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What are the Cognitive Elements in Strategic Thinking: A comparative study of students and professionals in Computer Science and Engineering

by

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Abstract

Research Purpose

The concept of strategic thinking is vague in the previous literature, and we lack an understanding of what strategic thinking is. The purpose of this thesis is to contribute towards the understanding of the cognitive elements or components in strategic thinking. To fulfil this purpose, we aim to collect survey and interview data from students studying Computer Science and Engineering at Lund University, and professionals with corresponding majors with several years' work experience in industries.

Research Questions

1. What cognitive elements are identifiable in the explanations of strategic thinking of students studying Computer Science and Engineering?
2. What cognitive elements are identifiable in the explanations of strategic thinking of professionals with a similar educational background with the students?
3. Are there any similarities or differences between the cognitive elements that identified in students and professionals?

Methodology

This study is based on a combination of deductive and inductive approach. Further, this multi-method study involves survey, interview and a computerised text analysis tool- Pertex. In the first step, students studying Computer Science and Engineering and professionals with corresponding majors were asked to write a text about strategic thinking process that leads to an important decision in the uncertain situation. The participants' texts were analysed by Pertex. Afterwards, structured interviews including general and specific questions were conducted among those participants. The interview data were analysed by content.

Findings

For students studying Computer Science and Engineering, analytical, creative elements as well as a new element - iterative are identifiable in their explanations of strategic thinking. Reflective and integrative elements were ranked the most important elements in strategic thinking as the analytical element in interview question two, but were not identified in students' Pertex and interview question one analysis directly.

For professionals with the corresponding majors of students, analytical, creative, flexible, future-oriented, holistic, process-oriented, reflective, synthetic, visionary elements, as well as two new elements - iterative and interactive are identifiable in their explanations of strategic thinking.

Regarding the similarities between students and professionals, the analytical element has been identified as an important element in both students and professionals' explanations of strategic thinking, and the intuitive element has been identified as an unimportant element in both students and professionals. Creative and iterative elements are identifiable in both students and professionals.

Regarding the differences, professionals demonstrate a more complex understanding of many elements in strategic thinking, whereas students have a simplified understanding of strategic thinking, only focusing on a few elements. Flexible, future-oriented, holistic, process-oriented, synthetic, visionary and interactive elements are identifiable in professionals in this study, but not in students.

Practical Implications

This study sheds light on the cognitive elements of strategic thinking identified in computer science and engineering background students and professionals. Further, this study serves as the cornerstone of the ongoing research project on strategic thinking at Lund University School of Economics and Management. Moreover, this study provides value to students and professionals who want to understand and develop their strategic thinking. For organisations, it might be beneficial for universities to develop the curriculum as well as for companies to develop employees' strategic thinking.

Limitations

Our research has identified certain limitations. Firstly, there is little literature on strategic thinking on Computer Science and Engineering. We could also have assessed a wider pool of students and professionals in Computer Science and Engineering if we are not constricted to ten weeks. Further, we only analysed the survey text by Pertex. There is no comparison between different text-analysis tools analysing the same text. We also see this as a limitation. Additionally, even though the clusters are automatically generated by Pertex, there is some degree of subjectivity when labelling the clusters. Finally, the language conducted in the survey and interview in English, which might have some impact on the accuracy in expressing their meaning since most participants are Swedish and Chinese.

Keywords: Cognitive Elements, Computer Science and Engineering, Interactive, Iterative, Strategic Thinking

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1 Introduction

1.1 Background

The digital technology is playing more and more important roles in the world. It has been there for years, but recently they start to affect the society and life more than ever. The famous companies like Facebook, Amazon, Netflix and Google are in our daily lives. For example, many people visit Facebook pages daily especially for younger generations, shopping on Amazon is common today, watching videos on Netflix as well as YouTube, and use google to search the information that would help us, all these are just some examples of these companies mentioned above. Besides those companies, there are also many famous companies that are playing significant roles in our lives, like Apple that brings revolution to the consumer world by iPhone, iPad and Mac; Spotify brings stream music to the users. All these fast-growing companies have one thing in common; their technologies are based on computer science and engineering.

Recently, there is a trend that more and more software focused companies also develop their own hardware business. Due to the need of increasing computation capability in the past years, by more and more people visiting websites or mobile apps, watching videos and listening to music online, the need for making even powerful chips are much stronger than ever. Apple has their chipsets for their devices since a long time ago. Meanwhile, Google started to make its computer chips since 2016 (Metz, 2016), and design their chipset for consumer devices from 2017 (King, 2017), they announced their third version of chips at May 2018 (Novet, 2018). Furthermore, the e-commerce leader Alibaba acquired one chip maker in China last month (Ruwitch, 2018). This trend in the industry indicates a massive need for talents in computer science and engineering.

These technology companies are growing fast and are more influential than they used to be. Many technology companies start to involve into traditional business like the bank, supermarket, automobile and taxi industries by using the artificial intelligence and machine learning. To keep growing, they need to make a lot of decisions, such as should they invest on new technology or not, should they develop new products or not, how to develop on the new product and which direction they should choose. Every strategy made by the senior managers would impact the company, might be good or bad. A right decision could move the company forward, and a bad decision could destroy the company. In the technology companies, many leaders or managers are graduates from computer science and engineering majors and probably started their career as engineers. However, there is few research on strategic thinking in the engineering field despite the importance of strategic thinking. Thus, it becomes fascinating to research what are the

cognitive elements in strategic thinking from the perspective of students and professionals in Computer Science and Engineering.

1.2 Research Purpose

Strategy has been defined as "the alignment of potentially unlimited aspirations with necessarily limited capabilities" (Gaddis, 2018, p.21). From the definition, strategy is about how people align and allocate resources to the future goals. In this sense, strategic thinking is about what people do to align resources against the future goals under conditions of uncertainty and complexity. In this study, we tried to look into what are the essential cognitive components needed when thinking strategically. The purpose of this thesis is to contribute towards the understanding of the cognitive elements or components in strategic thinking.

In the longer perspective, this might contribute towards developing the curriculum in Computer Science and Engineering, for instance, by using all the types of educational material. Moreover, it might also be beneficial for professionals to gain insights to foster strategic thinking as well as provide organisations insights on enhancing employees' strategic thinking. To fulfil this purpose, we aim to collect survey and interview data from students studying Computer Science and Engineering at Lund University, and from professionals of the same major with several years' work experience in industries.

Further, this study is a part of the research project "The Foundations of Strategic Thinking" at Lund University, School of Economics and Management (Kleppestø, 2018). The whole project aims to establish the ground for the further research of validating methods for measuring individual ability and exploring methods for improving the ability of strategic thinking (Kleppestø, 2018). This study will serve as the cornerstone of this ongoing research project.

1.3 Research Questions

As mentioned above, the purpose of this thesis is to contribute towards the understanding of the cognitive elements of strategic thinking. Based on the research purpose, the research questions are as follows:

1. What cognitive elements are identifiable in the explanation of strategic thinking of students studying Computer Science and Engineering?

2. What cognitive elements are identifiable in the explanation of strategic thinking of professionals with a similar educational background with the students?

3. Are there any similarities or differences between the cognitive elements that identified in students and professionals?

1.4 Research Limitations

There are few limitations in this research. Firstly, there is little literature on strategic thinking focusing on Computer Science and Engineering. It is known to us all that literature review is an important part of the research as it helps to identify the scope of works done so far in the research area (Dudovskiy, 2018). Moreover, literature review findings are used as the foundation for researchers to be built upon to achieve research objectives, while the scarcity of literature review makes a more difficult job for researchers.

Secondly, due to lack of enough experience in collecting primary data, there is a chance that the implementation of data collection method is flawed (Dudovskiy, 2018). Moreover, the analytical tool - Pertex was used to analyse the survey answer. Even though the clusters are automatically generated by Pertex, there is some degree of subjectivity when labelling the clusters. We tried to minimise the subjectivity by conducting the labelling by two of us together. Additionally, there is no comparison between different text-analysis tools analysing the same text. We also acknowledge this limitation.

Thirdly, the sample size in this qualitative research is around twenty, due to the time limitation. We do realise that conducting this research in larger sample size could have generated more accurate results even the sample size is not that important in qualitative studies than in quantitative studies (Dudovskiy, 2018).

Lastly, participants in this research are mainly Swedish and Chinese. Most of the participants are Swedish speaking or have studied in Sweden; they are more or less influenced by Swedish culture. It would be better if the participants are from different countries so that the dimensions of nationality can be taken into consideration. Moreover, the language conducted in the survey and interview in English, which might have an impact on the accuracy in expressing their meaning.

1.5 Outline of the Thesis

The thesis is divided into five chapters (see Figure 1.1). After chapter one on the research background and purpose, chapter two is the literature and theoretical review of strategic thinking in general as well as in Computer Science and Engineering. The goal of chapter two is to introduce existing theory regarding strategic thinking and to examine strategic thinking, especially in Computer Science and Engineering. Further, the limitations of current strategic

thinking research, especially the scarcity of research in Computer Science and Engineering, form a motivation for the development of this research.

In chapter three, the methodology of this research was discussed. Mainly focus on mixed inductive and deductive research approach, data collection methods and data analysis methods. Chapter four concentrates on analysing the data got from the survey and the interview. Moreover, the discussions of the data collected would be presented. After that, in chapter five, we sum up major findings of the thesis, and propose issues and provide recommendations for future research. Lastly, there are appendices in this paper which contain the survey question, interview questions, survey texts and Pertex analysis.

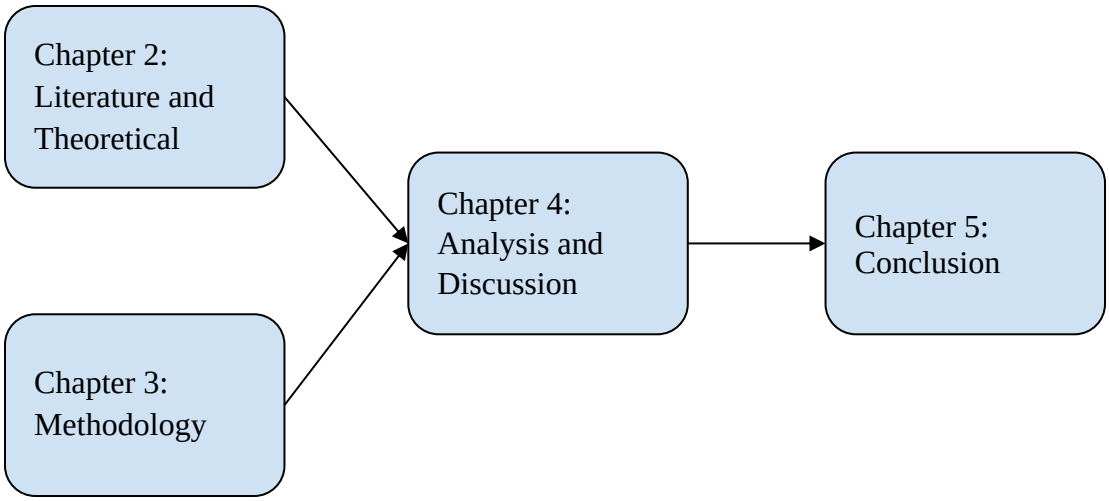

Figure 1.1 Structure of the Thesis

2 Literature and Theoretical Review

2.1 Definition of Strategic Thinking

There are different definitions of strategic thinking; however, to date, there is no agreement on what strategic thinking is. Many of these definitions focus on long-term and creativity. For example, strategic thinking, according to Ridgley (2012), means making use of tools to take actions that will lead to goal achieving, while Haycock, Cheadle and Bluestone (2012) claim that strategic thinking is a tool that would drive an organisation moving, innovating and accomplishing significant improvement in productivity. Moreover, Goldman and Cahill (2009) state that strategic thinking would bring an advantage to organisations even though it is a personal thinking activity. In their view, the purpose of strategic thinking is to find strategies that would bring the organisation to a much better position compared to the current position. Strategic thinking has also been defined as thinking ahead and making the best decisions based on the existing information (Bratianu, 2017). However, other definitions interpret strategic thinking as synthesis with intuition and creativity (Mintzberg, 1994). On the other hand, Haycock et al. (2012) further describe strategic thinking as an innovation and creative thinking process that would lead to solutions to solve challenges. It is clear there is no consensus on a definition of strategic thinking, without a clear definition, it is impossible to identify important factors for people to improve strategic thinking capabilities.

2.2 The Significance of Strategic Thinking

Through the practitioners' literature, an observation is that strategic thinking is necessary and vital for students, professionals and organisations. Ames and Archer (1988) emphasise the importance for students to develop ways of thinking and strategies, which includes strategic thinking to achieve goals in the classroom. Covington (1984) discuss strategic thinking and fear of failure of students. To be more specific, he argues that there are two factors which contribute to the lack of student effort in school: one is inappropriate classroom reward systems, another one is that students fail to develop strategic thinking skills. Further, he emphasises that schools need to provide instruction in strategic thinking to students in order to develop students' overall ability.

Strategic thinking is also very important for professionals, both non-leaders and leaders. De Graaff and Ravesteijn (2001) point out that Shell, a global group of energy and petrochemical companies attaches great importance to young engineers with potential on decision making, innovation and so on. Strategic thinking is one of the abilities that new engineers should possess. Moreover, Goldman and Goldman (2009) propose that strategic thinking ability is an essential requirement of an admired and a sought-after leader. Similarly, Kazmi (2016) also believes that strategic thinking is critical for leaders working on developing new product and innovation as strategic thinking enables leaders to analysis, explore, better understand complicated situations and develop action plans to achieve the best possible solutions. Consequently, learning to think strategically is essential for organisational leaders at all levels-experienced and emerging around the world in order to create and sustain strategic effectiveness (Sloan, 2016).

Strategic thinking is also vital for organisations to be in motion, especially in a contemporary society advancing technologies are setting traditional business methods and models on end, (Bughin, Chui & Manyika, 2010). Moreover, Bughin et al. (2010) also point out that senior executives in organisations need to think strategically to prepare organisations for the continually changing business environment.

2.3 Cognitive Elements in Strategic Thinking

Cognitive elements are given different names of cognitive concepts, cognitive processes or cognitive competencies in the literature (Isen, 1987; Ryan, Ennerling & Spencer, 1982; Singh & Sandelands, 2017). There is no clear terminology. However, we found Singh and Sandelands' summary sufficiently valuable for the purpose to apply again. Although this is not a strict discussion based on a very clear terminology, it is impossible for us in this project to build a terminology. Cognitive element would be used in this thesis to make it easy to understand and consistent.

Singh and Sandelands (2017), two students of Master in Management programme 2016-2017 at Lund University, identified fifteen cognitive elements of strategic thinking in their thesis by examining existing literature of strategic thinking. These fifteen elements predefined by them are analytical, creative, conceptual, divergent, flexible, context-oriented, future-oriented, holistic, integrative, intuitive, process-oriented, reflective, synthetic, systematic and visionary. They argued that if people have the strategic thinking, he or she should possess at least part of these fifteen core elements. The definitions of those elements summarised by them are in Appendix B.

There are several limitations of the fifteen elements by Singh and Sandelands (2017). Firstly, they list the fifteen elements with the sources that supporting those elements, but it does not refer to from which statements they conclude each element. Every reader has his view, besides the elements clearly stated by the authors. For example, they claim that elements such as context oriented, creativity, divergent thinking, holistic, integrative, process-oriented, synthesising,

systemic and visionary can be found from Bonn's (2001) work. However, we only found that creativity, holistic, visionary is clearly stated in the paper, Bonn agrees with Mintzberg's opinion on the element of synthesis, intuition, creativity, and Bonn agrees with Garratt's opinion on the element of process oriented. What's more, it is up to the reader to find out the existence of the element of context-oriented, divergent thinking, integrative, systemic in the paper of Bonn (2001). For example, the divergent thinking to strategic thinking cannot be found in the article of Bonn (2001), but creativity and innovation were mentioned. So, from the supporting sources to these fifteen elements, the connections are unclear.

The definition of systematic summarised by Singh and Sandelands (2017) is almost the same as the definition of holistic by Bonn (2001). The definition of systematic summarised by Singh and Sandelands (2017) is "an ability to examine how different concerns are connected, affect, and influence one another (Liedtka, 1998)". While Bonn (2001) points out that "a holistic perspective requires an understanding of how different problems and issues are connected with each other, how they influence each other and what effect one solution in a particular area would have no other areas". However, Singh and Sandelands (2017) have not stated in the paper why they summarised the definition of systematic from Liedtka.

Singh and Sandelands (2017) claimed that the integrative element was supported by Bonn, Liedtka, Kaufman, and Mintzberg, which may not be right. Mintzberg (1994) states strategic thinking "is about synthesis" and "the outcome of strategic thinking is an integrated perspective of the enterprise" (Mintzberg, 1994, p.108). On the other paper referenced from Mintzberg, it expresses the same opinion on strategic thinking. Liedtka (1998) doesn't define any integrative element in the paper, but only refer to the Mintzberg's opinion that is strategic thinking is a process of synthesising. In the paper of Kaufman (1991), can't find how he connects strategic thinking with integrative, but only mentions strategic thinking "dealing with the corporation as a holistic system that integrates each part in relation to the whole" (Kaufman, 1991, p.69), which is about holistic. Only Bonn argues "that strategic thinking is an integrative process that encompasses a variety of organisational dimensions spanning multiple levels of analysis" (Bonn, 2005), which is also about synthetic. In the four authors referred by Singh and Sandelands to integrative, more authors applying to synthetic than integrative. Thus, we would like to conclude that these two are overlapping and should only keep synthetic in the fifteen elements.

