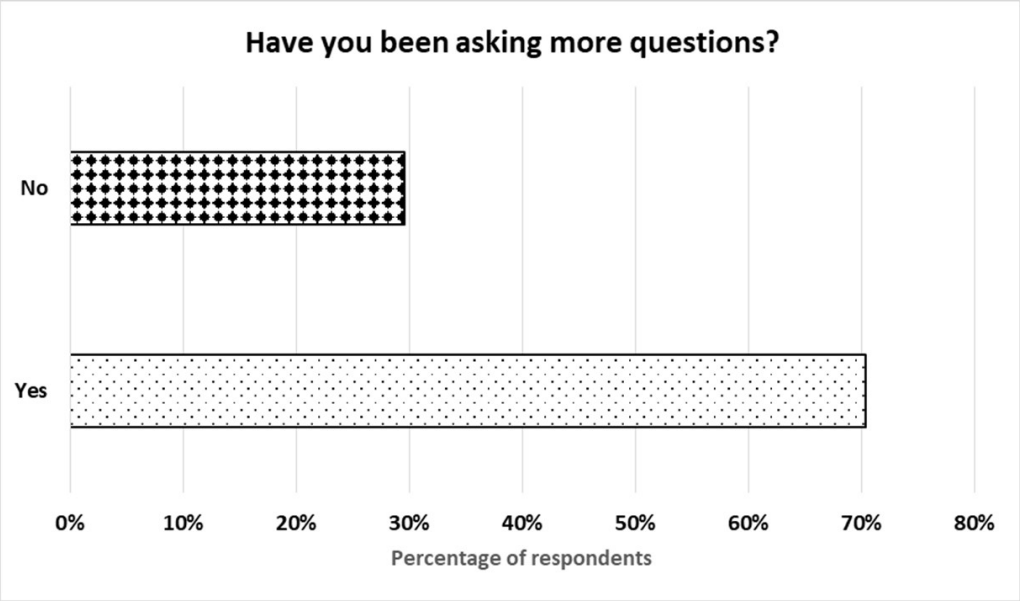


Figure 4.16: Cycle 2 Survey 1 Q3

Nineteen students (70%) indicated that they had been asking more questions in general (Figure 4.16).

Six students indicated that they were asking more questions in class. Five others said they asked questions to themselves whilst studying or that they asked their friends if they did not understand certain aspects. Some comments were as follows:

'Yes, but simple questions regards to topic.'

'I try to participate.'

'Yes, I asked myself question and go through the material to get answers.'

'Not in class, but when reading through the notes, I try to ask why more often.'

'Yes, I question my friends and myself.'

Two students said that they went to Google if they had questions. Three said they were too shy to ask questions in class. Some comments were as follows:

'Not really, but I have been going to the internet when unsure.'

'No, too shy and scared to ask a stupid question.'

Précis: It seemed that an awareness of the importance of asking questions had been created by the first lecture. I believed lecturers were encouraging questions from and interaction with students. No comments were made about feeling intimidated by lecturers, as in Cycle 1.

4: How have you adjusted your study methods?

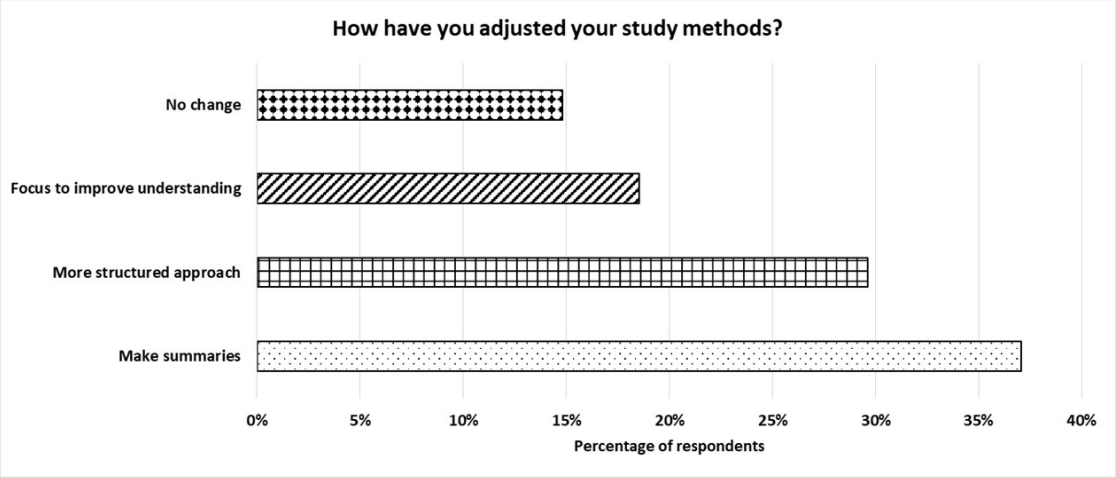


Figure 4.17: Cycle 2 Survey 1 Q4

Ten students (37%) had changed their study methods to make summaries. Eight students (30%) had started to take a more structured approach when studying. Five said they were trying to better understand what they were learning and how it would be applied in practice. Three students mentioned that they were doing more past questions to understand the work better. Some comments were as follows:

'I've tried to make colourful summaries and use different techniques to group ideas together (brainmaps, pictures, etc).'

'I'm trying to incorporate mindmaps and acronyms as opposed to my usual staightforward summaries.'

'Yes, trying to understand theory more than just studying it. Still battling to apply it in the questions asked.'

'I am focusing on idea generation more than on theory.'

Four students wrote that they had not changed their study methods. Their comments were as follows:

'No, I have always done summaries – best method for me.'

'No, I have been sticking to my usual methods.'

'No, I am behind with few chapters.'

'I think I forgot how to study.'

Précis: The majority of students had taken a more structured approach to studying and became aware that they needed to understand what they were learning rather than just learning to remember it for a test (Figure 4.17).

5: Have you found the Actuarial Control Cycle useful? If yes, explain, if not, why not?

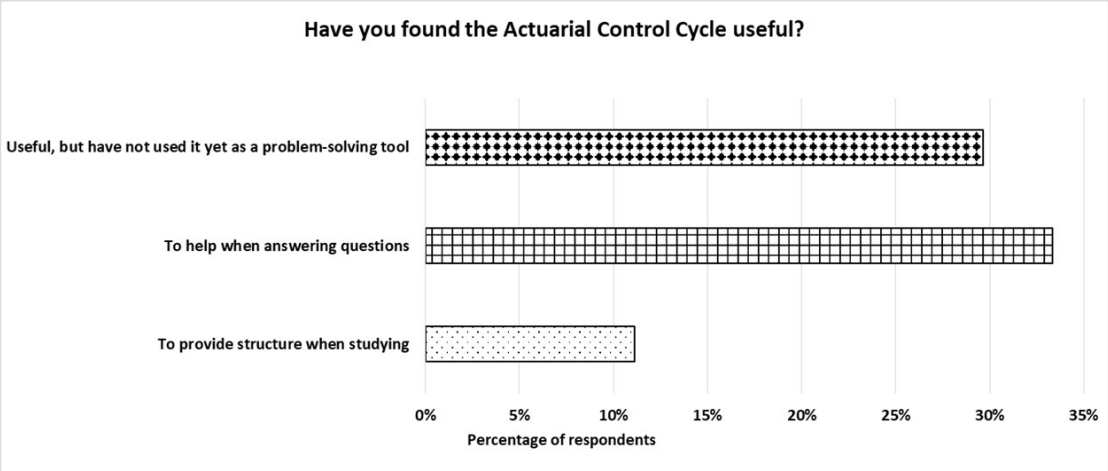


Figure 4.18: Cycle 2 Survey 1 Q5

Twenty-one students (78%) responded positively to this question. Nine students (33%) indicated that the ACC gave them structure to think about solutions and to generate ideas when answering questions. Three students said that they were using it while studying for understanding where the chapters fitted in. Some comments were as follows:

'Definitely, can be used to structure answer properly.'

'Yes, it gives the bigger picture of the whole material.'

'Very useful because it's an analytical way of problem-solving.'

'Yes, it highlights important chapters to consider when answering questions.'

Eight students (30%) said that they had not yet used the ACC as a problem-solving tool. Some comments were as follows:

'Haven't used it yet, but I think it will be a useful tool when answering questions based on more content, as it is interlinked.'

'I think it is useful but haven't used it a lot (probably since it is so early in the semester).'

'I don't think I know how to use it, does it apply to all problems? Does it help for all questions in tests?'

Précis: The majority of students had realised that the ACC could be useful to provide structure when solving problems or when studying. This was an improvement from Cycle 1 where more than half of the students had not used the ACC when they were asked this question. Students still needed practical guidance on how to use it optimally (Figure 4.18).

6: Any other comments/ideas/suggestions?

Eight students (30%) responded to this question. One mentioned that the example I did with the class where half of the class memorised a list and the other half memorised the words in a structure format was very useful to illustrate how important a structured approach is for the brain. One student commented that doing past exam questions to practise the techniques was helpful. Another was using the technique of asking questions to yourself while studying. Some other suggestions from students were as follows:

'More practical puzzles can help to learn how to think outside the box. One of each type of puzzle is not enough to create full awareness of types of problem-solving techniques.'

'We should write some mini-class test after every lecture so that we can get more practice of problem-solving techniques.'

'How to think creatively – I would like to know.'

Prècis: Students had found the first problem-solving lecture useful in creating an awareness of what was needed to start developing problem-solving skills. They needed ample opportunity to practise the techniques for them to become skilled problem solvers.

4.3.2 SESSION 2

Date: Thursday, 15 February 2018.

Place: Lecture hall Botany 2-23 at the University of Pretoria.

Participants: 26 students attended the second session.

Context: The students wrote their first class test on Monday, 12 February. At that stage, their lectures had covered the investment markets and external environment, life insurance and general insurance products as well as regulation. They also had an Excel skills course to assist with completing assignments and practicals.

4.3.2.1 PLAN

Similar to 2017, I intended to cover the strategies that would help students to define problems accurately as well as strategies to help them to develop multiple solutions to problems. The feedback from students from Cycle 1 indicated that the second session was useful in providing students with the strategies that could help them to develop problem-solving skills. They requested for this session to be held earlier in the year, which was why I scheduled this session within one month of the first session. They also requested that the lectures be made longer because of the large amount of information to absorb in two hours. Unfortunately it was impossible to adjust their timetable to accommodate this. To address this need, I planned to spend sufficient time on those strategies that came out as the ones that students were using the most and to spend less time on those that were not mentioned by any of the students.

I chose not to leave out any of the strategies from Cycle 1 since students agreed that different strategies could work for different students and that different techniques may also be required for different types of question. Students preferred to be introduced to a comprehensive 'toolbox' so that they could choose which strategies were most useful to them. Another improvement from Cycle 1 was that I planned to provide them with a summary of all the strategies shortly after the session. This would ensure that students would be reminded of all the strategies and encourage them to practise using the different strategies throughout the term.

Finally, students requested that they needed more practice to apply the techniques. This was the main aim of Session 3. In addition, the guidance that was given to lecturers encouraged them to include as many practical examples as possible in lectures. I now give a detailed account of the actions that were taken.

4.3.2.2 ACTIONS

I covered all the strategies that were described in detail in paragraph 4.2.2.2 of Cycle 1 but spent more time on the following strategies that proved to be most useful to students in Cycle 1:

- The technique of questioning each aspect of the problem statement to get to the clearest possible problem statement (discussed under 'Exploring a problem in depth' in 4.2.2.2).

- The statement/re-statement technique that suggests that the problem should be re-stated in different forms several times to try and arrive at the broadest possible problem statement.
- Osborn's checklist to increase the number of solutions.
- Taking creative approaches to solving problems such as considering pluses, minuses and interesting facts (PMI) about the problem statement and considering other people's views (OPV) when generating solutions (discussed under 'Removing mental blocks' in 4.2.2.2).
- The technique of using random stimulations when stuck by taking a random word and trying to generate ideas by linking that word to the problem statement.
- The technique of modifying solutions to previous problems in another context and applying them to the current problem statement (discussed under 'Analogy and cross-fertilisation' in 4.2.2.2).
- Lastly, explaining the process of incubation that requires one to stop actively working on the problem and letting your subconscious continue the work until a solution comes to mind (discussed under 'Incubation' in 4.2.2.2).