There are overlapping between process oriented and context-oriented too. Process-oriented includes the ability of self-awareness and the awareness of the environment (Olson & Simerson, 2015). Context-oriented refers to the ability to recognise the environment of operation, including individual and organisational (Bonn, 2005). However, Bonn (2005) argues that strategic thinking should be a focus on process orientation to investigate how senior managers set to attempt to understand the complex and ambiguous environment. Further, he points out that strategic thinking is affected by the social context in which an individual operates. In this sense, the overlapping of process oriented and context-oriented is that they both focus on the ability to recognise the environment. Thus, we would argue that those two elements should be combined

into one element as process and context-oriented with the definition of “the ability to recognize and to understand the environment and to be self-aware”.

Furthermore, some researchers hold different opinions on the factors of strategic thinking that are included in the fifteen elements, which may agree to some elements but not to all. For example, Karğın and Aktaş (2012) think strategic thinking contains some essential skills such as analysing, communicational skills, creative and critical thinking, communication skills, interpersonal skills, problem-solving, systems thinking, technological skills, team working and so on. In this case, some skills are not included in the fifteen elements summarised by Singh and Sandelands. Consequently, those fifteen elements need to be re-evaluated.

2.4 Strategic Thinking VS Strategic Planning

Researchers usually like to compare strategic thinking with strategic planning, to make readers understand the meaning of these two concepts and the difference between them. Some people confuse strategic thinking with strategic planning, considering that they are the same, Wilbanks (2007) points out that managers with technical background tend to think strategic planning is strategic thinking and they usually start planning without strategic thinking. In contrast, some researchers separate strategic thinking and strategic planning (Haycock et al., 2012; Abraham, 2012; Horwath, 2012; Goldman & Cahill, 2009; Karğın & Aktaş, 2012). For example, Haycock et al. (2012) state that strategic planning is the appliance of strategy. According to Abraham (2012), Horwath (2012), Goldman and Cahill (2009), the strategic thinking occurs all day as daily activities, it can be used in the strategic planning process, but the strategic planning only happens when required to make the strategy or to do planning. Meanwhile, Karğın and Aktaş claim that strategic planning is “analytic, convergent, and conventional” (Karğın & Aktaş, 2012, p.131) while strategic thinking is “synthetic, divergent, and creative” (Karğın & Aktaş, 2012, p.131). For this research, strategic thinking is different from strategic planning, strategic thinking happens much more frequently, whereas strategic planning only happens when developing strategies.

2.5 Strategic Thinking in Computer Science and Engineering

Despite the importance, there remains a lack of scientific research on strategic thinking in computer science. There is little literature about strategic thinking in this specific field. However, we do find some literature states the importance of strategic thinking for students, professionals and organisations, especially in computer science field. For instance, Faulk (2000) studies the industrial relevance and academic excellence in software engineering. In this article, Faulk

(2000) proposes that strategic thinking addresses the gap between technology and market. Moreover, he also points out that students in software engineering should develop the ability to address strategic goals. It is crucial for students in software engineering to assess, model and implements software engineering procedure that meets with business targets, which can be done by improving techniques to adapt software processes to develop products (Faulk, 2000). Furthermore, he also points out that it is necessary for them to consider how to conduct strategic development. Students in software engineering shall take a long-term view of combining software engineering technology development and improving cost and time to market of products together, which also valid for professionals in software engineering (Faulk, 2000).

Likewise, to be a professional in computer science, one must be able to "see their work beyond their field in a broad social context" (Chan & Stephanie, 2013, p.85). They should also possess strategic thinking ability to connect themselves with business and people from the nontechnical field (Chan & Stephanie, 2013, p.85). Karanja & Zaveri (2012) also address that IT leaders should be equipped with strategic thinking and planning ability, as well as having a good understanding of business operations and processes to integrate people and systems together. The purpose is to reach IT and business alignment to create value for the stakeholders in the organisations. Additionally, Fortino (2012) points out that Chief Information Officers (CIOs) must be able to integrate ideas with what matters to the business and recommend strategies that based on both sides. Strategic thinking will help CIO to combine initiatives with information to achieve organisational success.

2.6 Systems Thinking

Going through the literature review, we did not find many articles about strategic thinking in the field of computer science and engineering, but found systems thinking was mentioned a lot in the literature related to engineering or computer science and engineering.

2.6.1 Definition of Systems Thinking

Arnold and Wade propose the definition of systems thinking after reviewing many pieces of literature - "Systems thinking is a set of synergistic analytic skills used to improve the capability of identifying and understanding systems, predicting their behaviours, and devising modifications to them in order to produce desired effects. These skills work together as a system" (Arnold & Wade, 2015, p.675).

2.6.2 Systems Thinking VS Strategic Thinking

Bonn (2005) claims that systems thinking, as well as creativity and vision, are elements of strategic thinking. Moreover, according to Pisapia, Reyes-Guerra and Coukos-Semmel (2005), there are three strategic thinking skills: reflecting, reframing and systems thinking. Besides, in the view of McClain (2013), there are five strategic thinking competencies: scanning, visioning, reframing, making common sense and systems thinking. From these statements, systems thinking is usually considered as one element, skill or competence of strategic thinking.

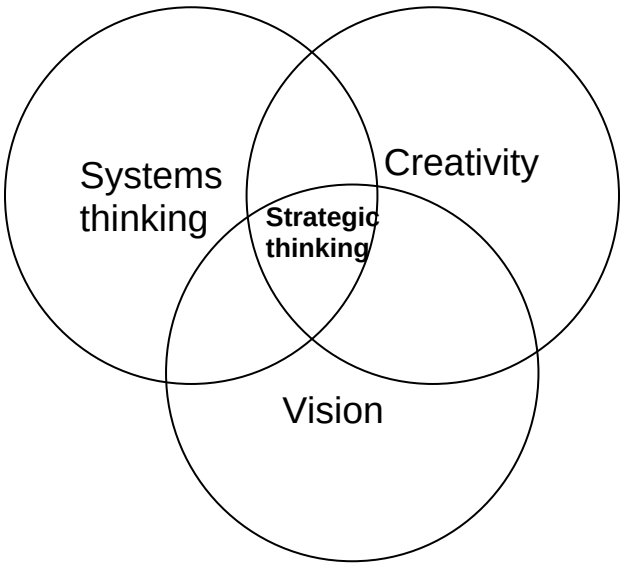

Figure 2.1 Elements of Strategic Thinking (Bonn, 2005, p.340)

From the definition by Arnold and Wade (2015) mentioned above, the key terms in systems thinking are: "systems, synergistic, analytic skills, identify, understand, predict and devise modifications" (Arnold & Wade, 2015, p.675). They make the definitions of key terms:

"**Systems**: Groups or combinations of interrelated, interdependent, or interacting elements forming collective entities.

Synergistic: Characteristic of synergy, which is the interaction of elements in a way that, when combined, produce a total effect that is greater than the sum of the individual elements.

Analytical skills: Skills that provide the ability to visualise, articulate, and solve both complex and uncomplicated problems and concepts and make decisions that are sensible and based on available information. Such skills include a demonstration of the ability to apply logical thinking to gathering and analysing information, designing and testing solutions to problems, and formulating plans.

Identify: To recognise as being a particular thing.

Understand: To be thoroughly familiar with; apprehend the character, nature, or subtleties of.

Predict: To foretell as a deducible consequence.

Devise modifications: To contrive, plan, or elaborate changes or adjustments." (Arnold & Wade, 2015, p.675).

According to the definition of those key terms by Arnold and Wade (2015), and the definition of core elements identified by Singh and Sandelands (2017), the following table was made. There are many similar elements between systems thinking and strategic thinking. We put the elements that have a similar meaning in the same row. For instance, Systems in systems thinking is similar with Systematic in strategic thinking since both are about the relationship between the elements of the system. The analytical element in strategic thinking could be treated part of the analytic skills in systems thinking. Integrative and synthetic are similar to each other about the combination, which is similar to synergistic in systems thinking. "Able to predict" means it should be future-oriented. "identify" is about the ability to recognise, and context oriented is also about it; holistic is about the ability to view as a whole, which is also about to identify. The reflective element in strategic thinking would help to understand the situation, so it is related to the term understand in systems thinking. For the reflective element, although Pisapia et al. (2005) think reflective is one of the strategic thinking skill, we would argue that it does help to understand, so we put it related to the term understand in the table. However, strategic thinking contains more items than systems thinking, those core elements in strategic thinking (visionary, intuitive, creative, divergent, conceptual, flexible, process-oriented) are not reflected in the key terms in the systems thinking mentioned above.

Table 2.1 Elements in Systems Thinking and Strategic Thinking

Key Terms in Systems Thinking	**Core Elements in Strategic Thinking**
Systems	Systematic
Analytic skills	Analytical,
Synergistic	Integrative, Synthetic
Predict	Future Oriented
Identify	Context-Oriented, Holistic
Understand	Reflective
Devise modifications	
	Visionary
	Intuitive
	Creative
	Divergent
	Conceptual
	Flexible
	Process Oriented

2.6.3 The Significance of Systems Thinking in Computer Science

According to Ercan and Caplin (2017), systems thinking would benefit engineers in the big and complex systems, and it is an essential skill for system engineers who work with modern systems that are complex. There are usually large and complex systems in computer science and engineering, either software or hardware. Thus, it is essential for students and professionals in computer science and engineering to develop the systems thinking skills.

2.7 Computer Science and Engineering Curriculum

The student participants are from two programmes of Lund University's Faculty of Engineering. One is a five-year programme, while the other is an international master programme. The reasons for choosing these two programmes is that the students study many similar courses during their studies. When they graduate, many of them would enter the IT industry and do the similar jobs.

2.7.1 Computer Science and Engineering programme

Some student participants are from the Computer Science and Engineering programme of Lund University's Faculty of Engineering. Since this programme is one of the Swedish teaching programmes, only the Swedish-speaking students can apply. According to the introduction of this programme (Computer Science and Engineering, 2015), to graduate and receive a master's degree in engineering students need to earn 300 ECTS (European Credit Transfer System) credits, and students are expected to finish this programme in five years ideally.

This programme train students with computer skills required by the industry, after graduation they should be able to develop IT systems or products with software or hardware (Computer Science and Engineering, 2015). This programme consisted of two parts. The 1st three years are of fundamental education, where students can choose the specialisation in the later two years (Computer Science and Engineering, 2015). From the courses for computer science and engineering programme page (LTH Courses, 2017), these are the following specialisations: Communication Systems, Design of Processors and Digital Systems, Embedded Systems, Images and Computer Graphics, Software, Software Engineering, Systems, Signals and Control.

2.7.2 Embedded Electronics Engineering programme

The other student participants are from the Embedded Electronics Engineering programme of Lund University's Faculty of Engineering, which is an international master programme. According to the programme introduction (Embedded Electronics Engineering, 2017), it is a two

years full-time programme with 120 ECTs credits. The students are from different countries, which is different from the Computer Science and Engineering programme.

This programme trains students' abilities in analogue and digital IC (integrated circuit) design (Programme fact sheet, 2017). Meanwhile, as mentioned previously, there is one specialisation in Computer Science and Engineering programme named as Design of Processors and Digital Systems, this specialisation also focuses on IC design. Compare the courses in the specialisation of Design of Processors and Digital Systems (LTH Courses, 2017) with the courses of Embedded Electronics Engineering (LTH Courses, 2018), found that nine of the twelve courses in that specialisation also exists in the courses of Embedded Electronics Engineering. It proves that there are many courses students from both programmes studies, and this master programme is quite close to the specialisation in Computer science and Engineering programme. "Computer engineering as an academic field encompasses the broad areas of electrical or electronics engineering and computer science" (IEEE Computer Society, 2016, p.9). Thus, this Embedded Electronics Engineering programme can be considered part of computer engineering.

2.8 Deficiencies of Previous Literature on Strategic Thinking

The previous literature of strategic thinking focuses on the business field. The research of strategic thinking in other fields is very little. There are few articles about strategic thinking in the area of Computer Science and Engineering. Further, the practitioners' literature has also been criticised for focusing on singular activities rather than longitudinal process (Porac and Thomas, 2002). Moreover, Porac and Thoma (2002) also point out that the previous literature focuses on decision-making process rather than developers of strategic thinking. Another problem of previous literature is that the elements of strategic thinking are overlapping, and the elements are not clear in strategic thinking.

2.9 Chapter Summary

The literature review has focused on the multidimensional scope of strategic thinking, where different aspects of strategic thinking that are relevant to students, professionals and organisations were considered. We reviewed the various definitions of strategic thinking and the core elements or elements in strategic thinking, while also comparing strategic thinking with strategic planning. We also focused on the literature of strategic thinking as well as systems thinking in Computer Science and Engineering. Finally, we also examined the curriculum in Computer Science and Engineering at Lund University, discussed the deficiencies in previous literature.

3 Methodology

3.1 Research Approach

Regarding the research approach, this research integrated both inductive and deductive research approaches. On the one hand, the text we got from the survey was analysed by an inductive approach. The inductive approach is driven from in the data, in another word, the theory is grounded in the data (Bogdan & Bilk, 1992; Pelissier, 2008; Snieder & Larner, 2009). Additionally, it is from specific to general and used for developing theories (Pelissier, 2008; Snieder & Larner, 2009). The theory in the inductive research is yet to be created, rather than a puzzle that the image has already been known (Bogdan & Bilk, 1992). The survey in this study is an open question, which aims to collect people's description of strategic thinking. We analysed the text without any preconceived notions in strategic thinking, let the data generate theories.

On the other hand, the interview after the survey was conducted by a deductive approach. The deductive approach is driven by theory (Wilson, 2010; Gulati, 2009; Babbie, 2010). Moreover, it is from general to specific and used for testing theories (Wilson, 2010; Gulati, 2009; Babbie, 2010). In the interview, the core of the five interview questions originated from the fifteen elements identified from last years' students' thesis on strategic theory and practice (Singh & Sandelands, 2017), are set out to prove or disprove the hypothesis that prior to this research (Bogdan & Bilk, 1992). In this research, new elements were identified, and the previous theory was tested. Consequently, this research integrates both inductive and deductive research approach.

3.2 Research Design

This research chose the survey research as the research strategy. The survey is the best suitable for this study since it is a method to collect information about people's idea or knowledge of description and comparison (Fink, 2003). We want to know the meaning of strategic thinking from people with a similar education background. Thus the survey is chosen instead of other research strategies.

In the extent of researcher interference aspect of this study, it would use the minimal interference, which means this research would not manipulate or do any simulation, but just let

event happens as it should be (Sekaran & Bougie, 2016). In this study, participants wrote down their understanding of strategic thinking and describe their thinking process when handling uncertainty; then participants were invited to the interview. Thus, for the participants, nothing has been changed or controlled, which is the minimal interference, and would help us get to know their real knowledge about the topic.

This research would be carried out in a non-contrived setting in the study setting aspect. Sekaran and Bougie (2016) claim that study setting is either contrived or non-contrived, the non-contrived setting means the research is done in a normal environment without artificial and events happen as usual, while the contrived setting implies it is artificial. This research does not plan to control or change anything in the environment but wants to know the idea in a normal situation. Thus it is a non-contrived setting. Moreover, the researchers would not conduct any experiments to get any relationship between cause and effect in this research. The non-contrived settings align with the minimal interference mentioned above, according to Sekaran and Bougie (2016), this is named field studies.

The unit of analysis would be individuals. Even though the target participants in this research would be people with a similar background in either education or occupation, the research aims to explore individual's definition of strategic thinking. The final result would reflect a shared understanding of the topic by individuals.

The time horizon of the research should be cross-sectional studies. According to Sekaran and Bougie (2016), cross-sectional study is a study where data are collected only once during the research. Although this research collected data twice from each participant, it is about applying two different collection methods on the same object within a short time, so it should belong to cross-sectional studies. It took more time and energy to collect data, but it provides more data to the research, which would help us understand participants' definition of strategic thinking.

3.3 Data Collection Method

The data collection consists of two parts in this research. At first, surveys were conducted among participants. The survey is an open-ended question about strategic thinking process that leads to an important decision in an uncertain situation in Appendix A. The question for those two groups were same so that results were compared for further analysis. The second part is to collect data by conducting the interview. According to Burgess (1982), interview is one of the methods to collect information. Further, he also points out that interviewing would be beneficial for researchers to probe deeply to discover new clues, and to open up a new dimension of the theory. As this research aims to explore the definition of strategic thinking, it would be beneficial to conduct interviews to get vivid and first-hand data from participants. The interview was conducted after analysing the text by a computerised analysis tool - Pertex (introduced in chapter 3.5).

Afterwards, the interview was conducted as a structured interview, mainly getting to know their ideas on the fifteen elements of strategic thinking. Interviewers would ask the participants the same questions to ensure consistency. The interview consists of five questions, which can be found in Appendix B. The aim to conduct half an hour interview is to validate our interpretations of survey responses. In the first interview question, we tried to explore the important elements or factors in strategic thinking before showing participants the predefined fifteen elements in strategic thinking from literature. As the second and third questions, participants were asked to score the importance of the fifteen elements and which element they use in strategic thinking. In the fourth question, we tried to find out if the Pertex result fits with them. In the last question, we tried to explore if they have read anything about strategic thinking in their work or education. The whole interview would be recorded for the following data analysis.

Concerning interview method, face-to-face interview, telephone and video interview were adopted, depending on the preference of participants. 19 interviews were conducted face to face, four interviews through telephone and one through video because of the distance.

3.4 Sampling

In this study, nine students and 12 professionals, all total 21 individuals participated in the survey. Among the 21 participants in the survey, 20 individuals, except for one professional participated in the interview.

The population of this research is the students and the professionals in computer science and engineering area. The sample frame of students are the students registered in embedded electronics engineering programme, and computer science and engineering programme from Lund University's Faculty of Engineering. The sample frame of professionals are connections from one of us. Consequently, the sampling design is quota sampling, as it is "to obtain information relevant to and available only with the certain group" (Sekaran & Bougie, 2016, p.251), which also requires a response from the participants. Due to limited time and resources, this research aims to have a sample size around twenty in total, which means ideally ten students and ten professionals from each target group.

During the execution, we got help from academic and career coach of Computer Science and Engineering after explaining the research to him. He sent out invitations to third grade and above students in computer science and engineering programme, as well as first-year master students in embedded electronic engineering programme. Around 400 students received the invitation. At last, four of the students from computer science and engineering programme, together with five students from embedded electronic engineering programme, joined the research. Three of them are female, and five are male. In all, nine students replied the survey and took the interview in this research.

Fifteen professionals were selected from our connections. They are working in computer science and engineering area, have an academic degree in computer science and engineering area including electronic engineering. They are Swedish or currently working in Sweden, with five years or more working experience. In total twelve professionals answered the survey. Due to time limitation, eleven participants took part in the interview.

We summarised the background information about the twelve professionals who answered the survey. Three out of the twelve professionals are female, and nine are male. Regarding their jobs, one is an engineering manager, two are project managers, and nine are engineers. Eleven out of twelve participants have worked in Lund or Malmo, Sweden. Further, they are now working at an IT department in various industries such as bank, car, mobile communications, security and traffic. Thus, the sample of professionals has generalizability in this specific field.

3.5 Data Analysis

Researchers need to know what kind of data they collect and based on that researchers analyse the data to achieve the research purpose. According to Sekaran and Bougie (2016), answers to the open-ended questions, transcription of recordings as well as notes from the interview are qualitative data since they are in the format of texts. There are three steps of qualitative data analysis: data reduction, data display and drawing conclusions (Sekaran & Bougie, 2016, p.332). We analysed the survey data by Pertex and the interview data by content analysis separately. In the analysis, S1 to refer to student 1 and P1 to professional 1. The rest was done in the same manner.

3.5.1 Text Analysis Tool - Pertex

Pertex is a computerised text analysis tool to improve text interpretation developed by Perspective Text Analysis (PTA) (Helmersson, 1992; Helmersson & Mattsson, 2001). The Pertex text analysis assumes three functions- intention, action, orientation, which can be reflected when we speak it out or write it down, and the linguistic counterparts appear in the text people provided (Helmersson & Mattsson, 2001).

There are several steps in analysing texts by Pertex. The text material collected will be first coded using a special dictionary (Helmersson, 1992). The dictionary consists of the stem of the verb as well as conjugation of verbs (Helmersson, 1992). According to Helmersson (1992), the English version has around 6000 items.

After that, the text will be designed and divided into different blocks based on the Aa0 (Agent-verb-Objective) paradigm (Helmersson, 1992). By definition, “a block is a set of words or a clause organised around a verb” (Helmersson & Mattsson, 2001). Additionally, according to

Helmersson & Mattsson (2001), a block consists of three parts: agent, verb and orientation. The block consists of the agent, which is the producer of the text and appears before the verb. Further, the block also contains the verb, which is an expression of action used by the agent (Helmersson & Mattsson, 2001; Matsson, Helmersson & Standing, 2018). Moreover, after the verb, the block contains an expression for orientation, which is the target towards which action is directed (Helmersson & Mattsson, 2001; Matsson, Helmersson & Standing, 2018). Consequently, the Pertex structures the text into different blocks, each including the textual counterparts of these functions-agent, verb and orientation. In other words, the combination of Agent-Verb-Orientation forms technical blocks (Matsson, Helmersson & Standing, 2018).

In the third step, if the expression of orientation is missing, PC-system Pertex will generate complete blocks by supplementing suitable Agents and Orientation based on the preceding or the following block in the text (Matsson, Helmersson & Standing, 2018). After the Pertex generating complete blocks, the next step is the generation of a matrix which depends on how agent and orientation are related in the text, which will indicate how the author's intention and orientation are connected in the text (Helmersson & Mattsson, 2001; Matsson, Helmersson & Standing, 2018). Furthermore, Matsson et al. (2018) also point out that the matrix is automatically generated itself. Then the generated O/A-matrix (Orientation/Agent-matrix) will be used in Ward's hierarchical cluster analysis method (Matsson, Helmersson & Standing, 2018). Lastly, the Pertex system will come out with the topological presentation of outcomes (Helmersson & Mattsson, 2001).

In this research, the text got from participants was analysed by using Pertex. The survey is about a topic that is very difficult to get clear answers from the participants. Pertex was selected since it is a useful tool that would help to find out the key messages from the running text and we got help from one of the professors in the school on how to use Pertex.

However, there are also limitations using the Pertex system to analyse texts. The text should be a normal running text with verb included. There will be problems, for instance, there will be no cluster if the text only has bullet points. This tool is good at analysing the text from one person, but it is not easy to get key messages from a group of persons' texts. The labels are given to each cluster, and its merged results are depending on the analysers' understanding of the text, which could be somewhat biased. There are too many steps to execute when analysing the text, which it is time-consuming and can be improved by the tool. It took around one hour to analyse each participant's text. Due to time limitation, we did not use another text analysing tool to do the analysis. Although limitations exist, Pertex completed the job as wished.

3.5.2 Analysis of Interview Data

The interview questions were analysed one by one. Further, interview answers from students and professionals were analysed separately to reach a clear structure. Then we compared the interview data from the two groups in the discussions.

The voice recording app - Otter was adopted to record the interview. After the interview, the conversations were transcribed into text with the help of the application. For the answers of the first interview question, we sorted out each participant's opinion, discussed the elements or factors behind the answers, summarised the findings and checked against the fifteen elements found by Singh and Sandelands (2017). For the answers to the second interview question, the scores from participants were analysed. Based on the scores for each element, the importance of elements was ranked, with the reasons from participants why they think it is important and less important to strategic thinking. The high-ranking elements were reflected in the cognitive styles and the deeper information the data expressed. For the answers to the third interview question, we analysed and sorted the scores about the elements participants used in their strategic thinking, and then compared against with the findings in the second interview questions. For the fourth and fifth questions, participants' opinions were summarised. In all, the analysis results help us answer the research questions and get to know the critical elements in strategic thinking from participants' view.

3.6 Validity and Reliability

A structured interview can help secure validity and reliability. Easterby-Smith (2012) points out that an interview can be structured, unstructured or semi-structured. Many studies show that a structured interview would be able to secure validity and reliability than the unstructured interview, for instance, one of the studies claims that "structured interviews are much more reliable and valid than unstructured interviews" (Levashina, Hartwell, Morgeson and Campion, 2014, p.242). As mentioned in data collection method part, this research conducted one survey and a follow-up interview. The survey and the interview questions were carefully prepared, we asked participants the same survey and interview questions. The interview is a structured interview.

Both the survey and the first interview question are focused on the same topic. According to Sekaran and Bougie (2016), parallel-form reliability measures the reliability by assessing the same group of people with two comparable sets. The survey and the first interview question are comparable sets, which would show parallel-form reliability. The rest of the interview questions are focused on the fifteen elements, get their opinion to the Pertex analysis result of the survey answer, and try to find out are they aware of strategic thinking before involving into this research. Accordingly, the way to conduct the survey and the interview increase the chance of having higher validity and reliability.

There is also challenge in this research that there might be inconsistencies between the Pertex data and the interview data as the mind of the human being is changing overtimes. However, the willingness of participating this research has implications for the validity of the data (Barriball & While, 1994). The way used in this research on validity should be the convergent validity, and convergent validity is verified when the result from different assessments to the same concept is

highly correlated (Sekaran & Bougie, 2016). The analysis results of the first interview question were mapped to the fifteen elements and compared with the scores given by the participants, as both are about the cognitive elements in strategic thinking.

While it is impossible for us to always take control of the environment and circumstances of the research project, the friendliness of the interviewers, the approach and manner towards participants can help in securing validity and reliability of the data (Barriball & While, 1994). This argument is also confirmed by Patton (1990) that the quality of the data obtained during an interview is dependent on the interviewer to some degree. The interviewers make appointments with the participants in advance, asked the same questions with the same order in the interview, to make sure all interviews were conducted in a friendliness environment, that would contribute to the validity and reliability.

However, some limitations might affect validity and reliability. First, the scores got from the second interview question may not always reflect what the participants want to express since different persons have the different understanding of “important” and “very important”. Second, the answers got from the third interview question - the elements participants used in their strategic thinking, may not always be accurate, we cannot measure or validate it. Some elements maybe were applied but not shown in the answer, while some elements may appear in some participants’ responses but not used in reality, based on their understanding of the elements with their activities or thinking process. Third, the sample size is not that big and not randomly selected in the whole computer science and engineering area. Fourth, during the Pertex analysis, we might be biased when naming the cluster generated by Pertex. Thus, we know the limitation, both the low number and the quality of the tool of collecting itself has an impact on the data.

3.7 Chapter Summary

This chapter provided an overview of the multi-methods conducted in this study. This study was conducted with the combination of deductive and inductive approach. Moreover, quantitative and qualitative findings in this study were generated from the various tools, such as survey, Pertex, and deep-interview. Further, structured interview form was adopted to ensure the validity and reliability.

4 Analysis and Discussion

4.1 Analysis and Discussion of Survey Data

The survey data was analysed using Pertex, which can generate the text into clusters. After that, we named the clusters and merged them into a final cluster that represents the meaning of the entire text; it is displayed as **Final Pertex Result** in the following sections. We do realise that there are a number of alternative ways of interpreting the Pertex data, and we lean for the following interpretations because it connects with the original meaning of participants well, and the structure is clear. The original texts from participants are at Appendix C, and the complete Pertex analysis results are at Appendix D.

4.1.1 Interpretation of Pertex Clusters

Interpretation of Students' Pertex Clusters

The below table shows the Pertex results of the nine student participants.

Table 4.1 Pertex Result of Student participants' Text

ID	Final Pertex Result
S1	Make decisions by retrying different methods
S2	Make decisions based on possible solutions' information
S3	Get information, evaluate options, make decisions
S4	Explore unknown stuff, get reliable data
S5	Consider expense and family
S6	Divide problem, priority, search information, make a plan
S7	Review, compare different ways, consider the worst case
S8	Maximize resource, re-evaluate to achieve the goal

S9	Get information, research, have a plan, solve it

The above results are consolidations of the survey student response where more full responses were provided. To better grasp how the final Pertex results were derived at, we chose S3 as an example to illustrate. The original text of S3 is as follows:

I may ask myself what kind of result I want if I need to make a big decision in my life. In this step, I may think about these questions: Benefits I want to get by making this decision, which aspect I should consider the most, the level of the cost I can accept and the drawbacks I may get by making this decision. These can influence the way I treat the problems. Then I may search some information online to see if there is anyone who are in the similar situation sharing their experience. This can help complete the ideas I got in the first steps although their experience may not be informative. If it is possible, I may ask someone that I know in the real life who have the same problems before. After I get enough information, I may have a general understanding of the outcome of the different decision. I should think about the risk if things is not going on well as my expectation, for example, I plan to work in another country, but I fail to get any offer, and if this happens, what will the plan B be. By considering all aspects of different choices and personal interests, I can make the decision at last.

In Pertex, three clusters were generated in S3's text (see Figure 4.1), they are "make decisions, get information", "plan B" and "search information, evaluate and make decisions". In the merger process, the first and second cluster were combined and a new cluster "get information, make decisions with plan B" generated. After that, the third cluster and the new cluster were combined to a final Pertex result of S3 "get information, evaluate options and make decisions".

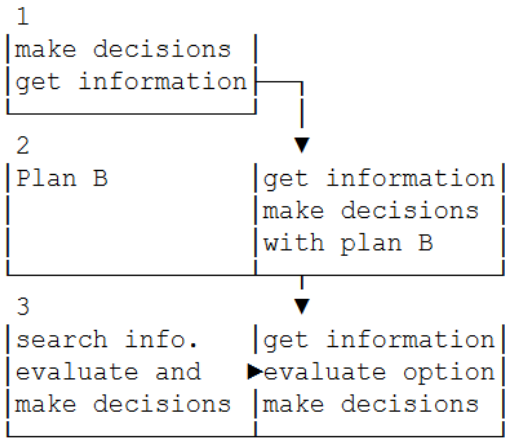

Figure 4.1 Pertex Analysis Result of S3

The primary finding from the students is that they, largely, focus on **analytical** thinking and decision-making process. They focus on gathering information and data, evaluating different options and making plans or decisions in the final Pertex results. When looking at results shared

among smaller numbers of the sample: two students discussed evaluating options; two students discussed making plans; and, three discussed the processes of making decisions. Three perspectives were similar to those expressed for the decision-making process. In this sense, students did not discriminate between either strategic thinking and decision making or between strategic and operational thinking.

Two students focused on retrying different methods and re-evaluation **iteratively** during the process. S1 valued retrying different methods again and again to find the best solutions for solving problems. Similarly, S8 paid attention to continuously re-evaluation during the process to achieve goals.

The results of students from Pertex indicate the use of analytical and iterative approaches for decision-making has been identified in their strategic thinking.

Interpretation of Professionals' Pertex Clusters

The below table shows the Pertex results of the 12 professionals.

Table 4.2 Pertex Result from Professional participants' Text

ID	Final Pertex Result
P1	Glean information, confirm expectation, evaluate the impact
P2	Synchronize with stakeholders, evaluate alternatives, make a plan
P3	Sort out option, get feedback, improve iteratively
P4	Self-aware of circumstances brought by plan
P5	Define vision, long-term goals, milestones, flexible
P6	Take actions, find the best approach
P7	Deal with data, awareness, find solution, decision
P8	Pick quick, safe solution, improve in the future
P9	Collect input, find options, evaluate, decide
P10	Evaluate current and new direction, action on feedback
P11	Analyse data and situation, decide the future path
P12	Get information and resources, communicate with parties

Professional participants paid attention to **analytical** thinking and decision-making process. They attempted to define the goal, collect data, conduct analysis, propose suggestions, evaluate, make decisions and receive feedback, which demonstrates an analytical way with a reason-based approach. For example, P10 analysed the situation, then decided on the future path. Conversely, in the minority P5 focused primarily on defining their vision. Almost every professional's Pertex result reflected the analytical way.

Three professionals included the **future-orientated** perspective of strategic thinking. For example, P5 is aware of the importance of the long-term perspective when setting up "long-term goals". Meanwhile, "improve in the future" from P8's Pertex result and "decide the future path" from P11's Pertex result show that they know the decision made would impact the future. Furthermore, from P4's Pertex clusters, "long-term" is displayed in one of the generated clusters.

Two professionals focus on self-awareness. "Self-aware of circumstances brought by the plan" from P4's Pertex result means the participant was quite self-aware about the impact of the decision. In another case, "awareness" appears in the P7's Pertex result. However, in the final cluster, the word "awareness" was used to replace "self-awareness" due to the word space limit in Pertex. According to the summary of Singh and Sandelands (2017), process-oriented is about the ability to be self-aware. Thus, the word **process-oriented** was used to describe self-awareness.

Further, two professionals emphasised the importance of synchronising or communicating with stakeholders. From P1's Pertex result, "confirm expectation" means discussing with stakeholders to know their expectation. In P2's Pertex result, "synchronise with stakeholders" clearly states the synchronisation is important. Furthermore, P12 would like to "communicate with parties" during the work. The synchronising with stakeholders also means much interaction with stakeholders. Consequently, the word **interactive** was used to describe all these interactions.

Besides those elements mentioned above, **flexible** and **iterative** were both shown in the participants' Pertex result. "Flexible" was part of the P5's Pertex result as P5 emphasised the importance of being flexible when dealing with uncertainty. "Improve iteratively" is part of the P3's Pertex result. It shows iterative element could be identified from P3.

The results of professionals from Pertex indicate that strategic thinking means decision-making process with future-oriented, process-oriented, interactive, flexible and iterative cognitive element involved.

4.1.2 Discussion of Pertex Data

There are both similarities and differences in the way students and professionals understand strategic thinking, and importantly, both share similarities and differences with the conception of strategic thinking found in the literature, particularly Singh and Sandelands (2017).

Comparisons between Literature and Pertex Analysis

Table 4.3 Comparisons of the Elements in Strategic Thinking from Literature and Pertex Analysis

Singh & Sandelands	Pertex (Students)	Pertex (Professionals)
Analytical	Analytical	Analytical
Creative		
Conceptual		
Context Oriented		
Divergent		
Flexible		Flexible
Future Oriented		Future Oriented
Holistic		
Integrative		
Intuitive		
Process Oriented		Process Oriented
Reflective		
Synthetic		
Systematic		
Visionary		
	Iterative	Iterative
		Interactive

**The light orange colour represents the most important element identified in Pertex data. The light green colour represents the new elements of strategic thinking discovered in this study outside of the 15 elements identified by Singh and Sandelands (2017).*

We made comparisons of the core fifteen cognitive elements predefined by Singh and Sandelands (2017) and the Pertex result (see table 4.3). Only four of the fifteen cognitive elements, analytical, flexible, future-oriented, process-oriented were found in the Pertex result. On the one hand, this phenomenon might indicate that the fifteen cognitive elements might need to be revised. Maybe some elements should be removed or replaced with other elements. On the other hand, it might also indicate the participants, especially student participants do not have enough understanding of strategic thinking, which needs further study.