4.3.2.3 OBSERVATIONS AND REFLECTIONS

This session still contained a large amount of information for students to absorb even though I spent more time on the techniques that students from the previous cycle found the most valuable and useful. Upon reflection, I think that this session needs to be split into two sessions with sufficient time to practise each of the techniques in each session. I would focus the first session on those techniques that were being used the most by students with ample examples and opportunity to practise the techniques. I would use the last session for the techniques that were not being used optimally at this stage, perhaps because the use of these techniques had not been demonstrated or practised sufficiently due to time constraints. This may be a better approach than using the last session to focus on the practical application of all the strategies, because this delays students' ability to start using the techniques immediately after the second session.

The students were engaging and participative. They appeared to enjoy the practical examples of the techniques. Towards the end of the session, some students appeared tired.

I requested feedback from students in the form of an online questionnaire containing the same 10 questions as in 2017. I explained to students that it was important for them to give honest and detailed feedback so that I could improve the offering. I appreciated the high response rate of 23 students who completed the survey out of 26 who were in the session. The results of seven questions/statements of the survey are shown in graphical form for ease of interpretation. The results of the three open-ended questions are discussed below the relevant graphs.

1: The lectures on problem solving provided me with useful techniques to help me define problems/understand test questions better

Twenty-one students (91%) felt that the techniques would be useful to them to define problems better or understand test questions better (Figure 4.19). This was a marked improvement from 76% of students who found these techniques useful in Cycle 1.

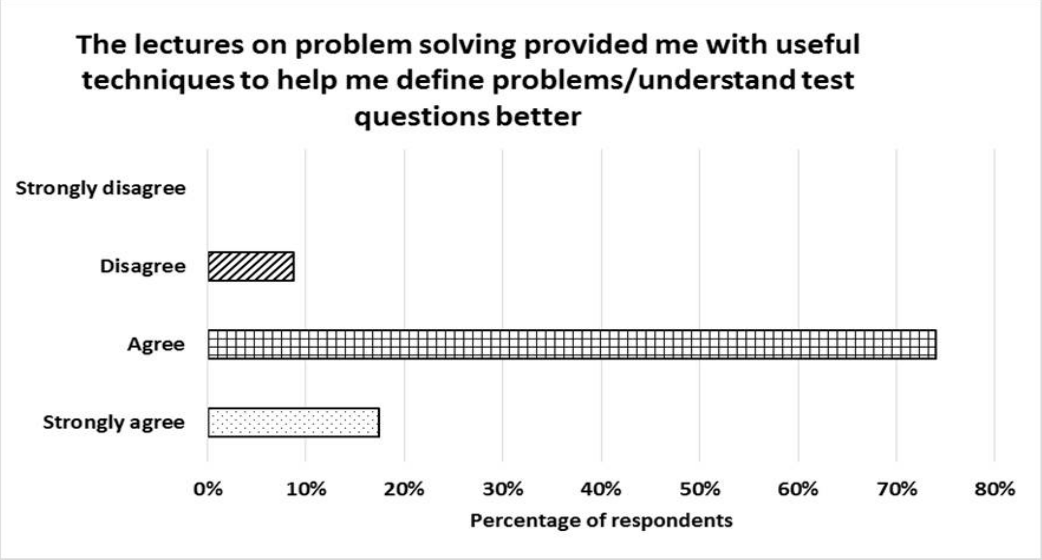


Figure 4.19: Cycle 2 Survey 2 Q1

2: Have you been able to apply some of the techniques that were explained in the problem-solving lectures to define problems/understand test questions better?

Eighteen students (78%) were using some of the techniques to define problems or understand test questions better (Figure 4.20). This was a significant increase from the results in Cycle 1

where only 57% of students were applying some of the techniques. I provided students with a Word document that contained a summary of all the techniques that were discussed. I called this document their 'problem-solving toolbox' (Addendum H) and loaded it onto ClickUP shortly after the session. I believe that this encouraged students to start practising the use of the techniques of Session 1 and Session 2.

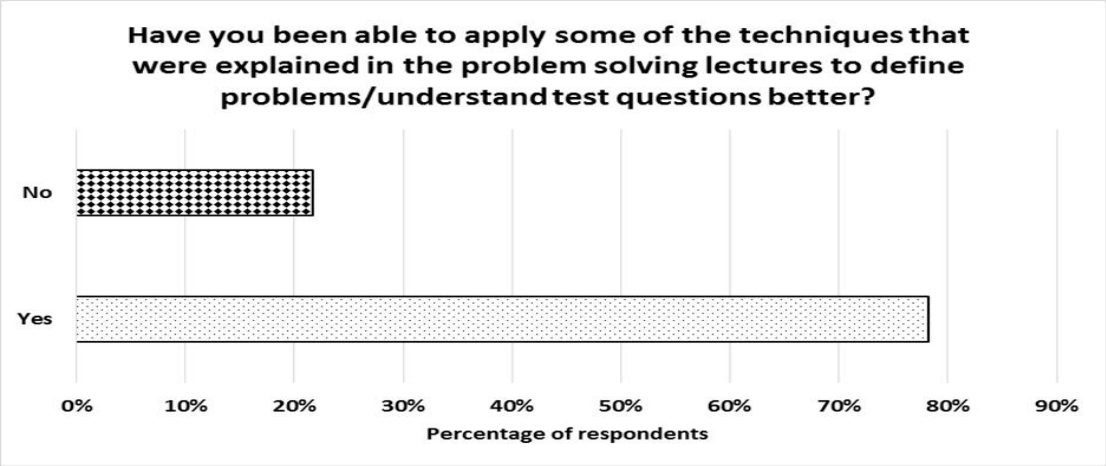


Figure 4.20: Cycle 2 Survey 2 Q2

3: **This question referred to Question 2 and was as follows:** ***If yes, which techniques have you applied (name/explain the technique/s)? If no, why not?***

The techniques that students had used to **define problems** were similar to those mentioned by students in Cycle 1 and were as follows:

Seven students mentioned that they used the method of taking a more structured approach to defining or solving problems such as categorising, keeping the big picture in mind, using the Actuarial Control Cycle or grouping similar ideas and connecting the ideas with a flow chart. I quote two of these students:

'Making use of diagrams en visual pictures to help me understand and remember the work.'

'I attempt to structure my response to questions in tests rather than answering without thought to the structure of the answer.'

Five students referred to the statement/re-statement technique of considering the key words in the question to get a better understanding of exactly what the problem was. I quote some of the students:

'When I was confronted with a question, I would quickly jot down some key words, then I would go in detail and answer each point in detail.'

'By breaking down the question and looking at the words used and associations with those words.'

'Used analysis of key words in the question to fully understand question.'

Two students mentioned the technique of exploring the problem and asking questions about the problem. I quote one student:

'Explore the problem: What, when, where, why, who affected, how could it have happened?'

Two other students said they considered the problem from different perspectives by considering the stakeholders' views.

Students who responded negatively said that they were still unsure of how to apply the techniques that were taught, especially under time pressure. I quote three of these students:

'Cannot consciously apply techniques first hand when given a question.'

'I forget the techniques under pressure.'

'Time in test/exam situation does not allow it.'

4: The problem-solving lectures provided me with useful techniques to help me generate more solutions to problems/questions.

Twenty-two students (96%) felt that the techniques would be useful to them to generate more solutions to problems or questions (Figure 4.21). This was a much higher percentage than 79% of students who responded positively to this question in Cycle 1.

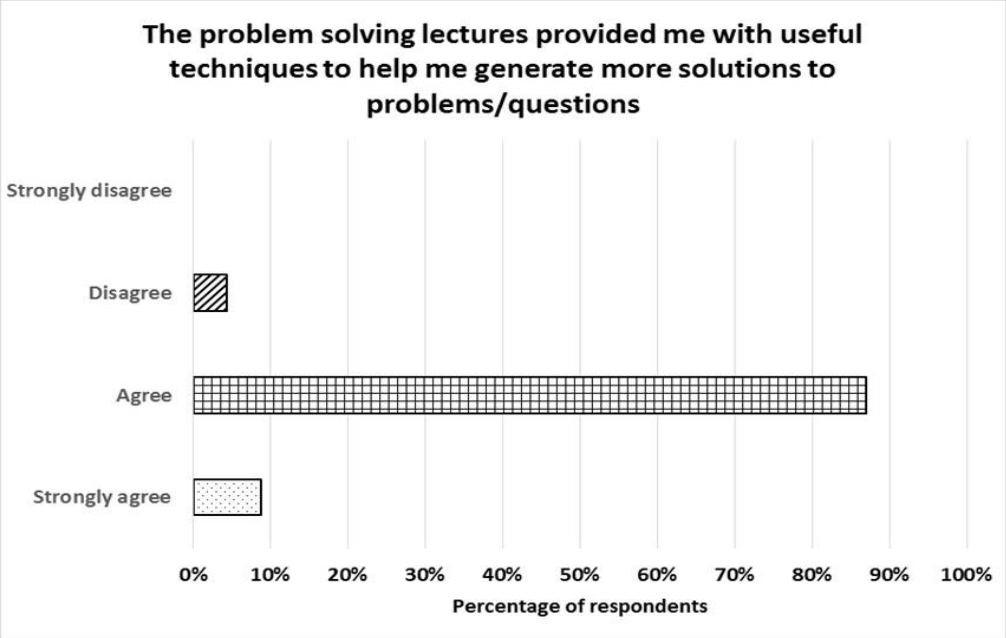


Figure 4.21: Cycle 2 Survey 2 Q4

5: Have you been able to apply some of the techniques that were explained in the problem-solving lectures to generate solutions?

Seventeen students (74%) were using some of the techniques for generating solutions (Figure 4.22). This was a marked improvement from only 50% who were using the techniques in Cycle 1. I ascribed this to the 'problem-solving toolbox' that was provided and to the fact that I spent more time explaining the most useful techniques in the second session.

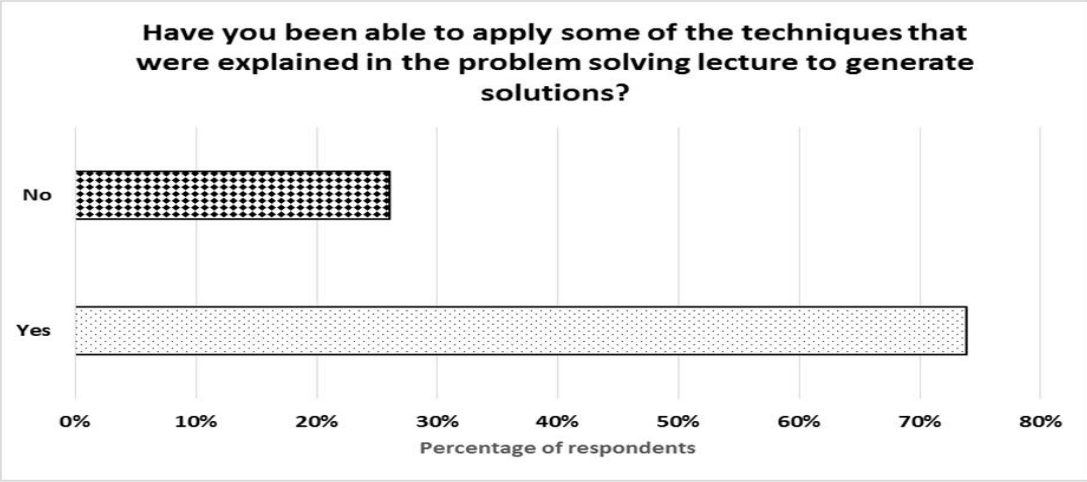


Figure 4.22: Cycle 2 Survey 2 Q5

6: **This question referred to Question 5 and was as follows:** ***If yes, which techniques have you applied (name/explain the technique/s)? If no, why not?***

The techniques that students had used to **generate solutions** were as follows:

Five students mentioned that they used brainstorming to help them to generate and link ideas.

Four students referred to using the key words in the question to help generate ideas. I quote two of them:

'I searched for key words, and wrote everything down, that I know.'

'Highlight the main parts on the question and think on the possible solutions corresponding to the highlighted main points on the question.'

Three students wrote that they took a structured approach to generating solutions:

'By structuring my answers I can generate more ideas.'

'The problem-solving structure and how it links to the actuarial control cycle.'

'Categorising information together that correlates with each other.'

Three students referred to blockbusting techniques and two of them specifically said they were using De Bono's method of PMI. One of them explained it as follows:

'Not only looking at the positive of a statement but also explaining some of the negatives regarding the statement.'

Two students mentioned that they used the method of random stimulation to help them to generate ideas and two other students used the method of incubation. I quote one of them:

'Letting ideas/thought/questions "brew" at the back of my mind so that I have more & better ideas the next time I tackle it.'