Similarities between Students and Professionals' Pertex Analysis

Both students and professionals attach great importance to the analytical element of strategic thinking. Almost all participants also gave attention to decision-making processes, based on a logical approach. Singh and Sandelands (2017, P.27) summarised that analytical is "demonstrating a logical, reason-based approach". This study confirms that analytical element is a significant element in strategic thinking in Computer Science and Engineering. It may connect closely with their educational background and work specialisation. Students and professionals need to be analytical to develop IT systems and products with software or hardware. Overall, participants have a view of strategic thinking that is heavily analytical (i.e. more like planning), especially for students, the other cognitive elements are neglected or unknown to them.

New Elements of Strategic Thinking: Iterative

The iterative element was also demonstrated in a minority of both professionals and students. One professional and two students have focused on iterative process or approach for continuous optimisation and improvement. Among them, P3 prefers to sort out option, get feedback and improve solutions iteratively during the process. Moreover, S1 values retrying different methods in strategic thinking. Similarly, S8 focus on continuous re-evaluation during the process because it is essential to make sure one stays on track to reach the goal. As iterative thinking promotes continuous optimisation during the process, it could be argued as a new element in strategic thinking.

Iterative thinking as a part of thinking is discussed in the literature. Lumsdaine, Hollander and Lumsdaine (1993) put forward that creative problem-solving processes are cyclic and iterative. Creative problem solving is a framework that needs iterative thinking in the whole brain to achieve the most effective sequence. Chance (2010) stated that by using iterative thinking, problems could be defined over time. Additionally, he urged that university and organisations should provide an environment that promotes critical and iterative thinking. Finally, Plattner, Meinel and Leifer (2011) emphasise that iterative process or approach is a powerful and necessary tool to achieve a desirable, user-friendly and economical solution as well as innovative products and services. Place of iterative thinking within the concept of strategic thinking suggested within the literature is therefore confirmed within a minority of our student and professional samples.

As discussed previously, there is no clear terminology of cognitive elements, cognitive concepts, cognitive components or characteristics. In future work, someone needs to create a sharp or stable terminology. We also realised that further study is needed to understand how iterative fit into strategic thinking as a new element discovered in this study outside of the 15 elements identified by Singh and Sandelands (2017).

Differences between Students and Professionals' Pertex Analysis

However, from the Pertex result, we can see that professionals demonstrate a more complex understanding of strategic thinking than students. Professional but not student participants demonstrated a focus on the future-orientated, process-oriented and flexible elements. The students do not focus on these three elements. An explanation might be that the focus on these elements is developed at work but not in educational settings. Alternatively, it could simply be a matter of experience, that the focus on these aspects comes with maturity developed over time, absent of professional experience.

The observation of professional participants showing more complex understanding of strategic thinking than students might also indicate that strategic thinking can be developed, which needs further study. In the longer perspective, this might also indicate that the importance and necessity of developing curriculum in Computer Science and Engineering towards strategic thinking, for instance, by using all the types of educational material. As demonstrated in the curriculum in the literature review, Computer Science and Engineering programme focuses on training students programming and software engineering.

New Elements of Strategic Thinking: Interactive

Traces of an interactive perspective were found in three professionals' Pertex result. P1 emphasised the necessity to discuss with stakeholders to confirm their expectations. Similarly, P2 paid great attention to the synchronisation with stakeholders and on readiness for dynamic change or get back to a normal situation that supports strategic analysis as early as possible. Furthermore, P12 valued communicating with different parties as well as involve all parties during the strategic thinking process. This might also be connected with their professional background since they normally work together to design products or provide services to customers. Thus, the interaction between different parties is considered vital by at least a minority to achieve desirable and user-friendly solutions and services.

Lundvall (1998) argues that the process of innovative thinking is characterised by the interactive nature. Moreover, Saeid (2001) puts forward that interactive thinking is vital in the design process. He also points out that in order to provide innovative products and services in the contemporary society, a thorough understanding of the demand from all parties and the interaction between different parties is necessary. Even at the organisational level, Normann and Ramírez (1993) have the vision to see that organisational strategy is no longer a matter of positioning a fixed set of activities in contemporary competitive society. Rather, they point out that the organisational strategy should be embedded with interactive thinking to reconfigure roles

and relationships among different actors, for instance, suppliers, partners and customers. The purpose of interactive thinking is to combine different players to mobilise the creation of value. Interactive thinking might be a new yet element in strategic thinking that can be further studied.

The same with iterative, we realised that further study is needed to understand how interactive fit into strategic thinking as a new element discovered in this study outside of the 15 elements identified by Singh and Sandelands (2017).

4.2 Analysis and Discussion of Interview Data

4.2.1 Interview Question One

In the first interview question, we asked participants "what are the important elements or factors in strategic thinking".

Analysis of Students' Answers to Interview Question One

All the answers from students were collected. The below table is the summary of what students said in their answers to this question.

Table 4.4 Students' Answers to Interview Question One

ID	The important elements or factors in strategic thinking
S1	Think free and think out of the box
S2	Logic, and the ability to consider different aspects
S3	Consider all the aspects
S4	Explore the reality
S5	Consider cost, work under pressure and have resources
S6	Form out decisions, break problems down into smaller pieces, categorise different things and put in boxes
S7	Consider which method I implement will benefit the most, compare different methods to solve the problem
S8	A clearly defined goal, gauge available resources
S9	Make a good plan before the start of the actual work

Seven of the participants included the analytical element of strategic thinking in their answer. For instance, S5 and S8 brought out resource as an important factor when thinking strategically. S9 thought that "making a good plan" was important, so that "you know what you are doing and what is your next step to proceed from". S7 stated that "comparing different methods" to "solve the problem" would be the priority, while S6 stated that it was important to "categorising different things" to "understand the problem more", which is also quite analytic. Consequently, **analytical** thinking is an important part of strategic thinking for students as also found in Pertex data. Conversely, S1 and S4 rejected or did not show the analytical element.

One of the participants included the creative element of strategic thinking in his answer. S1 emphasised the importance of "thinking freely" and "thinking out of the box". He also mentioned being "very open in your thinking when connecting the dots from previous experience", which reflects **creative** element in strategic thinking. The Pertex data of students did not reflect a creative element. Conversely, other participants did not show the creative element.

In the opinion of students, making a good plan, gathering information and resources, and considering as many aspects as possible are the priorities for strategic thinking. To a lesser extent, strategic thinking is about thinking outside of the box and thinking freely to find a better solution. Consequently, for interview question one, students hold the view that strategic thinking is a combination of decision-making process involved with the analytical and creative elements.

Analysis of Professionals' Answers to Interview Question One

Table 4.5 Professionals' Answers to Interview Question One

ID	The important elements or factors in strategic thinking
P1	Understand the situation, have a big picture, a helicopter view
P2	Analysis data and synthetic, stakeholder, industry and market
P3	Making trade-off, know what the product vision is, putting completely focus on that instead of going all over the place
P4	Need to think ahead of time, have a plan, have a strategy
P5	
P6	Find all the problem and requirements
P7	Try to get all the relevant facts around and gather as much information as you can
P8	What the requirement is, what is the cost and what's your final expectation

P9	Think ahead, has the foresight; visualise obstacles, find out how to solve them; be logic, creative
P10	Need to force yourself to have check-in am I on the right track, have to reassess what I think is valid
P11	What you are going to decide about, what we are going to do, what you want to see, look some statistics from the past, see the trends of the different timeline
P12	Think through with good vision and at the same time being realistic

* P5 was not interviewed.

Ten of the participants clearly included the **analytical** element of strategic thinking in their answers. For instance, P6 stated that the first need is to "find all the problem that you try to solve", while P7 stated it is important to "gather as much information as you can". P11 pointed out that people need to "look at some statistics from the past", while P12 claimed that "being realistic" is essential to strategic thinking. Conversely, S1 did not include the analytical element clearly. However, most professionals attached great importance to the decision-making processes, which is consistent with the result found in the Pertex data analysis.

Two participants included the **future-oriented** element of strategic thinking in their answers. P4 and P9 stated that it is important to "think ahead", which means being forward thinking.

The **holistic**, **visionary** and **creative** elements of strategic thinking were included in one of the participants separately in their answers. P1 emphasised "having a big picture and a helicopter view" is critical. "A helicopter view" means being able to view things from the top, which is the holistic element. P3 stated "know the product vision" is important, which relates to the visionary element. P9 stated the important factors of strategic thinking are "about logic, creative", which included the creative element.

One of the participants included the **reflective** and **iterative** element of strategic thinking. P10 stated that before making decisions, it is important to "check-in am I on the right track". He also stated that "to reassess what I think is valid" is necessary. "check-in" and "reassess" of the current status demonstrated the reflective and iterative element.

One of the participants included the **synthetic** and **interactive** element of strategic thinking from the answer. P2 stated "synthetic, stakeholder, industry and market trend", which reflects **synthetic** element. Being "synthetic with stakeholder" also indicated interactions with stakeholders, which might demonstrate the interactive element.

In the opinion of professionals, the priorities for strategic thinking are getting to define the goals and visions, have a big picture, and collect data and information from various channels. To a lesser extent, strategic thinking is having a helicopter view, being creative and synthetic,

proposing solutions with focus points, assessing them before making decisions, and reassessing them after decision making to make sure they are still valid.

For professionals, strategic thinking is a combination of decision-making processes with analytical, holistic, visionary, future-oriented, reflective, synthetic, interactive and creative elements, and yet another element iterative involved.

Discussion of Interview Question One

Comparisons between Students and Professionals' Interview Question One's Answers

From the above analysis, both students and professionals attach great importance to the analytical element as well as creative element, but professionals demonstrate a more complex understanding of strategic thinking than students. Besides the analytical element, professionals have demonstrated the element of future-oriented, holistic, reflective, synthetic, visionary, iterative and interactive, while students do not have the trace of the elements mentioned above.

One explanation might be that after graduation, professionals get to develop their understanding of strategic thinking through the implementation of different projects and the interactions with different customers and stakeholders. It may also indicate that they develop their strategic thinking through work experience.

Comparisons among Literature, Pertex and Interview Question One

We also summarised the elements in strategic thinking from the literature, Pertex data and interview question one data to make comparisons.

Table 4.6 Comparisons among Literature, Pertex Data and Interview Question One

Singh & Sandelands	Pertex (Students)	Interview (Students)	Pertex (Professionals)	Interview (Professionals)
Analytical	Analytical	Analytical	Analytical	Analytical
Creative		Creative		Creative
Conceptual				
Context Oriented				
Divergent				
Flexible			Flexible	
Future Oriented			Future Oriented	Future Oriented
Holistic				Holistic

Integrative				
Intuitive				
Process Oriented			Process Oriented	
Reflective				Reflective
Synthetic				Synthetic
Systematic				
Visionary				Visionary
	Iterative		Iterative	Iterative
			Interactive	Interactive

**The light orange colour represents the most important element discovered in Pertex and interview data. The light green colour represents the new elements of strategic thinking discovered in this study outside of the 15 elements identified by Singh and Sandelands (2017).*

From the table, we can see that the analytical element is consistent in literature, Pertex data and interview data. It is reasonably valid to say that analytical element is the most important element in strategic thinking in Computer Science and Engineering. One explanation might be that students sharpened the analytical skills and reason-based approach through their education, especially for those studying engineering.

Professionals have a somewhat more complex understanding of many elements than students who have a more simplified understanding of strategic thinking since they are only focusing on a few of the components explained in the literature. One way of understanding this might be work experience and time allows the development of an understanding of complexity beyond teaching in school. It might also indicate that there are orientations around strategic thinking that can be developed.

Overall, the Pertex data and interview data are relatively consistent. However, there are also some discrepancies. Several elements were identified in the Pertex data but not in the interview data and vice versa. For students, the analytical element was identified in both Pertex and interview, iterative was only identified in Pertex, and the creative element was identified in interviews. For professionals, the analytical, future-oriented, iterative and interactive elements were identified in both Pertex and interview, flexible and process-oriented elements are only identified in Pertex, and holistic, reflective, synthetic, visionary elements were identified in interviews. More of the elements in strategic thinking have been identified in professionals' interview data than the Pertex data. One explanation might be the interview question one does not have that limitation in expressing participants' ideas. Therefore, the future research can

change the way of querying the survey question or modify, refine the survey question, to see if there will be different results and compare those results.

4.2.2 Interview Question Two

In interview question two, participants were asked to score the fifteen elements in strategic thinking summarised by Singh and Sandelands (2017). Participants were also asked to explain the reasons why they give the scores regarding the predefined fifteen elements.

The table 1 and table 3 in Appendix E shows the scores given by students and professionals. We interviewed nine students, and eleven professionals out of a possible twelve participants. The final participant (P5) was not interviewed due to time constraints. The tables would help to understand the importance of each element in strategic thinking from participants' opinion. The average point is calculated by the accumulator score of each element over the number of participants, the formula is:

$$\textbf{\textit{Average point}} = \frac{\textbf{\textit{The accumulator score}}}{\textbf{\textit{The number of participants}}}$$

Analysis of Students' Answers to Interview Question Two

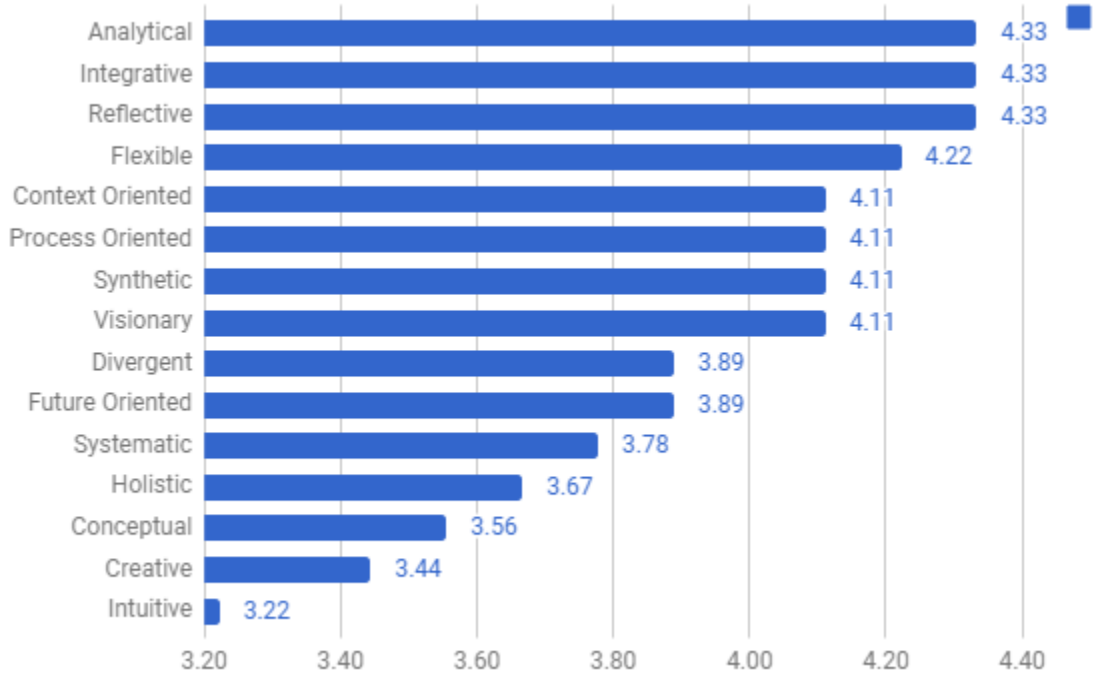

Figure 4.2 Average Points of the Importance of the Fifteen Elements from Students

From the above figure, it is evident that for students, analytic, integrative, reflective are the three most important elements identified in strategic thinking. Then students identified context oriented, synthetic, visionary and process oriented as relative important elements in strategic thinking. Also, it is obvious that students defined divergent, future-oriented, systematic, holistic as relative unimportant elements, while conceptual, creative, especially intuitive are the least important element in strategic thinking. Then it could be questioned why they think analytic, integrative, reflective are the most important elements while intuition is the least important element.

The students gave reasons during the interview to support their voting. Students thought that analytic thinking is the most important because it could lead to them making a better decision or finding a better solution. For integrative thinking, students held the belief that it is critical for people to make better decisions by combining different ideas. For reflective thinking, they argued that reflective thinking would help them to learn from experience and solve problems. One student also pointed out that reflectiveness element is very important in the sense that "it has something to do with the being able to re-evaluate the situation". For the intuitive element, although some students held the opinion that it is effective or important, in relation to intuition, most students argued that "intuition is not reliable". Most of the students gave relative low scores in the intuitive element.

In the cognitive styles tested by the CPP Assessment (Congadev Technical Manual, 2016), analytical style is operational and strategic (mixed) leaning, reflective increases operational thinking, and integrative style is supporting of strategic thinking. Further, in the CPP Assessment, intuition plays an important part in information processing competencies. When students assess themselves, intuition is not a big part of strategic thinking. From the analysis discussed above, students are both combined with strategic aspects and operational aspects.