Two students were using Osborn's checklist to generate more ideas.

The students who responded negatively again mentioned that time pressure in tests prevented them from using the techniques. I quote two of these students:

'Time in test/exam situation does not allow it.'

'Too stressed to think about the extra techniques, just focused on remembering the content.'

7: I valued the practical actuarial examples that demonstrated the techniques in the problem-solving lectures.

All of the students valued the actuarial examples used in the lectures (Figure 4.23) compared to 86% in Cycle 1.

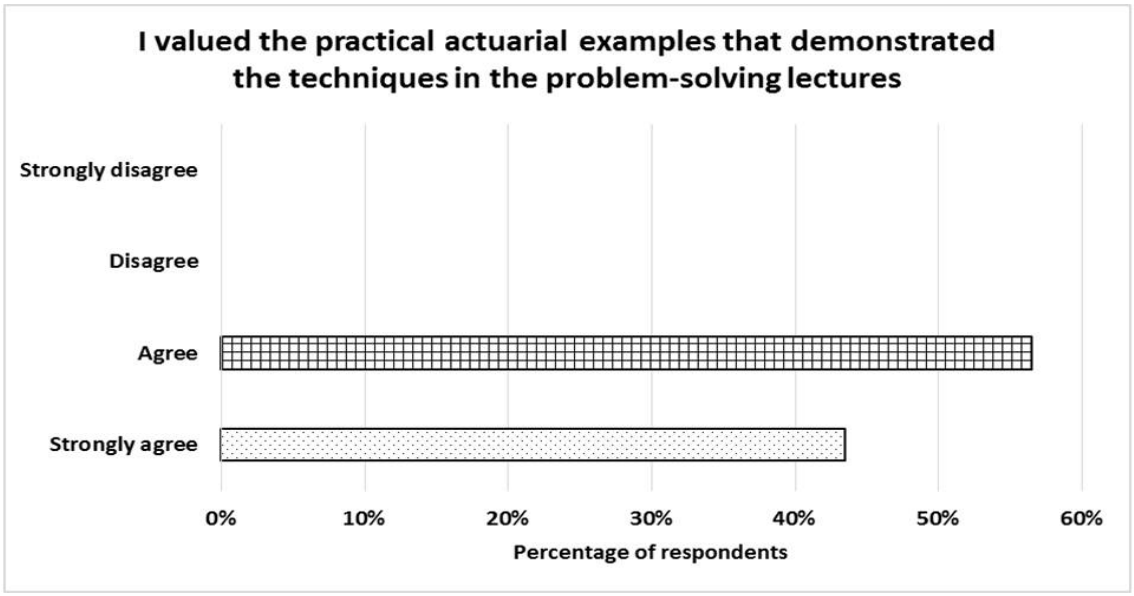


Figure 4.23: Cycle 2 Survey 2 Q7

8: I valued the non-actuarial examples that demonstrated the techniques in the problem-solving lectures.

Eighteen students (78%) valued the non-actuarial examples used in the lectures (Figure 4.24) compared to 71% in Cycle 1. Similar to Cycle 1, a greater proportion of students valued the actuarial examples used in the lectures, but there was a sufficient proportion of students who also valued the non-actuarial examples. I believe it is sensible to keep some non-actuarial examples in the lectures going forward, but to always show more actuarial examples than non-actuarial ones so that students are aware of how they would be able to apply the techniques within their field of expertise.

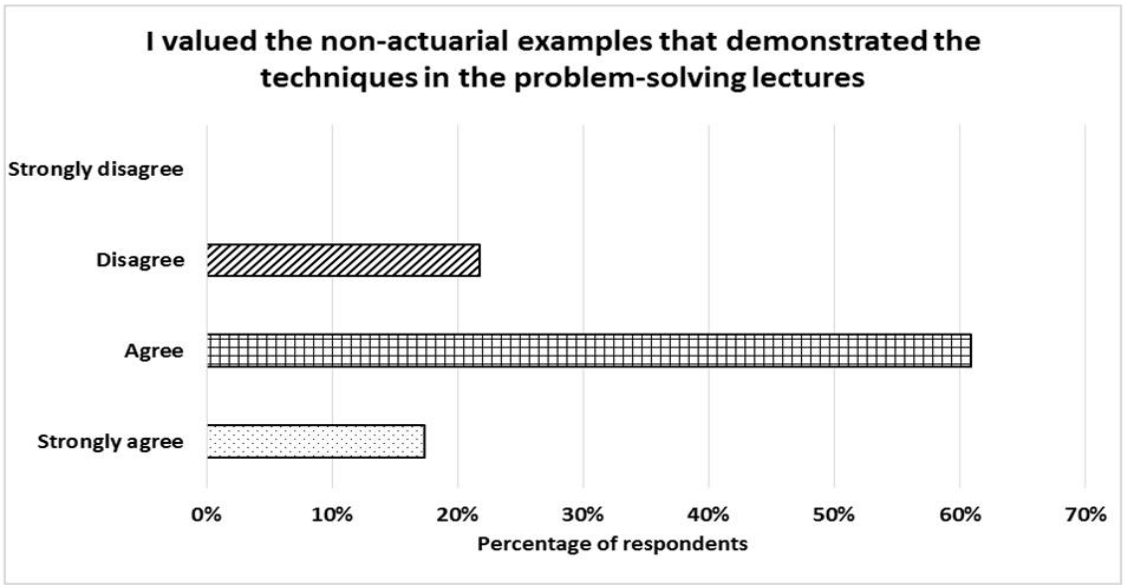


Figure 4.24: Cycle 2 Survey 2 Q8

9: The volume of content of the problem-solving lectures was: too little, just enough, too much.

Fourteen students (61%) said the volume of content in the lectures was 'just right' compared to only 43% in Cycle 1. Five students (22%) felt it was too much (Figure 4.25). Four students (17%) said it was too little. It may have helped students that I reduced the focus on some of the techniques to reduce the load of this lecture because the percentage of students who felt that the volume of content was too much dropped from 50% in Cycle 1 to just over 20% in Cycle 2. For the students who responded that the content was too little, I believe they needed more practical application of the techniques, which were addressed in the third and final lecture as in Cycle 1.

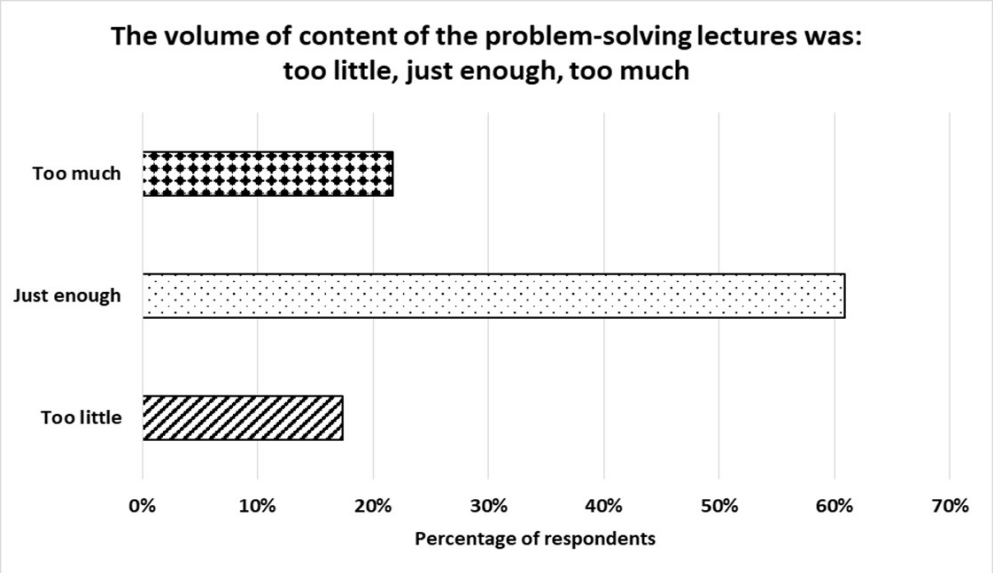


Figure 4.25: Cycle 2 Survey 2 Q9

10: Do you have any other comments/ideas/suggestions/needs for the final problem-solving lecture?

Eleven students answered this question. I group their responses as follows:

Five students requested me to focus on structuring answers and on generating many ideas in the final lecture. Some of their comments were as follows:

'How to see the bigger picture without staying focused on one particular solution i.e. moving on to finding more solutions and not hammering on one.'

'How to generate ideas quicker to be able to finish in time.'

'Other possible ways of generating the answers effectively and ways we can structure them.'

Three students requested to practise more actuarial examples through questions.

Two students needed a recap of the techniques. Their comments were as follows:

'Possibly doing a recap of the techniques that you feel will be most applicable to use right now and maybe techniques or ideas of how not to "burn-out" and stay motivated when studying, instead of us getting demotivated and just avoiding studying.'

'Perhaps a mind map overview or visual summary of all the different methods.'

One student gave the following positive feedback:

'The lessons help me find a structured way to look at a question and taught me ways to generate ideas.'

Another student commented that they needed to obtain skills related to working in a group.

Précis: As in 2017, the students needed practise in the practical application of the techniques. This would ensure that the use of the techniques became a natural and quick thought process to follow when solving problems. The third lecture would focus on this, but students needed to practise the techniques as often as possible to acquire the skill. Practising the techniques would address most of the suggestions requested by the students.

4.3.3 SESSION 3

Date: Thursday, 15 March 2018.

Place: Lecture hall Botany 2-23 at the University of Pretoria.

Participants: 20 students attended the third session.

Context: These students had covered just over 50% of their Actuarial Risk Management course material. They had written three class tests and would be writing their first semester test in two weeks' time.

4.3.3.1 PLAN

I planned to give students a short overview of what they were taught in the previous problem-solving lectures. As in 2017, the main aim of the final lecture was to practise as many actuarial examples as possible within the time allocated to the lecture. I wanted to make students aware of their thinking processes and techniques so that they could learn from their own thinking as well as from each other's thinking.

4.3.3.2 ACTIONS

Similar to 2017, I started by introducing Perkins's technique and then gave students an overview of the techniques that were taught in previous lectures. I continued by doing the same example as in 2017 to demonstrate how to use some of the techniques and to engage the students by encouraging them to participate and to become aware of their thinking.

The students actively participated to help define the problem and to come up with possible solutions using the techniques that I suggested. I then requested the class to divide themselves into three groups (around seven students in each group) and allocated a different question to each of the three groups (one covering Life insurance, one covering Short-term insurance, and one covering Pensions). The questions and model solutions that were discussed were the same as in 2017 and can be viewed in Addendum E. The format of the session was the same as in 2017: Each group had to discuss each of the three questions as a group. I gave them 10–15 minutes to discuss each question and then they gave feedback to the class for the next 10–15 minutes. The group feedback and discussion of each question were started by the group who was allocated the specific question. Afterwards, the other groups could freely add to the discussion if they felt an important point or points needed to be made. I remained aware of the time constraints and managed the time spent on each question better than in 2017.

4.3.3.3 OBSERVATIONS AND REFLECTIONS

The students appeared to participate actively in their groups. During the group discussions, I helped them to analyse their thinking and link it to some of the proposed techniques. This should encourage other students to use similar thinking techniques when attempting to solve problems and answer questions going forward. I could see how students benefited from the group dynamic by building on each other's answers and enhancing the depth of answers that were given. I encouraged students to spend more time practising this throughout the semester by becoming aware of the thinking techniques they were using and by doing a great deal of group work to learn from the group wisdom.

As in 2017, I obtained the final feedback from students who attended the problem-solving sessions through a focus-group discussion. Once again I used the independent education specialist, Dr Ina Louw, as the facilitator. She was a staff member of the Department of Education Innovation at the University of Pretoria at the time (hereafter, the facilitator).

For this cycle, I started the process of finding a suitable date for the focus-group feedback earlier than in the previous cycle. I checked the availability of the facilitator, then tried to align those dates with times that the students would be on campus. The students were writing their first semester test on Monday, 26 March 2018 and the facilitator was available on that date. At the start of the final problem-solving lecture, I checked with students if they would be willing to have the focus-group discussion on the same day as their semester test, as this would ensure they were on campus and would not need to come in specifically

for the feedback. The students indicated that they would be willing to stay behind after the semester test, but suggested that they should take a 30-minute break after the test and then come back for the focus-group discussion.

The focus-group discussion was held on Monday, 26 March 2018 at 11:30 in the Goldfields lab (Sci-enza Building, University of Pretoria). It lasted for 45 minutes. Fourteen students attended this session: 7 female students and 7 male students. In hindsight, it may not have been the best time to source feedback from students straight after their first semester test of their Honours year. These semester tests are notoriously difficult and students may have felt tired and disappointed with their perceived performance in the test and the feedback may have been affected by this. Furthermore, it was still much earlier in the semester than for Cycle 1 and students may not have had sufficient time to embed the techniques. These factors need to be taken into account when interpreting the feedback. It is also important to be aware of the fact that the questions and probes given to the facilitator were guidelines. The actual discussions determine the feedback ultimately generated by these groups and hence one needs to consider the overall feedback compared to the overall feedback from Cycle 1 since the questions would not have been exactly the same.

The questions posed by the facilitator and the summarised feedback from students are given below. The facilitator started by explaining that the discussions related to the techniques that students were taught during the problem-solving lectures to improve their problem-solving abilities.

1: Which problem-solving skill did you find most useful and why?

Three students found the structuring aspect of problem solving useful. I quote two students:

'I think the thing that helps the most is methods that you can start using immediately for example stuff like structuring your answers into different components and then describing each component.'

'It gave me a new view of how to approach problems – and the experience that I had with it are that there are many ways to approach a problem and there are better ways. I'd say it's more structured now – the way I used to approach problems had no structure.'

Two students mentioned De Bono's pluses, minuses and interesting factors (PMI) and two other students mentioned the importance of taking into account the impact on stakeholders and the perspectives of stakeholders when solving problems (OPV). They explained that

these skills were most useful because they were the most natural to implement and required the least thinking about what the techniques entailed.

Précis: Similar to 2017, students mainly used the skill of taking a structured approach to solving problems. Some were also using De Bono's PMI and OPV.

2: Which problem-solving skill did you find least useful and why?

One student said that she did not find De Bono's NO vs PO method useful because she did not fully understand how to apply it. Another student felt that the method of taking a random word to help generate ideas was a bit too random to be useful. I quote two students who said the following regarding the difficulty they had with applying the techniques optimally:

'I think there's not enough time in a test environment to first think about the skill that you have to apply and then think about the question and how to use them.'

'... and then methods that don't work are things that you have to remember actively like the hats thing. Then you don't remember the method, because it's just too different from your previous study methods.' This student was referring to De Bono's Six thinking hats.

Précis: Students had not been using the techniques optimally because they needed more training in applying the techniques to become a natural process for them. Time pressure in test situations prevented them from using the techniques. Time pressure in the normal course of events, that is, to get through the theory in time before each lecture, prevented them from practising the application of the techniques continuously. Contrary to the feedback from 2017, these students suggested that the focus should be on techniques that were most natural to implement and not to spend time on random methods.

3: Do you regard problem-solving skills as important?

Most students agreed that it was an important skill to acquire but that they had not been using it optimally yet. One student had the following comment on how to improve the usefulness of the techniques:

'I think it's very important, it's just difficult to translate techniques she is teaching us into actually applying it. It takes a lot more effort for us to do that. If she could structure it, or if lectures could be structured to be more applicable to the subject and like put more emphasis on that, then maybe we would be able to translate it better.'

Précis: Similar to 2017, students agreed that it was an important skill to acquire. Students needed more exposure to the modelling of the application of the techniques so that it would become a natural thought process for them to follow. They realised that they needed to practise applying the techniques, but were not finding the time to do so due to the pressures of their Honours year.

4: Did anybody adjust their study methods?

Students commented that they were asking more questions while studying. One student said she was highlighting each word and thinking of ideas. A few said that they had been making summaries. I quote the comments of some other students:

'Well I think you could draw out what you're reading so that you have a visual aid to help you remember.'

'I use a lot of pictures and diagrams and colours.'

The facilitator referred back to the comment from students that they were not using the techniques optimally yet because they did not get time to practise applying them: She asked students if they should not adjust their methods to spend half of their time on theory and half of their time on practising application. One student made the following comment to illustrate that they found it difficult to change their ways:

'I think one of the main problems is that we have been using very similar techniques from high school throughout our undergrad degree, so we're very set in our ways. So it seems strange to, so late in the game, change our study methods for CA1. And you know if it doesn't work, you know, then you would rather use your tried and tested method, than try and introduce the new method.'

Précis: Some students had adjusted the way they study but others found it difficult to change their ways so late in their academic life.

5: What do you think (or what can you remember from the lectures) is required to improve your problem-solving skills?

One student referred to asking questions:

'You have to identify who, what, where, when?'

Two students referred to identifying stakeholders.

'You must think about everyone that is influenced by a decision or project that you have to take on.'

'It could make you look at the problem from different perspectives and that could also help you generate more ideas.'

'So the most important thing that I took from all the methods is to consider different perspectives, because that's the most important for us ... But the problem is, if I take myself as an example, I have been studying theory a lot, not getting time for past papers, so I haven't been applying it yet. Maybe it's just too early in the semester.'

Précis: Students recognised that they would need to practise the skills in order to improve it, but felt that they did not have enough time to do that. I realised that this feedback session was two months earlier than the focus-group feedback requested in Cycle 1, which definitely had an impact on students' ability to have applied the techniques by the time the feedback was given. At the start of the semester, many students are barely coping with the workload of their Honours year, so I could understand that they have not had time to practise the techniques as for Cycle 1. They stated that they would benefit if they had more lectures where they could practise the application of the skills.

6: Any suggestions for improvements?

I quote some responses from students that would assist me to improve the course and hence their ability to develop the skills.

'I think a big thing is that we had three lessons only, and the first two were to learn, and the last one was to practice. But it's only been three in the last two months. I think the study techniques need to be introduced more gradually over time. So for life it's great to have it in Honours, but if you're trying to help Honours students cope with the work then maybe it should be introduced in undergrad maybe in second semester of third year, and maybe once a week. So that you could get exposure to it on a regular basis.'

'The lectures were too full.'

'... she just had such a lot to say in the time that she had so then she had to talk very fast ... and then you're trying to remember what she just said and while listening to what she's saying and then it makes you take in a lot less, than what you maybe would have if the lectures were spread out.'

'... maybe she could pick the most applicable methods, because there were a lot that weren't really relevant, so maybe she could just pick a few and then just reinforce those.'

'For me the only lecture that was actually useful was the one where we did past papers, or questions that were applicable to us, so maybe she could even introduce the methods by taking questions to which the methods are specifically applicable and only do that.'

Précis: The problem-solving skills should be introduced more gradually over time. Students needed to practise problem-solving skills throughout their Honours year by doing many practical examples to reinforce the skills. Lecturers could assist with this by using as many practical examples in their lectures as possible. At the start of the semester, lecturers should model their thinking techniques and gradually let students take on more of the application and modeling so that by the end of the semester, students can model the use of the techniques to each other and become proficient in using the skills.

4.3.4 CYCLE 2 SUMMARY

I received less feedback and slightly more negative feedback from the focus-group discussion by students in Cycle 2 compared to Cycle 1. When comparing the feedback from the focus-group discussion in Cycle 2 to the feedback from the questionnaires from Session 1 and Session 2 in Cycle 2, then this feedback was in some instances contrary to the feedback that had been received up to that point in time. This led me to conclude that the feedback could have been influenced by the timing of the focus-group discussion straight after the first semester test. However, there were important points that were raised that should be addressed to improve the training to foster problem-solving skills going forward and I discuss them below.

In Cycle 1, students requested for the sessions to be held earlier in the year to give them enough time to implement changes to their study methods and problem-solving techniques. As a result, I scheduled the sessions one month apart for Cycle 2 instead of two months apart as in Cycle 1. From the feedback in Cycle 2, students would prefer for the techniques to be introduced more gradually over time, preferably starting in their undergraduate years. Honours students had very little time to absorb all the information and to practise the techniques optimally due to the large workload of their Honours year. Students would prefer more lectures over a longer period of time to embed the techniques optimally.

Students needed continuous exposure to the techniques being practically applied to the type of problems that they would be facing both in their Honours year in tests and examinations,

and in practice. Lecturers could assist with this by doing more practical examples in class of workplace problems and how to successfully solve them. It would benefit students if they could receive feedback on how well they applied their problem-solving skills in tests and how they could improve on them. This was similar to the feedback from students in Cycle 1 where they requested debriefing sessions from lecturers after assignments and tests.

I could assist lecturers to do this by providing them with a rubric to evaluate students' problem-solving skills as applied in assignments, tests and examinations. They would need to be trained in the skills and the evaluation thereof. It needs to be investigated if such a suggestion is practical. An alternative would be for me to set up mock tests/examinations for students throughout the year and to rate their problem-solving skills application myself. However, students may not take mock tests seriously. Another approach that would be beneficial for students for the development of their problem-solving and critical thinking skills would be to evaluate each other's problem-solving skills through peer reviews of class tests or semester tests during the year (Broadbear, 2003). As for lecturers, students would need to be trained in the evaluation of the skills. They would need to be assessed on these evaluations to ensure that they take them seriously and give useful feedback to their fellow students(Broadbear, 2003).

Students expressed that they felt information overloaded after the sessions in Cycle 1 and in Cycle 2. I needed to reduce the number of techniques taught per session and needed more sessions in which to embed the techniques for students. I would then focus on the methods that are most helpful in the context that students will be applying them by considering which methods could be applied most naturally to some past examination questions or practical workplace problems. I would encourage the practical use of the methods by making use of the 'problem-based learning' approach (Tempelaar, 2006). This involves giving students the problem first, reminding them of the 'problem-solving tools' they have available and then letting them learn to use the techniques by solving the problem on their own. The lesson on the optimal way to apply the technique takes place after the practical application test was given.

In Cycle 1, students commented that it would help them if I generated a summary of the techniques that they could refer back to when practising at home. I loaded a 'problem-solving toolbox' for students on ClickUP shortly after Session 2, however, from the focus-group discussion it was discovered that some students were not aware of this. Communication needed to be improved in future when such a toolbox had been made available. If students

were encouraged to use the toolbox during the practical classes as suggested above, it would assist to solve the problem of students being unaware of the toolbox.

4.4 FINDINGS ACROSS CYCLES

The combined feedback from students across both cycles was similar and largely positive after Session 1. Students became aware that problem-solving skills were important to acquire in the Actuarial Science field and for life in general. They gained insight into what was required to develop the skills in themselves, namely:

- The majority of students (75%) realised that it was important to understand the big picture of what they were learning.
- Students were trying different methods to improve their understanding of what they were learning to ensure 'deep learning'.
- Seventy to eighty per cent of students indicated that they started to ask more questions – either to themselves while studying, or in class, or to their friends and family.
- Some students were taking a more structured approach to studying after the first session and 25–40% of students were making summaries, which they did not do before.
- Some students developed their creativity by reading wider than their field of interest and recording their study notes to listen to while driving.
- Students realised that they had to practise the techniques to acquire the skills but many admitted that they did not make or have enough time to practise the skills early in the semester. A good suggestion by students was to introduce discussion classes for this subject where they would be forced to practise and discuss the techniques and even assess each other's ability to apply the skills.

The combined feedback from students across both cycles on Session 2 varied more between the cycles and there was a marked improvement in Cycle 2 compared to Cycle 1. When interpreting my findings, the first number refers to the result in Cycle 1 and the second number refers to the result in Cycle 2. Seventy-five to ninety per cent of students agreed that Session 2 provided them with useful techniques that would help them to define problems better. Sixty to eighty per cent of students were able to apply some of the techniques which

will be expanded on below. Eighty to ninety-five per cent of students agreed that Session 2 provided them with useful techniques to generate more solutions to problems, with 50–75% of students having applied some of the techniques. The techniques that students had found the most useful at the time of taking the survey were as follows:

- Using each word in the problem statement to define the problem as clearly as possible and to generate a wider range of solutions. In the context of the literature review, I will label these techniques as the statement/re-statement technique and Osborn's checklist (Fogler et al., 1995).
- Many students stated that they had been taking a structured approach to solving problems such as using the Actuarial Control Cycle (ACC), mind maps, linking concepts, categorising problems and making associations to assist in the solving of problems (Fogler et al., 1995; Lyn et al., 2002; Soden, 1994).
- They also stated that brainstorming with fellow students assisted them to generate more solutions to problems (Fogler et al., 1995).
- Some students had been using creative strategies such as considering Pluses, Minuses and Interesting facts (PMI) about any given problem or proposed solution as well as considering Other People's Views (OPV) (De Bono, 2015).
- A few students mentioned the methods of random stimulation, incubation, analogy and cross-fertilisation.
- The few students who indicated that they had not been using the techniques stated that time pressure in test situations prevented them from applying the techniques. They said that they became too stressed to think about the techniques and how to apply them.
- Some suggestions by students after Session 2 were that they needed more practice of actuarial examples through practical questions, with lecturers assisting them on how to approach and solve the problems using the techniques that they had been taught. They needed help on how to generate ideas quicker when anxiety came into play. They also requested a summary of the different techniques to refer back to when practising the techniques. This was provided to students in Cycle 2.