Analysis of Professionals' Answers to Interview Question Two

The figure shows that professional participants think analytical thinking is most important to the strategic thinking, reflective and future-oriented are the second most important elements, and intuitive is least important to strategic thinking.

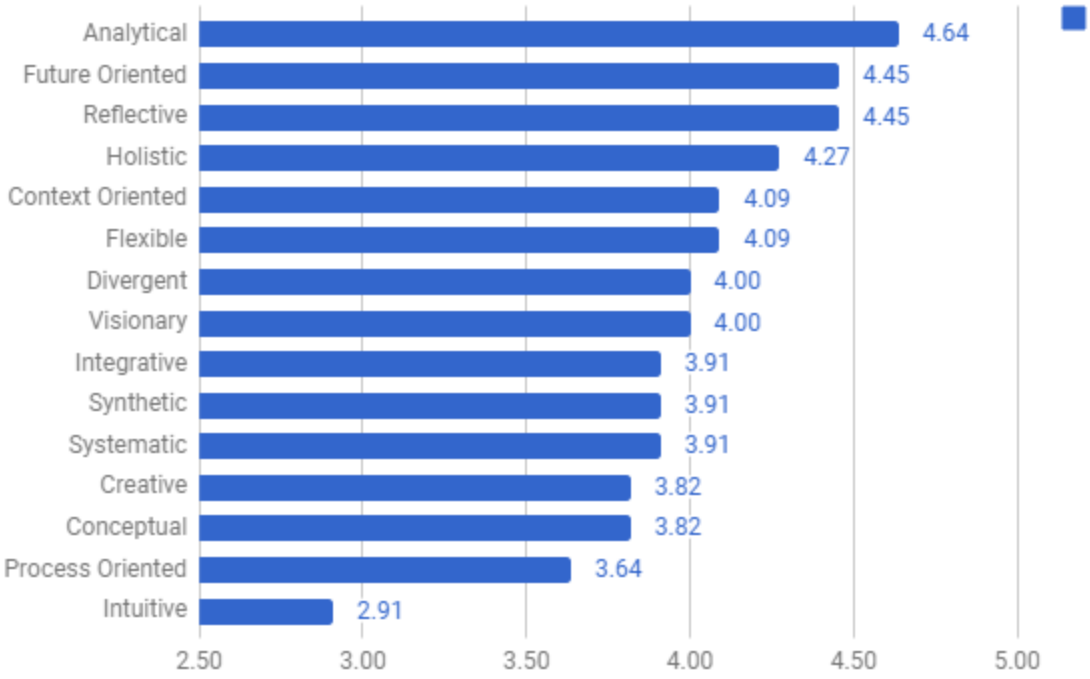

Figure 4.3 Average Points of the Importance of the Fifteen Elements from Professionals

The highest four elements from Figure 4.3 are also reflected in the CPP Assessment model of strategic thinking. The analytical style is operational and strategic (mixed) learning, reflective is more leaning to operational, and holistic style is more leaning to strategic, according to the cognitive styles in CPP Assessment (Congadev Technical Manual, pp.20-23). Although future-oriented is not mentioned or included in any CPP cognitive style directly, long-term orientation is needed when "move from operational to strategic" (Congadev Technical Manual, p.12), so future-oriented can be seen as supporting strategic thinking. Intuition plays an important part in information processing competencies in the CPP Assessment, as has been mentioned in the previous section. However, when professionals assessed themselves, intuitive was the least important in strategic thinking, which is similar to the result from students. The professionals showed a preference for a range of cognitive styles, some of which are considered strategic and some operational in the context of the CPP as with the students.

From the table 3 in Appendix E, only four of the participants gave elements score less than three; the other seven provided scores to all the elements from three to five. In the row of intuitive, it gets score two twice, gets score four once, and receives score three eight times. Some participants explain why they do not think intuitive is essential. They thought training is essential for their work, which against the definition of intuitive. It may also due to their work; they do not need to make a quick decision. Most of the professional participants think the intuitive element is neutral to strategic thinking.

For the analytical element, it is the most important cognitive element to strategic thinking from professional participants, both the scores and the participants' words. However, it may also be

interpreted as the analytical is the most familiar cognitive element to them, but it is uncertain that whether analytical is most important to strategic thinking. The participants may be biased when they answered the survey and gave the scores.

Discussion of Interview Question Two

Integrative and reflective elements were ranked highest with the analytical element by students, but did not show in students' Pertex and interview question one analysis. It may be interpreted as that students were unaware of these two elements before the interview. During the interview, when they read the definition of these elements, they probably started to realise the importance of these elements, giving scores based on their latest understanding of strategic thinking. We would still argue those two elements are important elements from the explanations of students.

The students' average point to the elements are smaller than the professionals, which could mean professionals values those elements more, or professionals give higher baseline scores. The geography of scores distribution of the students is gradual, whereas the professionals have a more complex understanding of elements. However, as the sample number is small, we only conclude that both students and professionals agree analytical is most significant and intuitive is least significant part of strategic thinking.

During the interview, we also found that some of the participants got confused with some elements, think those elements are similar. For instance, process-oriented is related to context oriented, and synthetic is similar with integrative. There are connections between these words according to the definition identified by Singh and Sandelands (2017), and they are likely overlapping in the meaning. For example, in the interview, five out of the nine students and two out of the eleven professionals questioned the difference between integrative and synthetic. It aligns with our criticism of these core elements in the literature review part, and they are overlapping with each other.

As mentioned in the literature review, systems thinking is important to the engineering students and professionals. The interview including the above scores also proves systems thinking is important to them. From the four most important elements in both groups, most of them can be mapped to the systems thinking. As mentioned in the literature review (in chapter 2.6.2), the analytical element is mapped to the analytic skills in systems thinking, and the reflective is related to the key term understand in systems thinking. The integrative element can be mapped to synergistic; while the future-oriented can be mapped to predict, holistic can be mapped to key term "identity" in systems thinking. From the education they have, they get the systems thinking ability to be able to solve the engineering tasks, which affect how they work or study. As most of the participants' work or study do not involve strategy making, so probably systems thinking comes first in their mind when they deal with strategic thinking.

There are some limitations on the data collection in this study. For example, the same element might receive different scores from different persons even though they might value the same in

their mind. So, some elements get a score of four from one person which means the same to another person, even though they score it five. Additionally, it is not possible to be sure that participants understood each element clearly, which might affect the scores provided. For example, the score of intuitive is low, may be due to misunderstanding the definition provided. Participants might give different scores if they were informed intuitive was about trusting the insight. Many people might believe their insight at the end when making decisions, even though they need much static from the past or information to do the analysis. But generally, the data collection is still valid and give us some insight into how people perceive those fifteen elements.

4.2.3 Interview Question Three

In the third interview question, participants were asked to answer which element they use in strategic thinking. The table 2 and table 4 in Appendix E shows the scores of those elements used by students and professionals, for example, the element used by one participant would be marked as score one in the table. From the tables, the average frequency was calculated by the number of participants that use the element over the number of participants, the formula is:

$$\textbf{\textit{Average frequency}} = \frac{\textbf{\textit{The number of participants using the element}}}{\textbf{\textit{The number of participants}}}$$

Analysis of Students' Answers to Interview Question Three

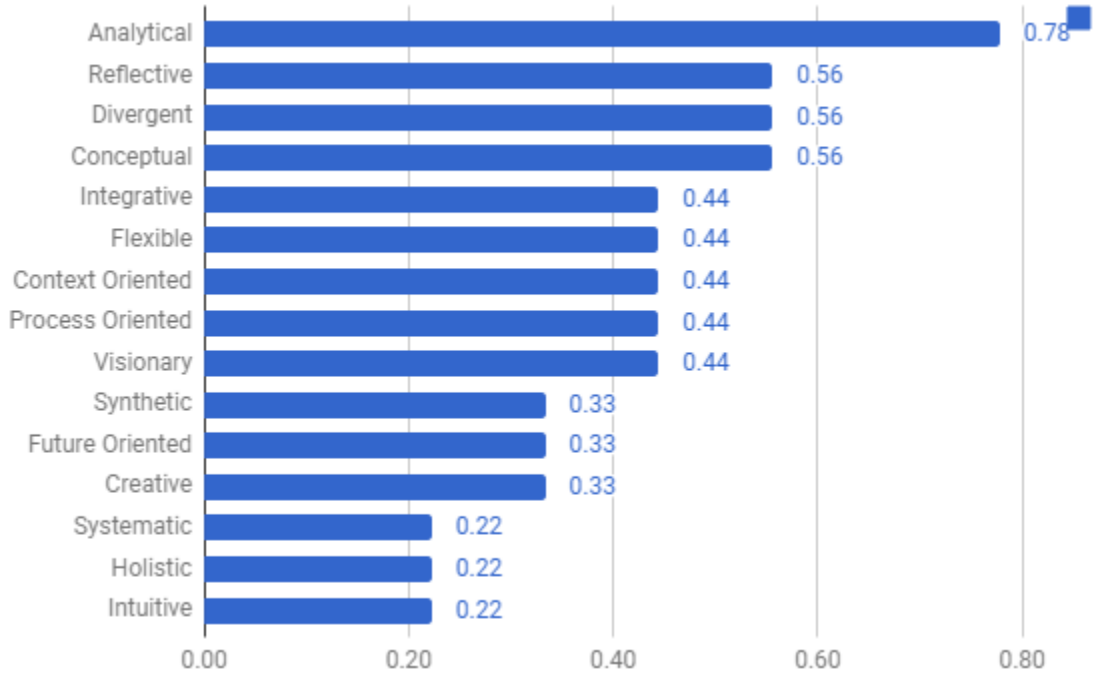

Figure 4.4 Average Frequency of the Fifteen Elements Used by Students

From the Figure 4.4, it is obvious to see that students use analytical the most in strategic thinking, then followed by conceptual, reflective and divergent elements, and visionary, integrative, context-oriented, process-oriented and flexible elements. Further, for students, holistic, systematic and intuitive are the least used elements in strategic thinking. Thus, analytical thinking has been ranked the highest both in the importance of the fifteen elements, and the element used the most in strategic thinking, while intuitive thinking as the least important and the least used element in strategic thinking.

Analysis of Professionals' Answers to Interview Question Three

The participants were asked which element they use in their strategic thinking. To make it easily understood, the table 4 in Appendix E was generated from their answers, the element used by professional participants in their strategic thinking would be marked as one in the table.

Figure 4.5 was generated with the average frequency of each element used by professionals, and its data source is from table 4 in Appendix E. It shows holistic, analytical and reflective are the most used elements in professional participants strategic thinking. After these three elements, divergent, flexible and future-oriented all are fourth most used elements. Intuitive is the least used element in these participants' strategic thinking.

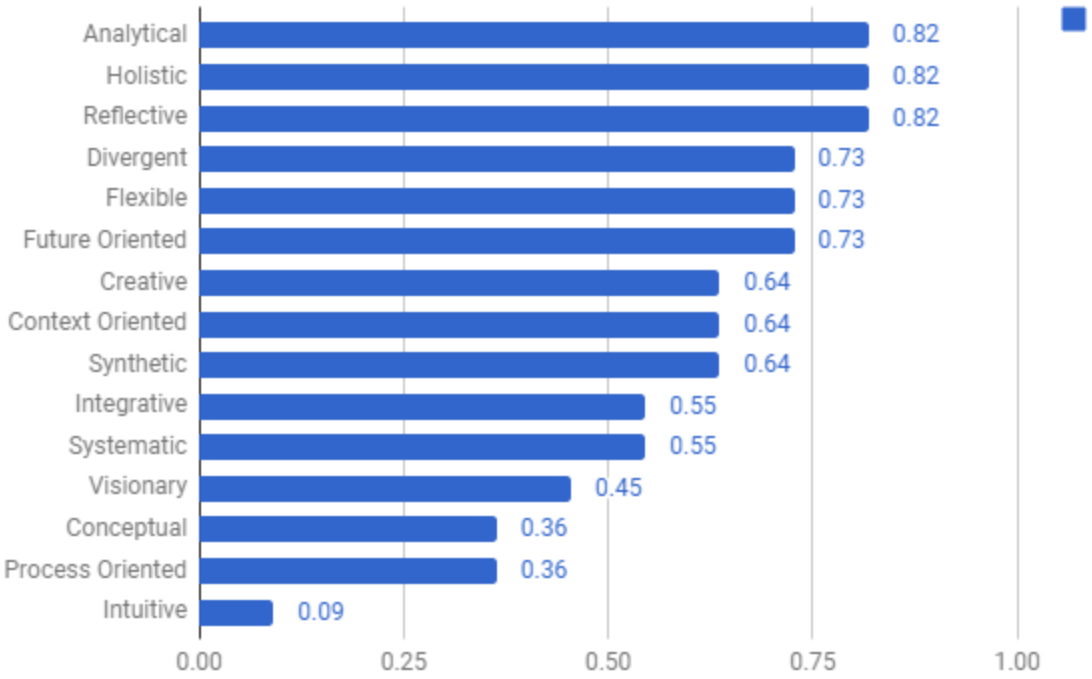

Figure 4.5 Average Frequency of the Fifteen Elements Used by Professionals

Discussion of Interview Question Three

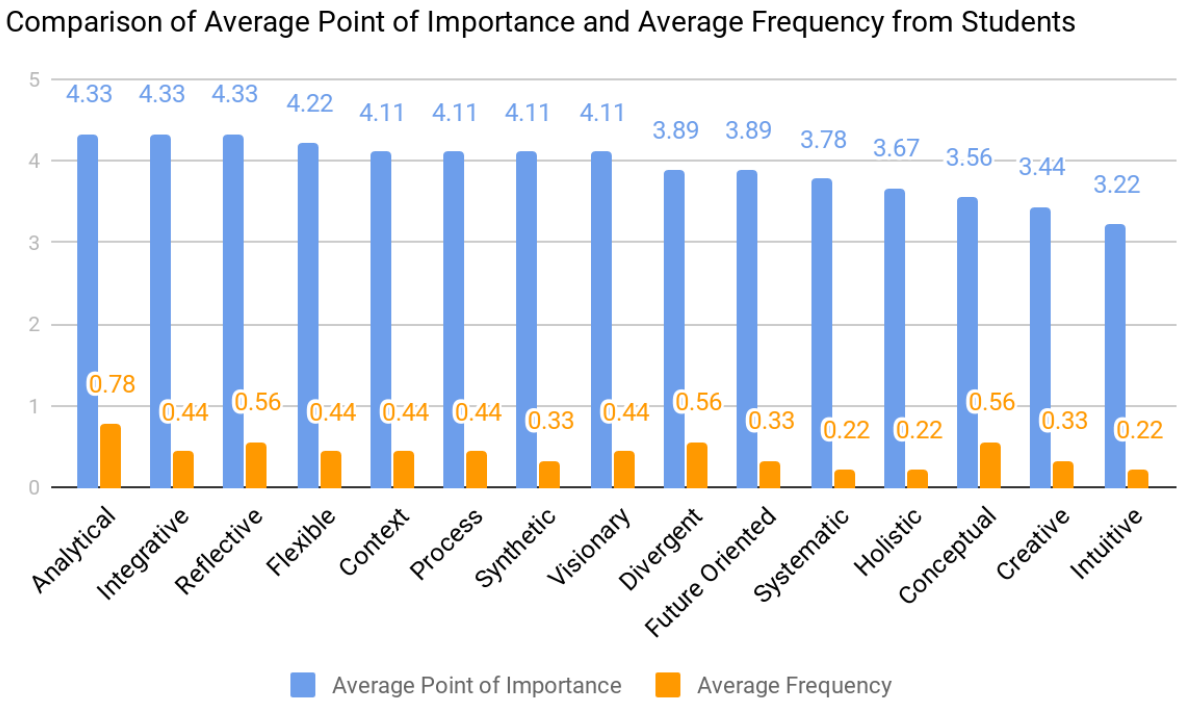

Figure 4.6 Comparison of Figure 4.2 and Figure 4.4

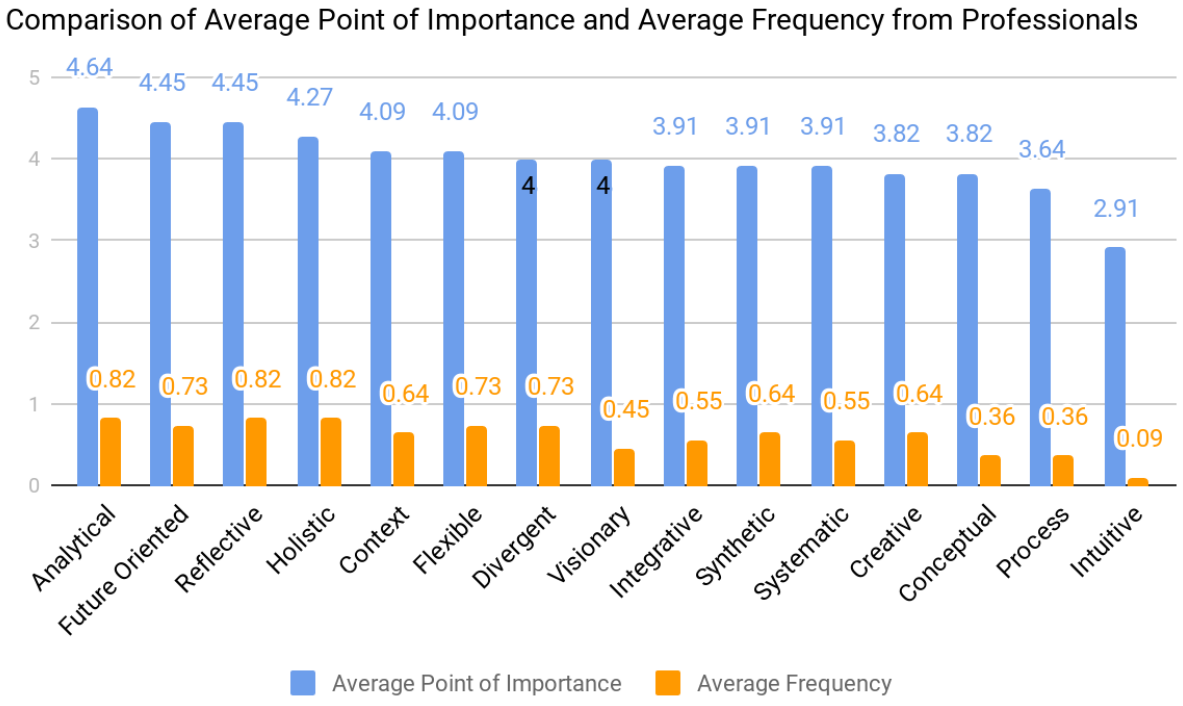

Figure 4.7 Comparison of Figure 4.3 and Figure 4.6

Analytical has the highest score in both groups in the third interview question, while intuitive has the lowest score. It is similar to the result of the second interview question, which can be found in Figure 4.6 and Figure 4.7. Both Figures are the comparison of the scores from the second and third interview question, Figure 4.6 is for students, and Figure 4.7 is for professionals. It most likely means participants are biased, giving the elements they used or familiar with high scores, and the elements they are unfamiliar with low scores.