The combined feedback from students across both cycles after Session 3 varied between the cycles but with the common themes mentioned in the feedback above coming through. The

feedback from Cycle 1 after Session 3 was much more comprehensive than that for Cycle 2 and slightly more positive. As explained in 4.3.4, I ascribed this to the timing of the feedback session in Cycle 2 being much earlier in the year, hence students had less time to practise the techniques, but also the feedback being requested straight after the first semester test of the year. Some suggestions by students after Session 3 were to:

- Distribute the problem-solving lectures more gradually over the Honours year or start earlier in undergraduate years.
- Reduce the load per session.
- Structure the lectures around those problem-solving strategies that will be taught in the lecture, from theory to practical application of the strategies, so that ample practice occurs within each lecture.
- Students wanted to be assessed on their problem-solving ability and needed feedback on how to improve.

4.5 CONCLUSION

This chapter presented my research findings as they related to the research question posed in Chapter 1. In an attempt to create a context for the findings, I introduced the reader to the participants, the date and place where the sessions were conducted as well as the context of the participants for each session of each cycle. The data presented in 4.2 and 4.3 were analysed using content analysis as explained in Chapter 3 to provide a clear understanding of the research findings presented in 4.4. The conclusions that could be drawn from these findings will now be used as the basis for Chapter 5, which will answer the main research question as well as present ideas for future research and the limitations experienced during this research study.

5. Conclusion

5.1 INTRODUCTION

The purpose of this study was to explore how effective the exposure to certain problem-solving strategies is in fostering problem-solving skills in Actuarial Science students.

Based on the literature review presented in Chapter 2, I focused on three aspects to improve students' problem-solving skills: educational strategies, problem-solving strategies and strategies to improve creativity.

Educational strategies require that lecturers and students develop techniques that would help foster problem-solving skills in students. Lecturers need to use teaching strategies that encourage 'deep learning' by students (Baron & Sternberg, 1987; Shepherd, 2010). Students should play an active part in the knowledge gathering process and their knowledge should be built up by connecting their past knowledge and experiences to new information (Shepherd, 2010). Students need to use learning strategies that would help them gain a better understanding of the work and an improved ability to apply the knowledge to solve practical problems.

Problem-solving strategies require that students adopt a structured approach to solving problems (Lyn et al., 2002; Soden, 1994). Students need to practise problem-solving techniques to enable them to define problems better and to generate multiple solutions to problems (Fogler et al., 1995).

Strategies to improve creativity require that students remain aware of the importance of maintaining the right mindset when solving problems and to practise techniques that would develop their creativity (De Bono, 2010, 2015, 2017; Fogler et al., 1995).

My research approach involved making students aware of 'deep learning' strategies to improve their understanding of the underlying theory, since that is the starting point of being able to solve problems. I then introduced some problem-solving and critical thinking strategies and helped them to apply these to practical problems. I recommended certain teaching strategies to lecturers that should assist students to develop these skills.

The main focus of my study was the students and to make them aware what they needed to do for these skills to be developed. I obtained feedback from students about the training methods I used and about which of the strategies they found to be the most helpful so that I could improve the training process going forward. Because of the nature of the study, I used an action research approach. The research design became a strategy of enquiry that helped me to identify problems and potential for improvement as the cycle was repeated (Zuber-Skerritt, 1992). In this chapter I present my conclusions from the data presented in Chapter 4, I discuss the limitations of my research study and I make recommendations for future research in this field of study.

5.2 ADDRESSING THE RESEARCH QUESTIONS

According to the data presented and reflecting on my experience of students' interactions in class, exposing students to problem-solving strategies had an impact on students' behaviour. I consider the research questions from Chapter 1 that guided the study to reflect on the impact of the research.

(a) How can exposure to applicable problem-solving strategies foster problem-solving skills in Actuarial Science students?

There is evidence that exposure to the problem-solving strategies mentioned above created an awareness in students of the importance of developing these skills and the important role they play in developing the skills in themselves. Students changed their behaviours in an attempt to improve the way they learn and understand new knowledge (see (b) below). Students started using some of the suggested strategies when faced with unfamiliar scenarios where their knowledge needed to be applied to practical problems (see (c) below). Some strategies were more helpful than others in assisting students to develop problem-solving skills (see (d) below).

(b) How does training in problem-solving strategies affect students' learning practices?

There is evidence that students became more actively involved in the learning process by asking more questions in the classroom as well as to fellow students outside of class. Students gained an awareness of how effective learning takes place and that they needed to apply their minds to understand how everything they learn ties together. They further improved their learning by the active participation of more students in class and learning from the group wisdom rather than just receiving information from

the lecturer without engaging with the work. Some students started taking a more structured approach to learning by making summaries and mind maps to see how concepts link to each other and by making sure they understand how everything ties in with the big picture of the subject. Some students realised the importance of broadening their knowledge beyond their field of expertise and started to read wider. There was a small number of students who were resistant to change their ways. Some of them were already doing some of the suggested techniques, hence no change was deemed necessary. Others felt it was too difficult to change their ways so late in their study career. I concluded that students needed to be taught how effective learning takes place because that is the first building block of improving their understanding of the underlying knowledge which is imperative to solving problems in their field of expertise (Norman, 1981; Shepherd & Bellis, 1994; Snyder & Snyder, 2008; Ramsden, 2003).

(c) How does training in problem-solving strategies affect the way students approach problems?

Students received a toolkit that provided them with helpful strategies to use when solving problems. Students gained an awareness of how to take a structured approach to solving problems. They became better at defining problems by asking questions and considering each word in the problem statement carefully. They started using some of the techniques that helped them to generate more solutions to problems. Some students realised that it was helpful to brainstorm with other students to generate more solutions to problems and to learn from one another's thinking. They realised that they needed to practise using the techniques for applying these techniques to become a natural process for them. Students found it difficult to apply the techniques initially, especially when there were time pressure in tests. I learnt that students ideally needed regular exposure to problems and to be continuously mentored in the solving of problems (Broadbear, 2003; Snyder & Snyder, 2008). This also corroborates what McPeck (1981) said about teaching students the 'how to', but they also need training in the 'to use' it.

(d) Which problem-solving strategies did students experience to be the most helpful in developing their problem-solving skills?

Students appeared to be the most interested in those strategies that they believed to be beneficial to them in their Honours year. They were interested in the strategies that would improve their understanding of what they were studying and which would help them to solve the type of problems that they needed to solve in their Honours year. They also preferred strategies that came naturally to them and not strategies

which appeared to be random. However, when having to list the strategies that they were using, some of the random strategies were mentioned, perhaps because they were so strange and that made the students remember them. Students also mentioned the problem-solving strategies that helped them to think critically about any information given in a problem statement and to think of all stakeholders affected by a problem. I concluded that it was helpful for students to have a toolkit of strategies that could guide them to take a structured and creative approach to solving problems (De Bono, 2010; Fogler et al., 1995; Soden, 1994).

5.3 REFLECTIONS

Reflecting on the findings, I concluded that students had gained an awareness of the importance of fostering problem-solving skills and most students had made small adjustments to start developing the skills in themselves. However, given the time constraints and pressures of their Honours year, this would not continue to happen naturally if students are not exposed to problem-solving strategies on a regular basis. I agree with the literature that lectures should be structured around problems relevant to the topic at hand so that problem-solving becomes an integral part of most lectures. The more opportunities students have to practise solving problems, the more natural it would become for them to use the techniques (Broadbear, 2003; Browne & Keeley, 1990; Johnson, 2010; Shepherd, 2010; Snyder & Snyder, 2008). However, this creates a dependency on lecturers to reconsider their way of teaching and to carry the responsibility to model these skills to students.

Another practical suggestion would be to introduce discussion classes in subjects and to use these classes to practise problem solving and to assess students' problem-solving skills. This requires lecturers to increase contact time with students and they may need to be trained in the problem-solving strategies and the assessment of the application of the strategies, unless such discussion classes are outsourced to external lecturers or tutors.

Reflecting on my own journey in completing this research, I have learnt that I could apply much of what I was teaching the students when faced with problems in my life and in this research study. Perseverance played an important role and at times I did not believe that I would be able to finish the study. I have learnt the importance of learning from others who have journeyed before me and listening to advice from those who have your best interests at heart. I have experienced the benefit of using an action research methodology in how it

changed the researcher as well as the participants. I will take much of this learning into my future teaching approach and continue encouraging others to think about how they could improve the way they teach, learn and solve problems.

5.4 LIMITATIONS OF THE RESEARCH STUDY AND RECOMMENDATIONS FOR FUTURE RESEARCH

My research did not focus on the training of lecturers of Actuarial Science students in education strategies that would assist students to develop problem-solving skills. This is a limitation because if lecturers lectured in a way that required students to use their problem-solving strategies and if they continuously modelled problem-solving strategies to students, students would develop these skills much quicker (Broadbear, 2003; Snyder & Snyder, 2008; Tempelaar, 2006). I had some interaction with lecturers to make them aware of effective teaching strategies, but I did not follow up to check if they had been applying it. It was challenging that part of the success of my research was dependent on how and if lecturers applied my proposed strategies. There is potential for future research on the effect of educational strategies applied by lecturers to develop problem-solving skills in students.

Linked to this, lecturers should be trained and encouraged to use assessment methods that require students to apply problem-solving strategies. As mentioned in Chapter 2, some effective assessment methods that have been proven to develop problem-solving skills are doing case studies, debating practical dilemmas from industry, requiring students to write essays about relevant topics as well as using a problem-based learning approach (Broadbear, 2003; Shepherd, 2010; Snyder & Snyder, 2008). It is a limitation of my research study that I did not encourage lecturers to use some of these assessment methods during the semester or to bring it into my lectures. The literature suggests that this is an important aspect to ensure that students are forced to use and apply the skills (Broadbear, 2003; McPeck, 1981). Students' learning is defined to a large extent by how they will be assessed (Shepherd, 2010). The nature of the actuarial examinations have been to largely test the application of the theory, and as such, possibly does not require too much change. However, research into whether sufficient subjective tools such as essay questions and case studies that require students to apply their knowledge to new situations can be done as a further study.

Broadbear (2003) suggests that frequent assessments of how effective problem-solving skills

were applied should also be incorporated into the training process. Students can improve their skills if they receive feedback on what they are doing right and what they could be doing better. As mentioned in Chapter 2, this could be done in various ways by a variety of people, for example lecturers, peers, tutors. It is a limitation of my research study that I did not formally assess students' application of problem-solving skills and that I did not teach them how to assess each other's problem-solving skills. An area for future research could be to determine the impact of assessment of the application of problem-solving skills on the development of problem-solving skills.

Another limitation of my study, is that I could not spend as much time with the students as I would have liked to. During the research process, I realised that the students would have benefited from more frequent interactions to be able to address some of the limitations mentioned above. I would have liked to have a few more sessions to focus on the practical application of the skills and on the assessment of their skills, but their schedule was finalised at the start of the year and it was quite full, so perhaps with better prior planning, I could have negotiated more time with the students. A recommendation was made by some students that training in problem-solving skills should start from their first year throughout their undergraduate studies with plenty of practical application throughout.

I support this recommendation since I mainly focused on the first two steps in the problem-solving cycle: 'Define the problem' and 'Generate solutions'. I would have liked to spend time on the last three steps, namely 'Decide the course of action', 'Implement the solution' and 'Evaluate the solution'. I touched on some of the factors to consider in those steps, but I needed more time to explain and to let students practically apply those steps in the problem-solving cycle.

I believe more extensive research can be done to ensure that the necessary changes could be made to education strategies, methods of assessment and other aspects of the curriculum at the University of Pretoria. Shepherd (2010) believes that all elements of the education system should work together to support the goal of fostering critical thinking and problem-solving skills, hence consistency between learning objectives, course notes, assignments, tutorials, examination questions and examination marking.