Looking back the definition of systems thinking defined by Arnold and Wade (2015), we would like to argue that the analytic skills are the most important in systems thinking. Without it, students or professionals in engineering field would not be able to work on their tasks or solve problems. To get a good result or make a good product, they need to be quite analytical during their work or studies. The result from interview question two and three also confirms that they think analytical is most important to them and used most in their daily life.

Professionals also think they use holistic and reflective quite much, as crucial as analytical. Thus, all the most used elements in their strategic thinking are also key terms in the systems thinking. So, we would argue that students and professionals in computer science and engineering have excellent systems thinking.

Compare the result from figure 4.4 and 4.5, we found out that only four elements have average frequency more than 0.5 in figure 4.4, and only four elements have less value than 0.5 in figure 4.5. Students might use several elements in their strategic thinking, while professionals use most of the elements in strategic thinking. It may mean professionals do develop more ability in strategic thinking than students, which also means there is more school can do to improve students strategic thinking ability since it could be developed. On the other hand, strategic thinking is new to most of the participants, the elements they thought has been used in their strategic thinking may not be the same in reality. There are risks that some of the scores to the elements may not be correct, but we did not have any other way to verify it.

4.2.4 Interview Question Four

In order to validate the interpretation of Pertex text analysis, interviewees were asked their opinions about the Pertex result, and the clusters found. Six out of seven students explicitly stated that the Pertex result perfectly reflected what they think about strategic thinking. However, S1 pointed out that “in general it fits quite well”, but “even if it says retrying different methods, my thinking is way outside the box”. Going for to state they would “draw solutions from something completely different” and “draw conclusions from experience, not just in the same field, but different fields”.

All professional interviewees agreed with the Pertex analysis result. They thought it is a good summary of their text about how they define strategic thinking or their thinking process when dealing with an uncertain situation. Overall, the orientations of Pertex data fits with the interview data. As the Pertex tool still has the subjectivity when interpreting the data, it is still necessary to conduct the interview to explore interviewees' meaning and thinking more behind their texts.

4.2.5 Interview Question Five

In the last interview question, we wanted to explore if interviewees have read something about strategic thinking from their education or work. We found something quite interesting. On the one hand, four out of nine students explicitly stated that they had read nothing about strategic thinking from their education, or even had "never heard about strategic thinking before". On the other hand, two students held the opinion that the education has sharpened their strategic thinking. For instance, S6 stated that "I think most studies here at LTH, many courses have given me insight on how to think and I have developed a lot, especially my critical thinking and my planning." Similarly, S9 argued that he "developed the strategic thinking ability through the course project".

It is interesting to see that even in the same or similar programme, different students have different interpretations on the programmes towards developing strategic thinking. But we can also see that students equal strategic thinking with problem-solving, planning and dividing tasks, which is also quite analytical. One explanation of their emphasis on analytical element might be the curriculum, and the design of this programme pay much attention to develop students' analytical thinking.

Most professionals had not read any book about strategic thinking. One read a book about game theory, and another read a book about lean start-ups, both of which had some connections to strategic thinking. Two of them attended education in business school after they have been worked for several years. So, none of them has read a specific book about strategic thinking, and only a few of them know strategy.

Overall, we can see that both the students and professionals interviewed have not had much exposure to strategic thinking literature or popular writing. In the theory chapter, we reviewed that it is important for students, professionals and organisations to possess strategic thinking. Thus, we would argue that universities should develop curriculum to foster students' strategic thinking, especially for the elements we identified in professionals. For organisations, to provide training courses on employees' strategic thinking should be put on the agenda. We also recommend the further research to validate methods for measuring individual ability and explore methods for improving the ability of strategic thinking (Kleppestø, 2018).

4.3 Research Questions Discussion

4.3.1 Research Question One

Which cognitive elements are identifiable in the explanations of strategic thinking of students studying Computer Science and Engineering?

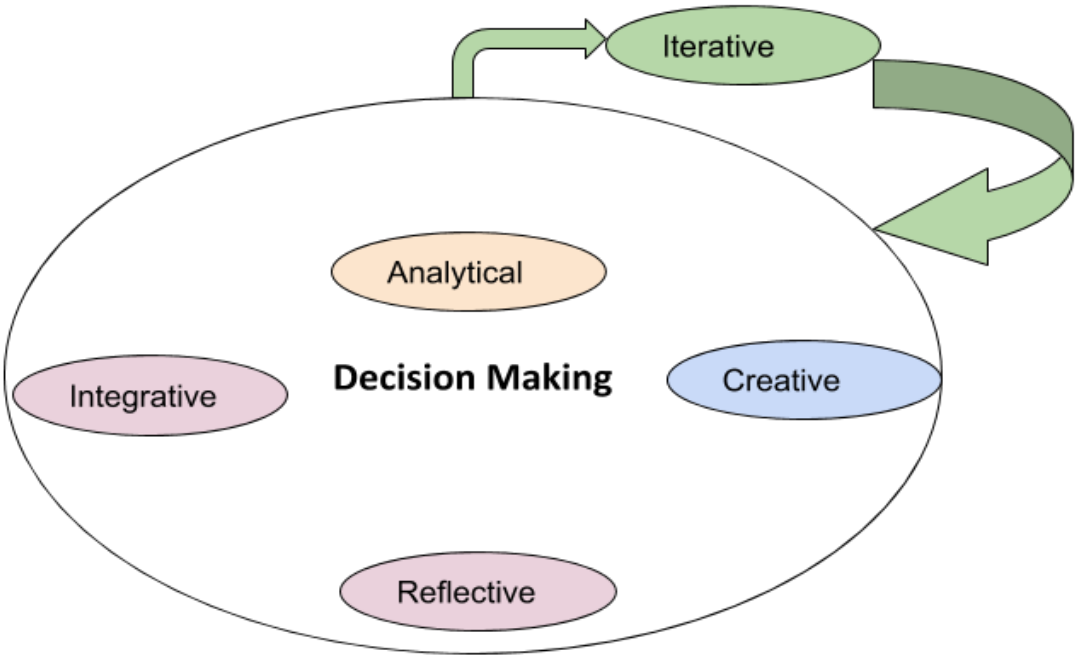

Figure 4.8 Model of Students' Strategic Thinking

* *The light orange colour represents the most important element identified by students. The light green colour represents the new elements discovered in strategic thinking in this study outside of the 15 elements identified by Singh and Sandelands (2017). The light magenta colour represents the most important elements ranked in interview question two as the analytical element, but have not been identified in students' Pertex and interview question one analysis.*

The model of students' strategic thinking was also constructed from the Pertex data and interview question one and two. From the Pertex and interview question one data, it is reasonable to say that the analytical element is an important and frequently used element in students' strategic thinking. Another element of strategic thinking identified by students was iterative from the Pertex data. One explanation might be that students focus on continuous improvement process of problem-solving or decision making to achieve desirable solution, which is also supported by Plattner, Meinel and Leifer (2011). They claim that iterative process or approach is a powerful and necessary tool to achieve desirable, user-friendly and economical solution as well as innovative products and services. Students also identified the creative element as a way to find better solutions or ways to solve problems or complete tasks in interview question one data.

In interview question two, students ranked reflective and integrative elements the most important elements in strategic thinking as the analytical element, while those two elements have not been identified directly from students' Pertex and interview question one analysis. One way of understanding it might be they have realised the importance of those elements, but they lack skills or specify training to combine those elements into practice. But we would argue it is still valuable to put those two elements in the model of students' strategic thinking because of the importance. The intuitive element is not an important element of strategic thinking for students from the ranking.

Further, we found other elements, conceptual, divergent, flexible, context-oriented, future-oriented, holistic, intuitive, process-oriented, synthetic, systematic and visionary have no clear trace demonstrated in students at this study. One explanation might be they have been mainly being immersed in the school environment. Thus, we would argue that the university needs to develop the curriculum, for instance, the teaching material to develop students' other concepts and make them prepared better for their future career.

To sum up, for students studying Computer Science and Engineering, analytical, creative as well as a new element - iterative are identifiable in their explanations of strategic thinking. Reflective and integrative elements were ranked the most important elements in strategic thinking as the analytical element in interview question two but were not identified in students' Pertex and interview question one analysis directly.

4.3.2 Research Question Two

What cognitive elements are identifiable in the explanations of strategic thinking of professionals with a similar educational background with the students?

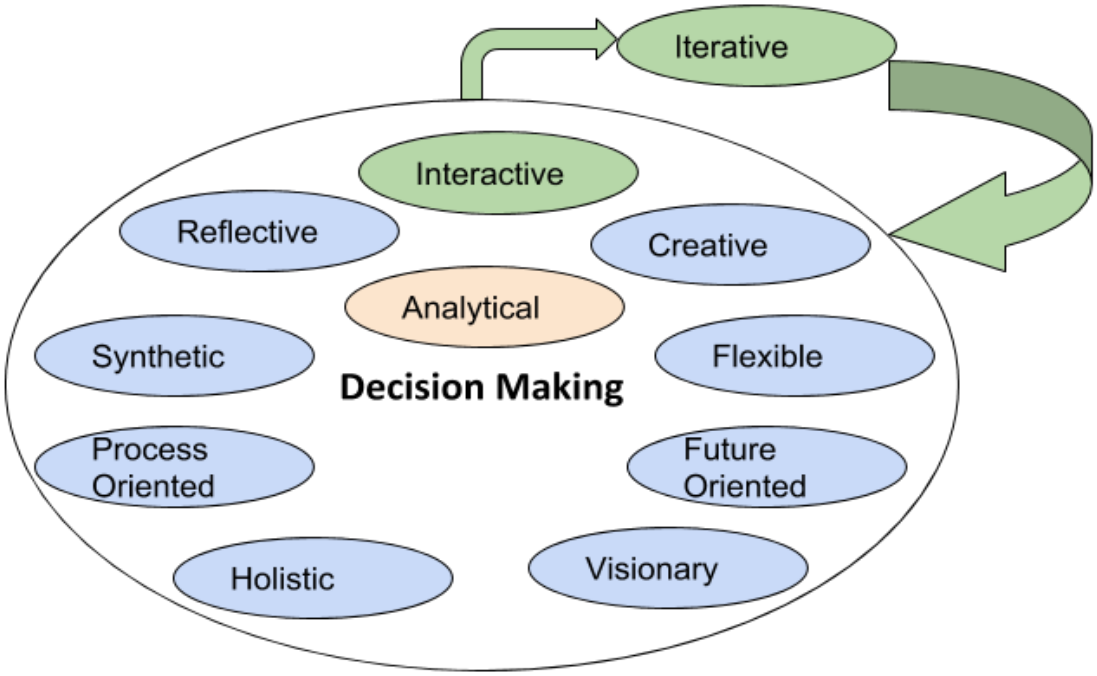

Figure 4.9 Model of Professionals' Strategic Thinking

* *The light orange colour represents the most important element identified by students. The light green colour represents the new elements discovered in strategic thinking outside of the 15 elements identified by Singh and Sandelands (2017).*

The model of professionals' strategic thinking was also constructed from the Pertex data and interview question one and two. First, as has been noted in the discussion of Pertex data and first interview question, strategic thinking means a combination of the decision-making process with analytical, creative, flexible, future-oriented, holistic, process-oriented, synthetic, visionary, interactive and iterative. The analytical is the most critical element to strategic thinking for professionals. Second, from the analysis of the second interview question, the analytical element is the most important to strategic thinking from the ratings and the explanation, while the intuitive is the least important element and neutral to strategic thinking.

This aligns with what professionals in computer science and engineering do in their work. Agile is being applied in more and more organisations, which requires professionals to be flexible and iterative. Innovation is also important in contemporary society, especially in computer science and engineering area. If an organisation does not value innovation, it would be lag behind by other companies. In the engineering field, being analytical, holistic, synthetic is important as well as future-oriented and visionary because professionals want to sustain their solutions as long as possible. Teamwork and cooperation are vital for computer programming, which requires process oriented and interactive elements.

In conclusion, for professionals, analytical, creative, flexible, future-oriented, holistic, process-oriented, reflective, synthetic, visionary elements, as well as two new elements - iterative and interactive are identifiable in their explanations of strategic thinking.

4.3.3 Research Question Three

Are there any similarities or differences between the cognitive elements that identified in students and professionals?

Table 4.7 Comparisons among Students and Professionals

Singh & Sandelands	Students (Pertex & Interview)	Professionals (Pertex & Interview)
Analytical	Analytical	Analytical
Creative	Creative	Creative
Conceptual		
Context Oriented		
Divergent		
Flexible		Flexible
Future Oriented		Future Oriented
Holistic		Holistic
Integrative	Integrative	
Intuitive		
Process Oriented		Process Oriented
Reflective	Reflective	Reflective
Synthetic		Synthetic
Systematic		
Visionary		Visionary
	Iterative	Iterative
		Interactive

**The light orange colour represents the most important element identified in this study. The light green colour represents the new elements discovered in strategic thinking in this study outside of the 15 elements identified by Singh and Sandelands (2017). The light magenta colour represents the most significant elements ranked in interview question two as the analytical element, but have not been identified in students' Pertex and interview question one analysis.*

There are several similarities between students and professionals in Computer Science and Engineering. First, the analytical element has been identified as an important element in strategic thinking, whereas the intuitive element has been identified as an unimportant element in both students and professionals. As discussed previously in the data section, one way of understanding it might be that they need to logical and reason-based to solve problems and complete engineering tasks. The programme they take or took has been focusing on developing analytical skills. However, being too analytical might decrease the sensitivity of intuition.

Second, creative and iterative elements have been found in both students and professionals. Those two elements are both related to achieving a desirable solution in study or work. People need to be creative to find better solutions to different problems or tasks, and people also need to improve the problem solving or decision-making process to the desirable, user-friendly and economical solution as well as innovative products and services.

There are also some differences between the perceptions of students and professionals on strategic thinking. Through the analysis and discussions of Pertex and interview data, professionals demonstrate a more complex understanding of many components, whereas students have a simplified understanding of strategic thinking, they are only focusing on a few elements. Flexible, future-oriented, holistic, process-oriented, synthetic, visionary and interactive elements were identified in professionals in this study, but not in students.

As discussed previously in data analysis and discussion section, their differences might come from work life experience. Work life experience is showing more complexity beyond the student teaching material. Through working on different projects and interactions with different stockholders, they realised that the world requires more of the elements from them. Professionals might develop their strategic thinking through work experiences, which might indicate that strategic thinking can be developed. Whether strategic thinking can be developed could be a topic for further study. Moreover, since students only have a simplified understanding of strategic thinking, we would also argue that universities should develop curriculum to foster students' strategic thinking, especially for flexible, future-oriented, holistic, process-oriented, synthetic, visionary and interactive elements that identified in professionals.

5 Conclusion

5.1 Research Purpose

Strategy has been defined as “the alignment of potentially unlimited aspirations with necessarily limited capabilities” (Gaddis, 2018, p.21). From the definition, strategy is about how people align and allocate resources to the future goals. In this sense, strategic thinking is about what people do in order to align resources against the future goals under conditions of uncertainty and complexity. In this study, we try to look into what are the essential cognitive components needed when thinking strategically. The purpose of this thesis is to contribute towards the understanding of the cognitive elements or components in strategic thinking.

In order to fulfil this purpose, we collected survey and interview data from students studying Computer Science and Engineering at Lund University and professionals with the corresponding majors in industries. In total, nine students and 12 professionals, 21 individuals participated in this study. Various tools, survey, structured interview and text analysis tool - Pertex are involved in this multi-method study.

5.2 Research Questions

Research Question One: What cognitive elements are identifiable in the explanations of strategic thinking of students studying Computer Science and Engineering?

Conclusion: For students studying Computer Science and Engineering, analytical, creative elements as well as a new element - iterative are identifiable in their explanations of strategic thinking. Reflective and integrative elements were ranked the most important elements in strategic thinking as the analytical element in interview question two, but were not identified in students’ Pertex and interview question one analysis directly.

Research Question Two: What cognitive elements are identifiable in the explanations of strategic thinking of professionals with a similar educational background with the students?

Conclusion: For professionals with the corresponding majors of students, analytical, creative, flexible, future-oriented, holistic, process-oriented, reflective, synthetic, visionary elements, as

well as two new elements - iterative and interactive are identifiable in their explanations of strategic thinking.

Research Question Three: Are there any similarities or differences between the cognitive elements that identified in students and professionals?

Conclusion: Similarities - the analytical element has been identified as an important element in both students and professionals' explanations of strategic thinking, and the intuitive element has been identified as an unimportant element in both students and professionals. The creative and iterative elements are identifiable in both students and professionals.

Differences - professionals demonstrate a more complex understanding of many elements in strategic thinking, whereas students have a simplified understanding of strategic thinking, only focusing on a few elements. Flexible, future-oriented, holistic, process-oriented, synthetic, visionary and interactive elements were identified in professionals in this study, but not in students.

5.3 New Elements of Strategic Thinking: Iterative & Interactive

Iterative and interactive are two new elements discovered in this study outside of the 15 elements identified by Sandelands and Singh (2017). Further study is needed to understand how these elements fit into strategic thinking. There are some interesting follow-up questions for iterative and interactive thinking that could be pursued in future studies. Most professional participants are engineers or first-line managers in this study, how do managers at different levels perceive iterative and interactive thinking? Are they included as personal preference or essential elements?

One of the research purposes of this study is to develop the curriculum of Computer Science and Engineering. If iterative is indeed an essential element in strategic thinking, the programme should add iterative approach to programming design course or software planning module. Agile iterative courses could be more useful as agile development becomes one of the popular trends in IT industry. Similarly, the interactive element of strategic thinking could also be embedded into the programme by involving students with big projects that need cooperation, communication, interaction with different parties, stakeholders or even people outside the field. Launching communication courses specially designed for Computer Science and Engineering students could also be beneficial. Those modifications or changes in the curriculum could help students equip better with strategic thinking and adapt in advance to achieve a desirable, user-friendly and economical solution as well as innovative products and services in their future jobs (Plattner, Meinel & Leifer, 2011).

5.4 Practical Implications

This research is a pioneering attempt to find out the cognitive elements of strategic thinking in Computer Science and Engineering. This study will serve as the cornerstone of the ongoing research project on strategic thinking at Lund University School of Economics and Management as well as providing a reference for further research.

Moreover, for individuals, this study provides value to students and professionals who want to understand and develop their strategic thinking. For organisations, it might also be beneficial for universities to integrate strategic thinking into the courses and develop the curriculum. It would be also beneficial for companies to hire and develop their employees, especially for them to take measures to improve strategic thinking of employees, for instance introducing training courses on strategic thinking.

5.5 Further Research

This study is the starting point of an ongoing research project. Thus, it would be interesting to compare the results of this study with other studies conducted in law and marketing so far. Moreover, it could be beneficial if more majors could be involved to explore broader the element of strategic thinking. The future research could also assess a wider pool of students and professionals in Computer Science and Engineering. This study involved 21 participants due to time limitation. We also recommend the future research to conduct similar studies in different universities to see if there are any differences.

Moreover, we designed the survey question mainly as describing the strategic thinking process that leads to a decision in the situation when they need to think strategically. Therefore, the future research can change the way of querying the survey question or modify, refine the survey question, to see if there will be different results and compare those results. Further, we used the Pertex tool to analyse the text. There is also subjectivity in the Pertex analysis since we need to label the clusters. Therefore, the future research would also be recommended to use other text analytical tools to compare different outcomes from the same texts.

Finally, this study has explored two new elements of strategic thinking- iterative and interactive elements. Further study is needed to understand how these elements fit into strategic thinking. It could also be beneficial if follow-up studies could re-examine reflective and integrative elements, and even explore future the elements of strategic thinking.

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Appendix A: Survey Question

You find yourself in an uncertain situation where you have to solve a problem/make a decision in your company/daily life that is of high importance and impacts performance. The data available is not reliable and the circumstances are unknown.

This is a situation in which you need to think strategically. How would you define this kind of thinking? Describe your strategic thinking process that leads to your decision to someone that is not involved in the situation.

Instructions

If possible, please provide your answer as detailed and specific as possible in a running text (no bullet points or similar). We do not aim to give you a minimum or maximum word count, so write until you feel you have covered the topic and have given a proper answer.

Appendix B: Interview Questions

1. In your opinion, what are the important factors or elements in strategic thinking?

2. In one previous study, researchers list the following elements that are important to strategic thinking. On the scale from 1-5, how important it is in strategic thinking? 1 is not important at all and 5 is very important. And why do you think so?

Element	Definition	Point
Analytical	Demonstrating a logical, reason-based approach	
Creative	Searching for new approaches and envisioning better way of doing things	
Conceptual	Forming ideas or concepts to provide answers to experiences, observations etc.	
Context Oriented	The ability to recognize the environment of operation	
Divergent	The ability to think in a different manner or ways	
Flexible	Displaying adaptability, able to handle change	
Future Oriented	Being forward thinking	
Holistic	Realisation that a scenario must be viewed as a whole, rather than within separate parts	
Integrative	The ability to combine concepts, thoughts, or ideas	
Intuitive	The ability to react instinctively	
Process Oriented	The ability to be self-awareness, and aware of the wider environment	
Reflective	The ability to draw upon and learn from past experiences	
Synthetic	The ability to synthesize (blend) ideas, information, or processes	

Systematic	The ability to examine how different concerns are connected, affect, and influence one another	
Visionary	The ability to convey a sense of direction, and provide a focus for all activities in an organisational context	

3. Which element do you use in your strategic thinking?

4. We analyzed your text by Pertex, and we saw these clusters, what do you think?

5. What have you read about strategic thinking from your work or education?

Appendix C: Survey Answer

Students 1:

When I find myself in a position to make a decision based on unreliable data and where the circumstances are unknown, I try to make decisions based on previous experiences. If the decision in question needs to be made very quickly, I tend to make my decisions based on my gut feeling. In this case, I can't immediately analyze my reasoning, mostly due to it being based on internalized knowledge.

On the contrary, when I have plenty of time to make my decision, I take my time to compare the situation to previous situations that I personally have experienced or that I know the results of. During this comparison phase, I search for similarities between the task at hand and experienced task with regard to operational factors such as available resources, process restrictions, desired results, and time frame. As I look at similarities between the current and experienced tasks at different stages, I might draw the conclusion that minor steps of a solution

method I know of might be applied at some stage of the current task. I might also decide that reusing a known solution in full might be the best answer.

When I have identified previous experiences that match the known conditions of the task at hand, I implement the most promising solution. If I get immediate output from performing the task in the chosen manner, I compare the results to the results of known experiences. If the result of the chosen method led to a poor result and if the action can be retried, I adjust my method and make another try. If the action cannot be retried immediately, I evaluate the results and retry the action when it is possible to do so. Finally, if the action cannot be retried anymore,

I just note the results of the chosen action.

Student 2:

First I will list all the possible decisions. Then I list all the possible results to each decision. And I list possible influence to me, my mom, my grandmother, my dad, and my friend about money, mental, and relationship. Then I organize plan 1 which i prefer, plan 2, plan 3...I prepare everything although some will have bad influence to other people and make decision until last minute. I tell myself never regret.

Student 3:
I may ask myself what kind of result I want if I need to make a big decision in my life. In this step, I may think about these questions: Benefits I want to get by making this decision, which aspect I should consider the most, the level of cost I can accept and the drawbacks I may get by making this decision. These can influence the way I treating the problems.

Then I may search some information online to see if there is anyone who are in the similar situation sharing their experience. This can help complete the ideas I got in the first steps although their experience may not be informative. If it is possible, I may ask someone that I know in the real life who have the same problems before.

After I get enough information, I may have a general understanding of the outcome of different decision. I should think about the risk if things is not going on well as my expectation, for example, I plan to work in another country but I fail to get any offer, and if this happens, what will the plan B be.

By considering all aspects of different choices and personal interests, I can make the decision at last.

Student 4:

If I am leader of some companies or enterprises, the first thing that I will think about is cost when I making a decision under a unclear situation. As the material mentioned, the database is unreliable for me. Therefore, the first thing I need to do is thinking about where can I get the reliable data. This situation maybe cost me a lot, so I will try to cut the cost of the after work.

For unknown circumstance, the better way to explore is using the nepotism. The leader will always have some people he or she can trust the most. If I am under this kind of case, I think the best way is using the followers to explore the unknown stuff and also, this is an effective and safe way.

Student 5：

First of all, I will consider my expenses, because i have no very strong economic ability right now. Therefore, after determining that the difficulties I encountered will not cost money beyond my ability, I will continue to consider the second case - family. after I make this kind of decision, if it have a great influence on my family, I think I still don't want to do it. Finally, I'll compare the time and money i spent with what i get after i done this，if the repay is enough then i think i can do it.

Student 6：

This is a question that has no specific answer in my mind; it all depends on the situation. Is it a personal obstacle? Is it work/school related? Is it urgent or do i have a long time to think about the problem at hand? What will happen if I don't succeed? These are all questions that will change the awnser greatly.

The first thing I do when faced with an important or big problem is to digest it, put it into categories and, if possible, divide it up in a few smaller problems. I have found that personal matters is not as easy to divide into smaller pieces as work/school related problems is.

I very much like to think for myself when dealing with more personal problems. It feels as if there are certainly many wrong things I could do with not nearly as many right things. Also, the solution to the problem is often not something you could easily find online, though it might give some guidance. With enough time, though, these seem to mostly work out in the end.

With work/school related problems, I much prefer working with a small group though. If I feel stressed I often feel better knowing that I'm not alone in working on the problem. I still like working alone though and some tasks requires it. With these kinds of problems there is often more answers to be had online, but if i find myself in a situation without clear answers I might turn to brainstorming/thinking of possible solutions. The risks and consequences of failure for these problems seems to often be more direct or straightforward.

I would define this kind of problem as intense thinking where you might not always find the right answer, or the answer you/others were looking for. But where if you have a "game plan" you can at least make it easier for yourself.

Student 7：

Firstly, I will review the issue comprehensively in my mind, then I will list several ways to solve this problem. Comparing different methods with each other, and the most important thing is that I will consider the worst case in the process. Finding the right way to deal with it simultaneously. After these I will choose a proper way to implement. Furthering, I think a reliable database is necessary for a company.

Student 8：

A situation in which the circumstances are unknown and there is a lack of reliable data is of course a more difficult situation than one where much us known, but the approach which one would take to formulate a strategy with which to solve a problem or make a decision does not differ that much from any other scenario.

To use a strategy to solve a problem means to make use of available resources in as an effective way as possible to achieve certain goals. As such, defining the goal or goals should always be the first step. Stating the goals one have in as a precise and specific way as possible is of vital importance, as it of course is impossible to progress without knowing towards what one is striving.

With a goal defined, taking stock of the available resources would be the next step. Even if there are a lot of unknown factors and circumstances regarding the problem, a lot of things can be divined when a well defined goal has been set up. For example, which actors will be affected, and in what way, by the reaching of this goal? Answering such a question can provide information about who you might cooperate with and who or what might oppose the solving of the problem. With unreliable data and uncertain circumstances, finding partners to work with can often be key. Resources could could also mean different tools that can help, both material and

immaterial ones. This may include physical tools such a machine, a source of knowledge or even a concept.

With a defined goal and known resources, the next step would be formulating the actual plan where the resources at one's disposal is put into action to reach the goal. The specifics will vary according to the problem or decision. For example, if the scenario involves making a decision where data is unreliable and circumstances unknown, an effective use of resources would try to mitigate the problems caused by this lack of information, and maximize the usefulness of information one actually have. If the scenario involves solving a certain problem, the use of resources would be planned so that the problem would be solved in as good a way as possible.

Another important part in approaching a problem in a strategic fashion is to be observant of feedback. If the problem solving process allows for it, it's often good to incorporate feedback and new ideas one encounters on the way. The first approach that appears might not be the correct one, and it is often worthwhile to take pause and take stock of the available options along the way. Continuous re-evaluation is important to make sure one stays on track to reach the goal. In the same way, making use of knowledge gained in the past is also important. Learning from ones mistakes and from what has worked in the past can also be key to formulating and executing a successful strategy.

In summary, I think sound strategic thinking can be seen as composed of:

Clear statement of the goals, taking stock of available resources, plan the use of available resources, continuous re-evaluation.

Student 9：

When approached with a problem of which I lack understanding, I always try to gather as much information as possible about the problem. After that I try to understand the problem until I feel somewhat comfortable about it. If I still feel unfamiliar with the problem I do some more research until I feel familiar enough about it. When solving a problem it is also important to have a concrete plan for the process.

Professional 1：

Firstly, I will try to understand the current situation that I am in, such as the involved teams, stakeholders, if it is internal or externals, and confirm the due date for decision making. Then I would like to get a bigger picture and see if my decision would contribute to other bigger goals by talking to upper management and understanding their expectation. Once I evaluate the importance and impact of my decision, I will get started to glean information for my decision making and also maybe use the unreliable data for reference.

Professional 2：

Strategic thinking in my opinion is to involve stakeholders to:
1. understand the current situation;
2. position to-be target (must do, good to do, least to do) as well as related requirement such as max acceptable cost etc.;
3. analyze, evaluate and select alternatives;
4. then specify how to get there.

The question “The data available is not reliable and the circumstances are unknown” removes the necessary condition to make strategic decision, in my opinion.

In such situation, I would suggest to firstly clarify with stakeholders about the priority of this decision based on not only impact but also urgency, secondly agree about the deadline of decision, thirdly make plan to finish above steps. Sometimes it is not ineffective to take one step back, on-hold is an option of decision too.

But if a decision must be rushed in an extreme urgent situation without time to go through the steps, I would suggest to split in small parts one by one instead of big bang if possible, go for the alternatives with least impact/risk and fastest to correct, meanwhile synchronize with stakeholders to be ready for dynamic change or get back to normal situation that supports strategic analysis as early as possible.

Professional 3：

I'm not so sure if what I do can be called strategic thinking. But here it is anyways.

I see life as an iterative process of trial and error.

When I'm faced with a tough decision to make, I lay out my options and and sort them in order of how much it's under my own control: 1) completely 2) partially 3) not at all.

I try not to get into situation 3 at all in life generally.

And most stuff falls into category 2. Here, for parts that are under my own control, I find ways to act out to improve my chances - act out and see what feedback I receive and then improve upon it; I do this iteratively; I also try to take as small an action as possible each time to avoid causing extensive damage.

The more feedback I get, the easier it is for me to access situations and therefore to make decisions.

Professional 4：

I will try to understand the problem and its impact on my life or professional career. I will start thinking, is this a short term problem or long term problem.

If it is a short term problem for example the money crisis or the specific work issue which will be lost in few weeks to few months. I will make a plan to get the money arrangement by taking loan from the bank or friend or if it is a work issue, I will try to discuss with the related people to address it in a good way.

if the problem is long term problem or it will lost for few years, then I will start thinking about long term approach to solve the problem in an iterative way, having a plan for 6 months, one year, and two years. I will think about the problem as what will be its impact in 2 years time or 5 years time.

Regarding uncertainties, I will try to make some moves and see if there are any uncertainties that become clearer.

In the case of any data available but not reliable then the first step will be to validate the data or the reliability of the data. We are living in a dynamic world where the circumstances are changing all the time, I always try to be self aware of the circumstances and its impact on my team, my family, and me.

Professional 5：

This is a very vague question and I'm not sure I can give you a valuable answer. Personally, I'm not sure I like this type of highly academic inquiry, as it deals in hyperboles and deliberate ambiguity.

"Affects performance". Of what? The speed on my bike, keystrokes per minute on the keyboard, the speed of my computer?

"Data is not reliable" – what type of data? What am I supposed to do?

"The circumstances are unknown" – if I have no idea of what the context is or what the expectations are, I'll automatically assume there are none.

I rarely deal with strategy being an engineer. Strategy is too long-term for my role. At most I deal with tactical and operational – defining milestones, risk analysis and conducting implementation efforts.

Strategy is about defining vision, long term goals and direction. I can't see any other strategic thinking to your posed question than to gather more reliable data, define desired end-state, and try to stay flexible when faced with uncertainty.

Professional 6：

When dealing with ambiguity I find it important to start out by looking at the problem from different angles and analyze the available data as well as the lack of data to find the best approach for an appropriate answer and/or action. If similar situations has been handled previously it could be good to reference these and their outcomes when finding the approach to the current problem. Since the problem is also of high importance and the taken action might give large implications, a risk analysis would also be beneficial; i.e. how the different answers/actions could affect the outcome.

It's also good to discuss the problem with other parties in the organization or team since they might have different takes on the situation. With the lack of available data, any additional input should be beneficial. If the answer/action is agreed upon with the other parties it will also be easier to keep the morale up in the case of any set back and improve morale in case of success.