The results from my action research methodology may not be generalisable, but some important learning could be derived from the research to shape and improve the education offering provided by the University of Pretoria.

5.5 CONCLUSION

From my research, I have seen that exposure to applicable problem-solving strategies has helped students to start developing problem-solving skills in themselves. Some strategies were more helpful than others. I believe it could be that students did not practise using such strategies enough or lacked understanding in how some of them could be used in practice. I have realised that it would take time and practice and regular exposure to the strategies to acquire these skills (McPeck, 1981; Snyder & Snyder, 2008). During this study I corroborated the theoretical framework of Soden (1994) and McPeck (1981) that problem-solving skills could be taught and should ideally be taught in the context within which they would be applied. My students commented that strategies that could be applied to their field of expertise were the most helpful.

The results of my research also supports Fogler et al. (1995) and Shepherd (2010) who proposed that a structured approach to problem solving would lead to improved problem-solving skills. Students have become brave enough to question why they should believe something and have learnt that they should tie everything they learn to something they already believe to be true. This is the first step to develop critical thinking skills, which are imperative for developing problem-solving skills (Baron & Sternberg, 1987; Broadbear, 2003; McPeck, 1981; Tempelaar, 2006).

I have identified that the study had limitations which possibly prevented students from applying more of the strategies more effectively. I believe if these limitations could be addressed, even more pleasing results there could be possible. However, the study did provide certain promising possibilities for future research in this field and it did generate knowledge worth noting in the field of problem-solving education.

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Addenda

ADDENDUM A: ETHICAL CLEARANCE

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences
Ethics Committee

E-mail: ethics.nas@up.ac.za

24 May 2018

ETHICS SUBMISSION: LETTER OF APPROVAL

Prof AF Harding
Department of Mathematics and Applied Mathematics
Faculty of Natural and Agricultural Sciences
University of Pretoria

Reference number: EC180402-183
Project title: Exploring teaching interventions to equip students with problem-solving techniques as part of their Actuarial Science Honours degree at the University of Pretoria

Prof Ansie Harding,

Your application was granted retrospective approval by the Faculty of Natural and Agricultural Sciences Research Ethics committee.

Please note that you are required to submit annual progress reports (no later than two months after the anniversary of this approval) until the project is completed. Completion will be when the data has been analysed and documented in a postgraduate student's thesis or dissertation, or in a paper or a report for publication. The progress report document is accessible off the NAS faculty's website: Research/Ethics Committee.

If you wish to submit an amendment to the application, you can obtain the amendment form on the NAS faculty's website: Research/Ethics Committee.

The digital archiving of data is a requirement of the University of Pretoria. The data should be accessible in the event of an enquiry or further analysis of the data.

Yours sincerely,

Chairperson
NAS Ethics Committee

ADDENDUM B: CONSENT LETTER PARTICIPANTS

Faculty of Natural and Agricultural Sciences

INFORMATION LEAFLET AND INFORMED CONSENT

Evaluating the impact of teaching problem solving techniques to UP Honours students

Primary investigator: Ms E Gouws **Supervisors:** Prof A Harding, Ms M Venter

Dear student,

You are invited to participate in a study conducted in the Faculty of Natural and Agricultural Sciences (NAS). This information leaflet will help you to decide if you would like to participate.

WHAT IS THE STUDY ALL ABOUT?

The study aims to investigate the impact on students' problem solving abilities when introducing dedicated time for teaching problem solving techniques in the subject IAS712.
The research focuses on equipping Actuarial Science Honours students with techniques to help them to integrate the theoretical knowledge obtained throughout their degree with practical workplace problems and/or exam questions of a practical nature. This involves teaching them methods to improve their understanding of the underlying theory as well as problem solving techniques to enable them to apply this knowledge in a range of unfamiliar circumstances.

WHAT WILL YOU BE REQUIRED TO DO IN THE STUDY?

These classes have been worked into the normal IAS712 lecture schedule so as to ensure that minimal effort is required from students to participate in the study.

You will need to sign a register to indicate that you've read this informed consent form and that you agree to take part in the study. By signing the register you also agree that the results of this study could be used for research purposes.

You will be required to give feedback as requested during and after completion of the course to comment on the usefulness or otherwise of the interventions aimed at improving your problem solving skills. There is no risk involved as your information will be pooled with others and your identity will never be reported.

The benefits of participating in this study are:

- You will make a contribution towards establishing how problem solving techniques could be taught to students in the most effective way.
- You will assist in establishing best teaching practices in the design of modules in the faculty to ensure that students are able to better apply what they've learnt in practice.
- You will have the opportunity to reflect on your own learning and problem solving habits and most probably experience some improvement in these areas over the period.

Please note that you **will not** be paid to participate in the study.

All information obtained during the course of this study is strictly confidential. The data will be coded so that it will not be linked to your name. Your identity will not be revealed while the study is being conducted or when the study is reported.

Your participation in this study is entirely voluntary. You have the right to withdraw at any stage without any penalty or future disadvantage whatsoever. It is important to know that the researcher is in no way involved with your IAS712 assessments. We kindly request you to indicate to us when you withdraw. This could be done with or without giving your reasons for doing so.

Contact: Ms E Gouws at gouws.elsa@gmail.com if you have any questions/comments.

Your co-operation and participation in the study will be greatly appreciated.

CONSENT TO PARTICIPATE IN THIS STUDY

I confirm that the person asking my consent to take part in this study has told me about the nature, process, risks, discomforts and benefits of the study. I have read this form (Information Leaflet and Informed Consent) and I understood the information regarding the study. I am aware that the results of the study, including personal details, will be anonymously processed into research reports. I am participating willingly. I have had time to ask questions and have no objection to participate in the study. I understand that there is no penalty should I wish to discontinue with the study and my withdrawal will not affect any treatment in any way.

I have received a signed copy of this informed consent agreement.

Participant's name ..... (Please print)

Participant's signature: ..... Date.....

Investigator's name ..... (Please print)

Investigator's signature ..... Date.....

Witness's Name ..... (Please print)

Witness's signature ..... Date.....

ADDENDUM C: ACTIVITY TO DEMONSTRATE STRUCTURE HELPS THE BRAIN

South

Portugal

Central

Tanzania

Africa

Kenya

South Africa

France

Spain

United Kingdom

Egypt

Botswana

Zimbabwe

Germany

Greece

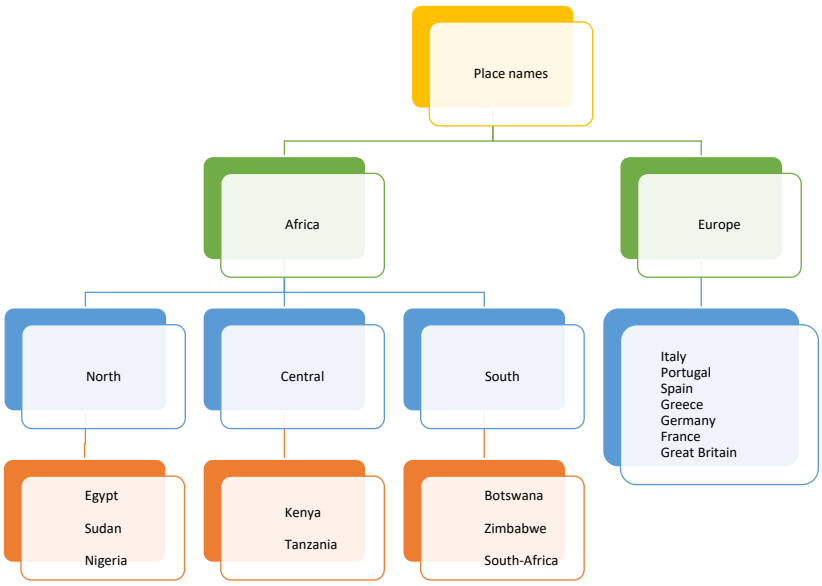
Sudan

Europe

North

Nigeria

Italy

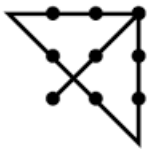


ADDENDUM D: NINE DOT PROBLEM

Nine dot problem

Connect all of the **dots** using four straight lines, without removing the pen from the paper once you start drawing:

The solution lies in thinking outside of the box created by the nine dots and moving some lines beyond the perceived confines of the nine dots.



ADDENDUM E: SESSION 3 CLASS QUESTIONS

Example question

The Spice Cup has been a regular soccer league in South Africa since 1889 and has been played annually from 1968 till the present.

There are two divisions: the famous and very visible premier division and the less well known first division. The premier division features the top eight teams from the previous year and teams in this league generate significant revenue from TV broadcasting rights, sponsorships, well attended matches at their stadiums etc. The first division teams often do not have these privileges and may struggle to generate revenue and attract sponsors.

Every year the team that finishes last in the premier division gets "demoted" or "relegated" to the first division. The winner of the first division is granted entry into the premier league.

An insurance company is considering offering insurance to teams for the event of a premier team ending last and being relegated to the first division at the end of the season.

Discuss the factors that the company should consider when deciding whether or not to introduce this product (including but not limited to whether this is an insurable risk). [12]

Outline Solution (proposed techniques shown in bold)

ACC & questions: Problem statement: Will this be a viable and successful product i.e meet needs of clients and make profits for company? Will someone want to sell it? Who will buy it? What are the risks involved? Is it an insurable risk and other legal/regulatory requirements to consider? System requirements? Capital requirements? Accounting? Sensible level and form of benefits. Scope for flexibility in take-up or early leaver? Development costs and annual maintenance costs.

Develop solutions: What terms and conditions to manage risks? What premium? What SA and other benefits eg early leaving and late joining not allowed. Are there any competitors offering similar products that we could learn from? Improve on? Charge appropriately.

Purpose: Protect teams/clubs against loss of income when downgraded after losing in premier league. **Structure:** Charge an appropriate premium related to risk, for an appropriate sum assured considering loss of income (not same for all teams).

Insurability and meeting need: (underlying theoretical principles)

Policyholder must have interest in risk being insured to distinguish between insurance and wager: [$\frac{1}{2}$] Clearly the relegated team stands to lose income and income potential in the event of being relegated and will be in a worse off position in the event of losing the league. Due to the pressure to perform well, the pride associated with winning and shame with losing, there is an argument that the insured would not want the risk event to happen at all. [$\frac{1}{2}$]

Risk must be financial and reasonably quantifiable in nature: [$\frac{1}{2}$] The loss incurred is related to lost income and is hence financial in nature. [$\frac{1}{2}$]

Amount payable by the policy in the event of a claim must bear some relationship to the financial loss incurred: [$\frac{1}{2}$] It should be possible to estimate potential lost of earnings, at the very least looking at the income generated during the last season. Alternatively a fixed sum assured based on the average of all teams earnings may be used. [$\frac{1}{2}$]

Individual risk events should be independent of each other: [$\frac{1}{2}$] Only one team can claim in a specific season, ie correlation and accumulation should not be an issue here. [$\frac{1}{2}$]

The probability of the event should be relatively small: [$\frac{1}{2}$] A claim in any given season is certain. The claim amount may be uncertain, depending on the structure chosen. [$\frac{1}{2}$]

Large number of potentially similar risks should be pooled in order to reduce variance and hence achieve more certainty: [$\frac{1}{2}$] We only have eight potential policyholders and one claim is a certainty, hence this condition is probably not satisfied. [$\frac{1}{2}$]

There should be an ultimate limit on the liability undertaken by the insurer: [$\frac{1}{2}$] It should be possible to either specify the finite sum assured at the outset of the season or impose a maximum amount if the liability is calculated at claims stage. [$\frac{1}{2}$]

Moral hazards should be excluded as far as possible: [$\frac{1}{2}$] This product introduces significant moral hazard as teams may lack incentive to perform well, especially in the final stages of the league if they are bottom of the log and lack the motivation to perform. This may be addressed by not having a sum assured that is too lucrative or introducing a minimum performance measure (ie at least 2 matches won etc) although the latter may be difficult to sell. Might still be better for teams to end second than last with payout due to pride and status associated with premier league. [$\frac{1}{2}$]

There should be sufficient data/info to enable the insurer to estimate the extent of the risk and its likelihood of occurrence: [$\frac{1}{2}$] The extent of the risk (ie range of possible sum assured) should be known as the income of the top and bottom placed teams can be estimated for

recent years. For a given team we should have plenty historical performance data, but in this case this is not very likely to always be relevant/applicable to team sports since the composition of the team changes constantly. [$\frac{1}{2}$]

Other factors ($\frac{1}{2}$ each) – marketability, profitability, capital requirements:

What will be the sum assured? Top teams in premier division probably earn a lot more than the others. Do you only replace income for 1 year, or for how long?

Marketability: top teams are unlikely to buy this cover as they have consistently been in premier league and their past performance keep attracting top players ensuring future success.

Since a claim is guaranteed, the premium is likely to expensive, especially since we have only eight teams. This problem is compounded in the light of the comment above. Who is the insured party – the club's owners or the players? (both set to lose income) Would have to have restrictions on when policy can be taken out. Not just before last game. Must take at start of season. Or gets more expensive as season goes on up to limit. Will have to be compulsory for all teams to take it out, iot get bulking/pooling. Top league might see it as a tax, however, it's necessary to have players keen to join even bottom of league teams, otherwise the whole league loses anyways – if there is no league. • League might consider offering this insurance themselves...

Question 1 (Life insurance)

A life insurance company sells only unit-linked savings and immediate annuity business.

The unit-linked regular premium savings product is designed to fund for a pension in retirement, and so its maturity date is the retirement date selected by each policyholder. Some of the policies have a guaranteed annuity option whereby the policyholder will receive a fixed amount of annuity per 1,000 of fund value at the selected retirement date if they take the option at that date. Otherwise, they are free to purchase an immediate annuity either with the same company or in the open market, using the unit fund value. The guaranteed annuity rates are set when the product is sold.

Following a recent government legislation change, at retirement the company's policyholders can take 25% of the fund value as a tax-free lump sum. The remainder of the fund value can either be taken as a taxable cash amount or it can be used to buy an immediate annuity. Under the previous legislation, policyholders similarly had the option of taking 25% of their

fund value as a tax-free lump sum, but the remaining fund value had to be used to purchase an immediate annuity.

The proportion of policies purchasing an immediate annuity is known as the 'annuity take-up rate'. Taking the guaranteed annuity option is equivalent to purchasing an immediate annuity.

i. Assess the potential impact of this change in legislation for the annuity take-up rate for policies that do not have a guaranteed annuity option. Your answer should include consideration of factors on which the impact will depend. [7]

ii. Assess how the impact on the annuity take-up rate would be different for policies that do have a guaranteed annuity option. [4]

Outline Solution Q1

Purpose and questions: Why is this an important question to ask for companies? What is the possible intention with the legislation change? How will policyholders most likely react? What is rational behaviour? Do they act rationally? What is in their best interests? Who helps them to decide what to do – brokers? How would they advise them? What options do they have w.r.t products? What factors affect annuities that we should consider? How would those with guaranteed annuity option behave different than those without? What is the purpose of the Guaranteed Annuity Option? Do policyholders understand when it's valuable or not?

OPV/Stakeholders: Company (wants to sell their products), Client (what are my options?, tax efficiency, good rates, flexibility), Government (people to have flexibility but use money wisely at retirement, state pension, gets more tax quicker if clients take all at once), Brokers (sell products)

PMI: Plus, Minus, Interesting things about government's decision: Plus: Small amounts can be taken as cash rather than admin-intensive immediate annuity. Flexibility to client to choose how they want to use their retirement money. Government gets more tax (plus/minus). Minus: Client don't understand risks of not ensuring guaranteed income. Becomes government's problem. Perhaps loss of sales to insurance companies. More tax payable by clients. Annuity rates affected as perhaps only healthy lives take it up.

i. The change in the legislation would be expected to reduce the annuity take-up rate (as policyholders can now withdraw the full fund value of their policy rather than having to take

out an annuity). (How would policyholders react to the change in legislation? – **assumption**) In fact, the rate of annuity take-up would be expected to reduce significantly from the current level (**Assumption**, why? Due to low fund values, ill health, choice). For the tax-free lump-sum, it is likely that the policyholders will continue to utilise this feature and the proportion of policyholders taking this amount would be expected to remain high (state the obvious in exams. Will there be a change in behaviour wrt tax-free part?).

The level of the reduction in take-up rate will depend on a number of factors: (What will affect the amount that policyholders will now take as cash at retirement?)

Level of fund value – the lower the level of the fund value, the more inclined policyholders may be to take the remaining amount as cash.

Availability of alternative products eg drawdown products. The greater such availability, the less inclined policyholders may be to take the remaining amount as cash.

Annuity rates in the market at the time of retirement – The more expensive the conversion rate from fund value to pension, the lower the perceived value for money the annuity becomes and policyholders will be more inclined to take the fund value as cash. This is likely to get worse as only healthy people will take annuities and so annuities will have to be re-priced to reflect this.

Personal preferences of policyholders – they may feel the cash amount gives them greater flexibility. As they could use the additional cash to pay off any remaining loans or mortgages or fund any large purchases such as cars or holidays.

State of health of policyholders – those in relatively poor health would be more likely to take the cash payment.

Level of advice taken or financial awareness – policyholders may not fully understand the options available to them. They may not have sought professional advice prior to making a decision; and may not appreciate that by taking the remaining fund value as a cash amount they might incur more tax than they had appreciated; or that by taking the cash amount they may burn through the funds and leave themselves without funds later in life, as opposed to receiving a guaranteed income through life with the annuity.

The level of tax applied and any tax allowances included If the remaining funds are taken as cash amount, then they are treated as taxable income. Depending on the way the tax system

works, this may mean that there could be a large tax bill to pay for the policyholder in the year that they retire.

The level of pension income from other sources, such as state pension and pension from Defined Benefit schemes. If this is high, then more cash will be taken.

ii. Similar to those without guaranteed annuity option, the rate at which policyholders take the tax-free lump sum should remain fairly stable following the change in legislation (state the obvious). If the guaranteed annuity option is not in-the-money then the change in take-up rate experience would be expected to be similar to that for the policies without the option. Assuming that it's heavily in-the-money, then it would be expected that policyholders would still utilise the guaranteed annuity option as that is the more valuable option. And that the annuity take-up rate would be similar to that prior to the legislation change. However, policyholders don't always act rationally and despite the guaranteed annuity option being the more valuable option, they may still elect to take the fund as cash (especially if the fund is relatively small). The extent to which this will happen will depend on how aware they are of the existence of the guaranteed annuity option. And the extent of their understanding of how valuable it is. And on their personal circumstances.

As with policies without the guaranteed annuity option, the actual experience may not be stable initially and may take some time to stabilise to a long term rate.

Question 2 (General)

An insurance company in Fictasia is considering launching a new product to the market to cover cyber risks including perils under the following categories: • Virus damage • Hacker attack • Infringement of intellectual property, slander or libel • Online identity fraud

i. Describe events a policyholder might experience that could give risk to a claim under this policy. [6]

ii. Propose potential benefits that can be provided in the event of a claim. [6]

Outline Solution Q2

Purpose and questions and **link** to what you know/have **experience** of, also **random stimulation**, **Osborn's checklist** to help think big and small about how wide it can affect, **stakeholders**: What is the purpose of this insurance? What would the structure be? Who would benefit most from such insurance? Banks could be good starting point of reference.

How can virus cause damage? What could be negatively affected due to virus? Same with hacker. How can Intellectual Property be lost, or slander or libel happen. What is risk with online identity fraud? What risks/problems/viruses have I faced with computers or have I heard of? What have I seen in movies w.r.t hackers?

For part ii, **Present state/desired state**, how can I be put in same position as if cyber problem event didn't happen? Or **Duncker diagram** – make it okay not to get to desired state e.g can't get worktime lost back, but can encourage employees to work overtime to catch up and pay them extra.

i. Losses suffered by the policyholder when using their internet or email. Losses relating to damage to, or loss of information from, IT systems and networks. Business interruption losses to the policyholder arising from loss of use of IT systems/ hardware/websites as a result of an insured peril.

Virus damage: A virus infecting a computer system and causing damage; Such as failure to start certain programmes; Slowing performance speed; Corrupting or deleting data; Employee accidentally opens an infected email; Policyholder accidentally transmits the virus to anyone they do business with or via their website.

Hacker attack: A hacker takes control of computers; or website; and steals customer data; or releases data; uses computer for malicious purposes (eg distributing spam). A hacker may hold organisation to ransom; threatening to release data; or damage a website (feels like repeat, but see the difference and extra points created). May access or steal assets; Or intellectual property. Policyholder's use or access to their own systems may be suspended during a police investigation into a hacker attack.

Infringement of intellectual property, defamation or libel: Policyholder accidentally infringes a trademark on their website. Email from policyholder (or its employees) causes defamation or libel; or policyholder's website.

Online identity fraud: A third party fraudulently uses policyholder's online identity to enter into a contract/agreement. Other perils not suggested: Personal data or privacy issues e.g loss of or disclosure of private data. Losses relating to breaches or actions by suppliers or business partners.

ii. Policies generally include significant assistance with the management of the incident itself rather than or in addition to paying a 'sum insured'. This can help to minimise reputational damage associated with cyber breaches.

Virus damage: Insurer could help rebuild computer system/website following damage. Insurer could help restore company data. Payments for increased costs of working or business interruption. Negligent onward transmission of virus managed or restored.

Hacker attack: Insurer could pay to repair a damaged website. Pay for remedial legal costs. Pay for remedial PR costs. Pay a ransom to hacker threatening to destroy website/release sensitive data. Provide loan equipment/Pay to replace equipment for duration of any police investigation. Costs of any amounts extorted. Coverage for costs of notifying customers of a security or privacy breach. Coverage for any investigation costs into attacks; and defence costs and/or civil damages arising from breach.

Infringement of intellectual property, defamation, libel: Cover compensation policyholder has to pay.

Online identity fraud: Insurer could pay costs incurred.

Question 3 (Pensions)

A small company currently operates a final salary pension scheme for all employees. There was a small surplus at the last triennial valuation. The company directors are concerned about the ongoing costs of providing future benefits within the scheme, and also the risk that there might be a deficit in future. Explain the actions that could be taken to reduce the chances of a deficit arising in the future. [10]

Outline Solution Q3

Statement re-statement: use terms in the question: small company, final salary scheme, small surplus; triennial valuation; costs of future benefits; reduce chance of deficit. **Purpose, structure, Questions** and **stakeholders**: What is purpose of Defined Benefit scheme? Structure? (contributions by employer and employees, benefits accrue and gets paid out as pensions, there would be paid-up benefits of employees leaving the scheme). Trustees, Members, Asset managers, **Present state/Desired state:** never deficit/chances of deficit very small. What causes deficit? Think of contribution and asset side as well as liability side.

Funding: Pay more employee/er contributions into the scheme; Cease accrual to redirect contributions to accrued benefits; Or reduce benefits in some way subject to legislative constraints; Fund scheme on prudent basis; So that risk of assumptions not being borne out is less; Regular valuations to keep check on funding level; Offer trustees security/contingent assets.

Investments: Investigate matching the assets to liabilities; With advice from investment adviser; So Gilts/Bonds; Either Fixed or Index-Linked depending on nature of liabilities; Possibly using cashflow models and Asset Liability Matching; Could use derivatives although scheme is small so unlikely to be available; Matched position likely to lead to lower discount rate and therefore increased deficit; But future funding position more stable.

Liability management: Insure some liabilities to remove or mitigate risk eg using annuities; Or buy-in/buy-out which is likely to be expensive; Or liability reduction exercise e.g reduce pension increases subject to legal restrictions; Make sure any options are cost neutral e.g early/late retirement so that there is no loss to scheme on these events; Subject to restrictions in scheme documentation or regulation.

ADDENDUM F: LECTURER CHEAT SHEET

1. Students (preferably with your help) must create a structure of the content for themselves so that they can 'save' each new piece of information in a structured way to extract it more easily when having to solve problems. It is important to bring the topics together so that students understand how it all fits together (even with previous year's topics where applicable) so that they build a bigger picture for themselves, and build on existing knowledge. The Actuarial Control Cycle (ACC) is a problem-solving tool, but for you and the students, it could provide a structure for the work that you are teaching.

2. The order of learning is important and could play a role in how well they understand what they are learning. Students need to understand the big picture before the small/detailed things will make sense to them or be interesting to them. They must understand the purpose of what they are learning (Why am I learning/doing this? Why is this important? How does this link back to my role as an actuary and previous classwork?)

3. Students learn better if they can 'link' it to something that they already know and understand. For example, if you can relate new learnings to the working of a bank account or a student loan or perhaps a medical aid, then that should help them to make a better connection with the work.

4. Lecturers should identify the core concepts that students definitely must know and understand to function as a professional in the field. These are the core things related to the subject as a whole, but also relevant to each section.

5. Students need to ask questions because that ensures that they are using mental operations and procedures that will help them to understand new learnings better and hopefully file the new learnings more efficiently. Their mind is working when they are asking questions. A safe environment is critical, so please encourage them to ask questions. Don't ridicule, don't laugh. Rather encourage them, probe further, help them to learn to use their minds optimally. Don't be too quick to provide solutions. Encourage them to use their minds to get to a reasonable solution on their own or together with classmates. Similar to the brainstorming concept. One thought ignites another idea from another student.

6. Students need to practice problem-solving in class. Try to do more practical examples and encourage them to critically think about such problems and to come up with a range of solutions. Don't be satisfied with the first solution that comes to mind. Probe for more alternatives to the first one that's given. They need to know that there are a lot of grey areas, and given different circumstances, the answers could be very different. Encourage them to think about that. For example, ask them in which circumstances their proposed solution might not be appropriate.

7. There is a Monash philosophy of predict, observe, explain. It forces students to THINK first (what do they think will happen?), not just observe and then explain. This links in nicely with Woods (1985) who suggests problem-based learning: "In 'problem-based' learning a situation is presented before any knowledge is given. Then once the knowledge is acquired, it is applied back into the problem. The students are in control because they must select the knowledge needed to solve the problem, learn that knowledge and relate it to the problem. They select their pacing and sequencing. Often they evaluate themselves."

8. Think about this: real science or mathematics should not have a single right answer or a series of rules/statements/theories that you have to drill into their heads. It should teach logical thinking and deduction skills that take into account the circumstances and facts around the problem statement and then come to a logical conclusion based on scientific evidence. Students should spend more time interacting with ideas than spending time studying the notes (?, ?).

ADDENDUM G: OUTLINE SOLUTION CYCLE 2 SESSION 1 CLASS QUESTION

Use any sensible structure to help you to generate solutions to this question in a structured way. I suggest thinking through the process of designing and pricing a product, selling it, administering it, valuing it and handling claims within the context of a general economic and regulatory environment.

1) What type of products will the company sell?

- What needs of clients will the product meet? Products must provide useful benefits to consumers, else risk that it does not sell and hence that it is not profitable to company.

- How to differentiate your product from the rest of the market?

- Reputational risk – if you don't provide benefits that you've promised or if products don't meet clients' reasonable expectations.

Risk of getting your assumptions wrong when pricing the product e.g more claims than expected.

- Risk of change in buying behaviour. This changes sales volumes and/or mix over time which invalidates your assumptions.

- Risks inherent in the product e.g high capital requirements, high cost of guarantees, charges not meeting expenses. These risks can be reduced by offering product in Unit Linked form with low/no guarantees. Could make charges flexible to reduce capital requirements.

2) What distribution channel will I use to sell my products?

- What channel would be best suited to reach the target market?

- What channel would be best equipped to sell my product depending on how complicated the design is, level of underwriting required, etc?

- Would I consider multiple channels?

- Would I price differently for different channels?

- Training for salesforce needs to be set up.

Risks: - Salesforce selling inappropriate products/mis-selling products .

- Persistency risk – leading to losses especially when asset share is negative, but also fewer policies to spread overheads across.

- Salesforce don't sell because they don't like the remuneration structure.

- Volumes, types and mix of business different to assumed hence pricing assumptions turn out to be wrong (eg demographics, expenses).

- Sells too much – don't have sufficient capital to back – could lead to insolvency.

- Sells too little – expenses not covered sufficiently by premiums.

- Persistency – risk of non-recovery of clawback commission.

3) Expenses of setting up the business, new premises costs and running a business and marketing the products.

- Ensuring you set up sufficient loadings in products to cover expenses – risk that it's not sufficient.

-Employing good quality, well-trained staff and retaining them.

- Risk that company cannot contain costs, including inflation risk.

- Risk of not selling enough business to cover development costs and overheads.

4) Economic environment that your company will be operating in.

- Availability of assets – and quality of assets, and security of assets, yield of assets.

- Are insurance products more/less attractive than other available products (or not investing at all eg money in box under bed/in bank).

- More volatile markets have more expensive insurance products (due to relatively higher capital requirements due to increased uncertainty of investment returns) – risk of less take-up.

- Risk of required rate of return on capital not being achieved.

5) Legal environment – consider all regulation/legislation that you have to adhere to.

- What is required to set up company – licensing fees, etc?

- Becoming a registered financial services provider.

- Risk of policyholders' reasonable expectations not being met from expectations created in marketing material/process.

- Make sure all contract terms are fair and in line with current legislation.

- Make sure sales staff understand all relevant legislation and consequences of mis-selling/misrepresentations, so they have to be trained properly.

- Ensure all staff understands legislation relevant to company.

- Risk of legislation changing (especially if changed retrospectively) – this could also lead to a negative perception of insurance in general.

- Opportunity if recent legislation/regulation is affecting the way other companies do business, then you can start fresh without legacy/reputational problems that was created by change in legislation/regulation.

6) Regulatory environment - Consider regulation impact on contract design eg types of contract, terms and conditions, prem rts and charges, etc.

- Consider wider regulatory environment to understand all your competitors – not level playing field.

- Risk that regulation changes.

7) Taxation - Understand how your company will be taxed.

- Register for tax at SARS.

- Consider taxation of premiums, taxation of life insurer's funds and then tax of policy benefits to determine overall attractiveness of life ins product.

- Effect of fiscal regime: • Different types of life ins business (eg in our country Insurance business vs Investment business) taxed on different methods

• Could be lower cost for consumer to get benefit in one form/type of bus rather than another

• Tax treatment of life insurance products may make it a more/less attractive savings vehicle than other contracts offered by savings institutions subject to different regime – could make sales of certain contracts easier and influence buying habits of policyholders

• Risk that taxation changes

8) Competition - Understand who your competitors are and what they are doing.

- Find out how you can differentiate yourself from your competitors eg innovation, service, price.

9) General - Consider company structure/type. Do you want to set up a mutual or a proprietary company?

- Easier access to capital with proprietary, but may be difficult to find shareholders until you've established yourself.

- Attracting and retaining good quality staff.

- Risk management – decide on level of risks that company is prepared to take on and how to reduce risk.

- Reinsurance could be used to get technical assistance with pricing and underwriting and getting data to help price correctly.

- Reinsurer could also act as a source of capital eg financial reinsurance arrangements, reducing reserving requirements.

- Company is new in market so must find a way to get brand awareness – must decide between advertising or using brokers to sell.

- IT systems to use and set up – decide whether to use consultants or employ people from the start.

- Data requirements – where to get appropriate data to assist with modelling.

- Models will be used to do projections of sales revenue, cashflows, pricing, valuations, etc.

- Risks involved in models – eg model risk, parameter risk, random fluctuations. Success of models depend heavily on credibility and applicability of data used in the models.

ADDENDUM H: PROBLEM-SOLVING TOOLBOX

1) When going through each chapter of the notes, ask yourself the following questions:

• What is the purpose of this chapter? Why is it important? Where/how would I use it in practice? How has it been tested in past exam questions? This would help you to know how to apply it to practical problems. Also, think about the purpose of each product, stakeholder, asset class, each of the terms and conditions, strategies or tools whilst learning about them.

• Consider where the chapter fits into the structure of the subject as a whole. Consider using the Actuarial Control Cycle to create structure. For each product/asset type/model/risk management tool, think about its structure and why it has that particular structure? Think about its main features, and why it has those features.

• What is the 'link' to other chapters? How do other chapters affect this product/asset class etc.? In other words, consider the big picture and how these fit into it. How does it 'link' to what I already know about similar things e.g. bank accounts or other methods of saving/protection?

• Remember, how information is learned and stored in memory could inhibit or enhance your ability to extract that information when needed to solve problems. The mental procedures required for problem solving will be applied most effectively if you have stored the information in an organised way.

Good problem solvers: a) Organise information into categories or concept structures and know relationships between the different categories; b) Re-organise their concept structures as they acquire more info; and c) Understand the fundamental principles in their subject. You have to know your work, or more importantly, understand what you've learnt.

2) Remember the following tips to help you to solve problems:

• Find a starting point that allows you to move forward (What do I know about this problem?)

• Generate alternative courses of action (What options are available to me in this situation?)

• Identify potential future consequences of proposed courses of action

• Consider the advantages and disadvantages of the possible courses of action

• Recall similar problems and actions and generalise it to the current problem (Have I encountered a similar problem? How can I use whatever worked on that problem to also be of help in this situation?)

• Do a reasonability check to see if the actual, underlying problem will be solved by this approach. Ensure that you are not just treating the symptoms.

• For mathematical-type questions: what is a ballpark figure? Should my answer go up/down given the circumstances surrounding the problem?

3) When solving problems, use a problem-solving structure to guide you:

• Define the problem accurately (using the techniques mentioned in 4 below)

• Develop solutions (using techniques mentioned in 5 below)

• Choose the best solution considering all the facts and stating all assumptions

• Implement solution

• Evaluate/monitor success to learn from the process and improve your problem-solving skills

4) Defining the real problem:

• Look at the information that you've got. Explore the problem: What, when, where, why, who affected, how could it have happened?

• Recall or study theories or fundamentals applicable to this type of problem.

• Collect missing info (or in exam scenario, state your assumptions about missing info).

• Verify information – check, cross-check, distinguish facts from opinion.

• Solve a simplified version of the problem to obtain a ballpark answer

• Hypothesize what could be wrong with the current situation.

• Brainstorm to guess an answer – recalling past or related problems and experiences.

• Draw graphs or diagrams to help you see trends.

• Present state/desired state: Find solutions to the problem by stating the desired state so that an appropriate path can be found from the present state to the desired state. Every

concern in the present state should be addressed in the desired state. Re-work statements until they match.

• Duncker diagram: also uses present state/desired state technique, but as an alternative, it finds solutions that make it okay NOT to get to the desired state (find ways to make it okay to live with the present state).

• Statement/re-statement: Vary the stress pattern in the problem statement (emphasis on different words)

Substitute terms with something meaning the same thing

Make the opposite statement Change 'every' to 'some', 'always' to 'sometimes', 'sometimes' to 'never' or vice versa

Add or replace persuasive words into the problem statement e.g. 'obviously', 'clearly'.

Express words in the form of an equation/picture.

5) Generating solutions:

• Identify mental blocks and get rid of them by having an awareness and changing your mindset and knowing your work!

• Find ways to improve your creativity e.g.: • Pose new questions to yourself every day and try to find unique solutions; • Keep abreast of your field; • Learn about things outside of your specialty; • Be open and receptive to new ideas; • De Bono's PMI (What are the 'plus', 'minus', 'interesting features' of any statement; • De Bono's 'NO' vs 'PO' strategy e.g. PO products can be sold using only your cell phone. • And his 6 thinking hats to consider different viewpoints: White (facts and figures), Red (emotions and feelings), Black (cautious and careful), Yellow(speculative-positive), Green (creative), Blue (control of thinking)

• For Actuarial Science students - think of all the stakeholders and how they will be impacted.

• Brainstorming – involves an unstructured free association of ideas to solve problems. You should include wild or unusual solutions without regard to their feasibility. In groups, people can build on each other's ideas or suggestions. Do a group mock exam (past paper) and discuss your answers amongst yourselves without looking at the memo before everyone had their say.

• Osborne's checklist for adding new ideas:

Adapt – how can this product/idea/plan be used as is?

What are other uses it could be adapted to?

Modify – change the meaning/material/pricing...

Magnify – add a new ingredient. Make longer/stronger/wider cover etc.

Minify – split up, take out, make lighter/lower/shorter/stricter terms for cover, etc.

Substitute – who, where, what else? Another ingredient/approach?

Rearrange – Interchange parts. Other patterns/ layouts? Change positives to negatives. Reverse roles. Turn backward or upside down. Sort.

Combine – combine parts, units, ideas. Compromise. Combine from different categories.

• Random stimulation – use a random thought or word from a dictionary or book to stimulate a new flow of ideas.

• Futuring – Focuses on generating solutions that are currently not feasible but could be in the future. What are the characteristics of the ideal solution? You visualize the ideal state and work on devising ways to attain it.

• Analogy and cross-fertilization – ideas, rules, laws, facts and solutions of one discipline transferred to another discipline – transfer of knowledge to other situations. 1) State the problem, 2) Generate analogies (this problem is like trying to ...), 3) Solve the analogy, and 4) Transfer the solution to the problem at hand.

• Incubation – stopping active work on the problem and letting your subconscious continue the work.