Professional 7：

Even if the data might be unreliable, I would say that I would try to collect as much data as possible. Even though it might be unreliable, it is good to know that you are dealing with unknown data in some or all areas.

For example, if buying a house and it is unknown how the constructions/maintenance has been done, knowing that there are a lot uncertain items could make you aware that you might have to invest a lot of time and money if buying, it could also make you abstain from buying since it might cost too much time and effort after buying.

I would feel much more comfortable with discussing the matter at hand with a couple of persons, discussing what the possible circumstances could be, and what would be appropriate actions would be in that case (finding the worst possible scenario and the best scenario).

After getting convincing myself that I got a feeling for the possible scenarios, or may I still feel very uncomfortable about the different options, then I can take a decision, since I got a feeling for what the cost/benefit might be.

Professional 8：

I don't know how to exactly define this kind of thinking. Maybe, it is strategically thinking, as what you have defined. From my point of view, it is a kind of thinking to consider what we can gain or lost. As software engineer, we normally let data tell us answer. If data is not available, we make tests to get more data. However, if test is impossible or there is no available research result. I would prefer an easy solution which could be implemented quickly. The quick implementation may give me an overview of performance and tell me where is bottleneck. From this overview, I can make a better decision.

If the circumstances are really unknown and deadline is coming. I will pick a “reasonable”, existed (non-creative) and “safe” solution based on the balance between cost and performance. Company always prefer a safer solution. A safer solution give customers an acceptable result at least. It also means we can meet the basic requirements, reach a milestone and get more money or budget to improve our solution in the future.

Professional 9：

First of all I would need to figure time frame for this problem to solved or the decision made i.e. find out the deadline as close as possible with the data at hand. Then depending on the time frame there could be different options. Since we know that the current data is not reliable and circumstances are unknown my first priority and goal would be to gather more data or even more important, more reliable data. This of course would probably require some time and depending on the time frame might or might not be possible. But as far as it is possible this must be a priority. I would also try to get input from other people with relevant experience to make the best choice possible. Using this data and input I would go through the result and evaluate the rewards compared to the risks for each possible decision. Now with regards to strategic thinking I think the next move is more about your personal characteristic than anything else. Depending on how risk averse you are you would probably make very different decisions. From my point of view as person that is rather safe than sorry; unless I now was really sure about my data I would take a very pessimistic standpoint and choose the decision that would make the least damage assuming everything went downhill. I’m sure this is not always the best decision as you might miss out on great business opportunities, but from my point of view I rather miss a business opportunity than risk my company.

Professional 10：

Many people I've encountered are phenomenal at strategic thinking.

Like chess players they make up moves then evaluate the opponent's move in response to that. And then what possibilities that would lead to. And they are able to perform this for many “iterations”.

In my professional career I've met practitioners in many kinds of occupations - manager, project manager and developers alike. At times I have had the feeling that this mindset is encouraged by the context in terms of organisation where I worked.

However, I have myself never had a talent for this kind of thinking. And I have come to the understanding that there are also great risk with that kind of mindset. As the iterations increase the more speculative the possible motives and outcomes will become. And with increasingly less grounded the speculations can lead you or your organisation you may be leading very stray.

I prefer a short term goal and action plan and then I always seek to receive some sort of feedback on that. As I have no problems navigating ambiguity I can be quick on taking action. Since I feel

no prestige in being wrong I strive to be open up for new direction and correct my course when the feedback is received.

Of course, there lies a trade off in being able to take new direction and maintaining the current course. But you need feedback from your environment to best decide where that trade-off lies.

Professional 11：

I would define the situations as: strategic decision based on uncertain circumstances.
I would analyze and categorize the data, check the tendencies globally and compare it to our vision and goals.
Do a swot analysis and from there decide which path to take.
I would try to predict the future and therefore see which options would take me closer to the my future.

Professional 12：

Case:
Problem to solve: set up linking between requirement to source code to test set up and to test results with existing tools.

Uncertain situation: No one seems have done that in the company that in a good way with ALM (IBM rational tool chain). The existing examples are weak, and unclear, and not seem to fulfill our purpose. There might be other projects has done some similar, but there is no existing solution heard. The tools itself has quite some limitation.

Unknow:
Clarity of one project how they set it up . Got a rough picture, but not crystal clear.
Clarity of what GC (new tools feature) could help with the solution

Importance: very important piece to build traceability of the test process.

How would you define this kind of thinking? thinking strategically?
Describe your strategic thinking process that leads to your decision to someone that is not involved in the situation

How to solve the problem?
1. Find all possible aligners and helpers.

Within a big company, there are many people who has went through similar situation.
(background: a small site in a large company, don't really have enough development resource to do everything from scratch)

Aligners in this situation are:
- Tools colleagues close by
- Test responsible in the project
- Higher Tools organization who are interested in common problems

Helpers: Other tools colleagues who might have more information.

At the same time: talk to key persons to get as much detail as possible gather enough information to format a user case to present to people about our requirement, it should be not too simple, but definitely not too much in detail.

The focus of this step is to gather as much information as possible and initiate contact regarding the issue. It might be many communication needed to be repeated and followed up.

2. The step one might end up with:
   1. no solution that close to what we want
   2. There are some closer solutions, but not exactly what want
   3. There are existing solution.

In this case, since the writer has gather some information already. Most probably 2 would be the case. or something between 1 and 2. 3 would be a simple case but might not be realistic.

Next step is to compare what we want to the existing solutions that close to our needs. What enablers are needed? It might be: Update on a plugin, challenge and create the way of working in the test management tool might need other tool to support or a stable workaround?

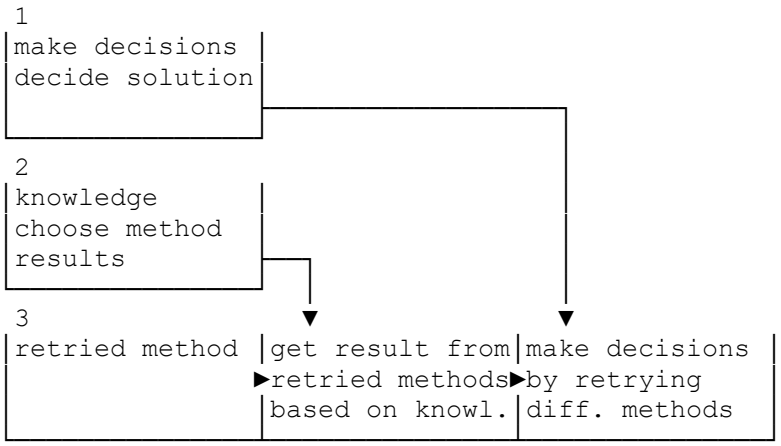
Same as step 1, if the enablers are feasible, we could decide on a solution with all parties involved this time is to propose the possible solution to the people who will be working the enablers to become true. A good selling point would be a good solution that other project could reuse.

If very unfortunately the result is more like the enablers would be too much that we would not able to do, we might need to lower down our requirement a bit or reconsider to
user some other test management tool. Having a concrete requirement would help a lot about communication though, well, of course the requirements needs to be adjustable since the project has a deadline.

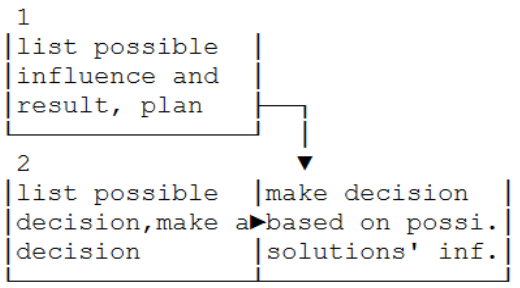
3. Risk management ?
   - What if this fail?
   - Sorry the writer is too optimistic, there is always a way to solve a problem.
   - But probably a good point to chat with experienced people to get some perspective.

All the steps and how many time to spend on each step needs to be aligned with the project time plan.

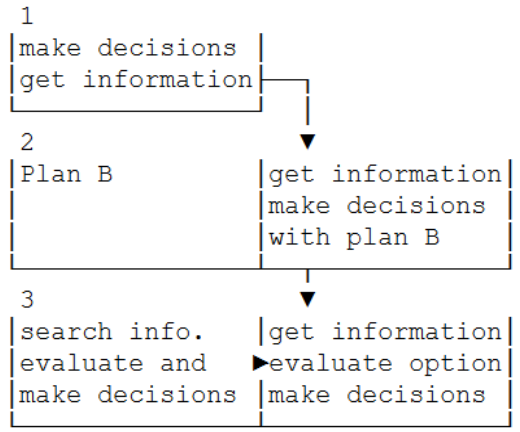
Appendix D: Pertex Analysis Result



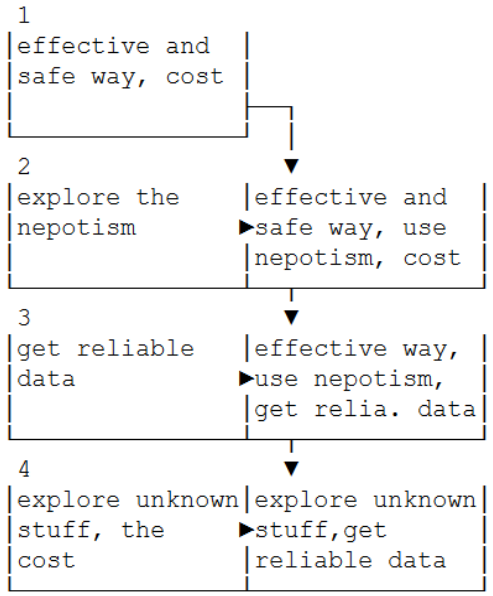
Pertex Analysis Result of S1



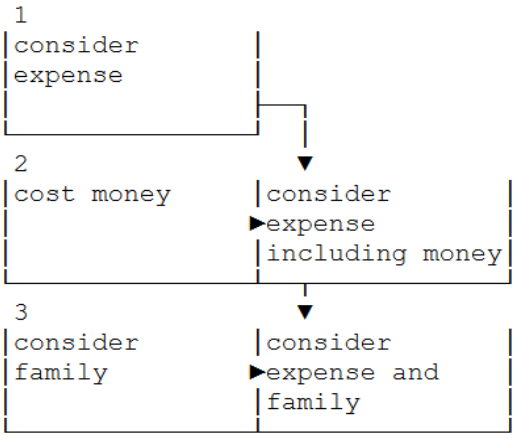
Pertex Analysis Result of S2



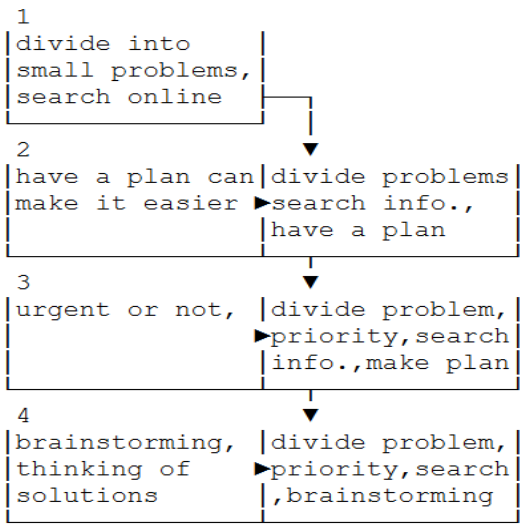
Pertex Analysis Result of S3



Pertex Analysis Result of S4



Pertex Analysis Result of S5



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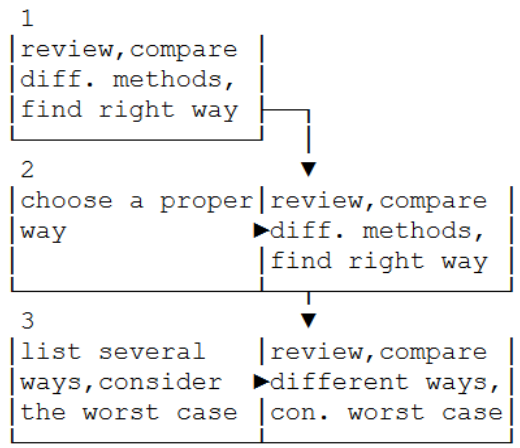
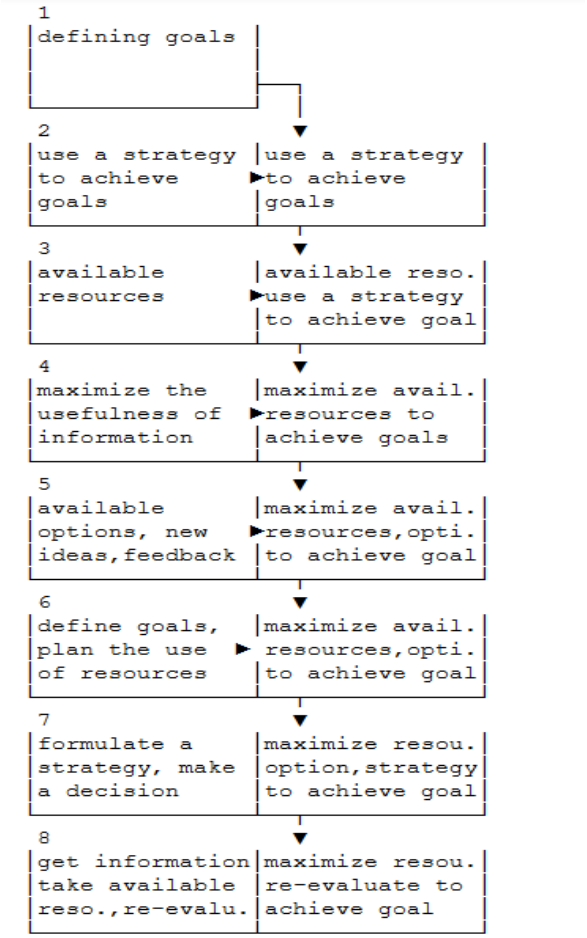
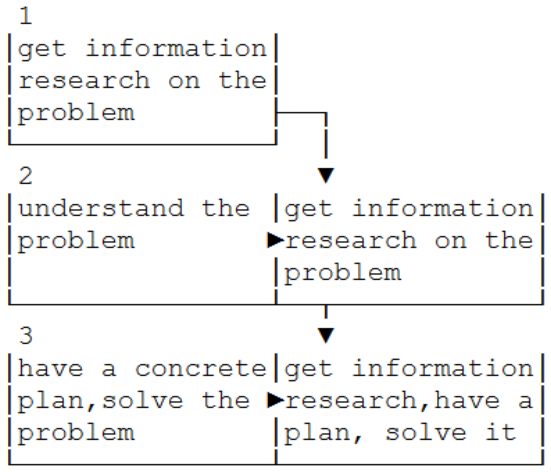


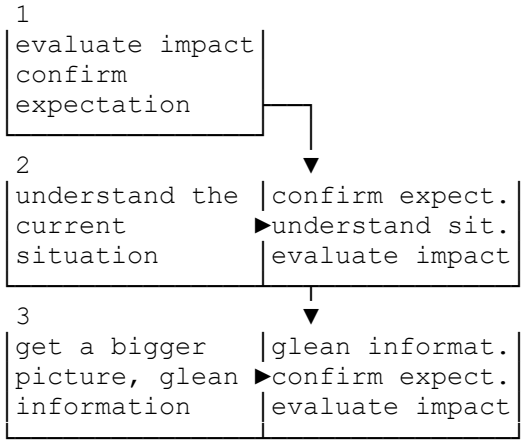
Pertex Analysis Result of S7



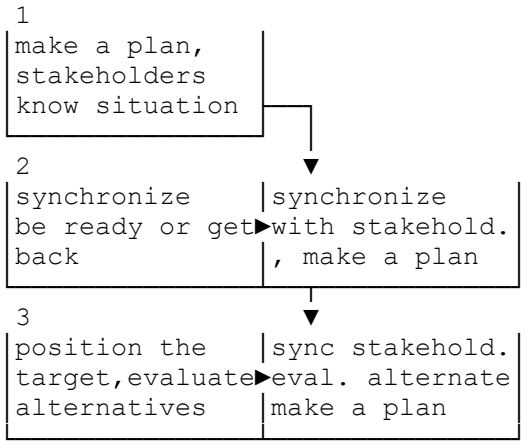
Pertex Analysis Result of S8



Pertex Analysis Result of S9



Pertex Analysis Result of P1



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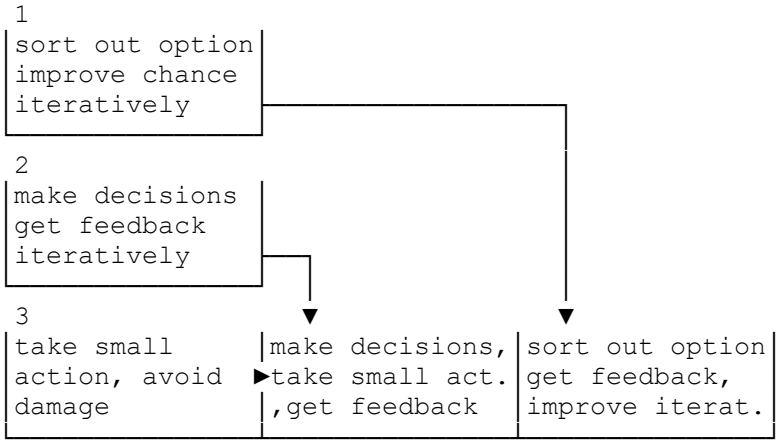

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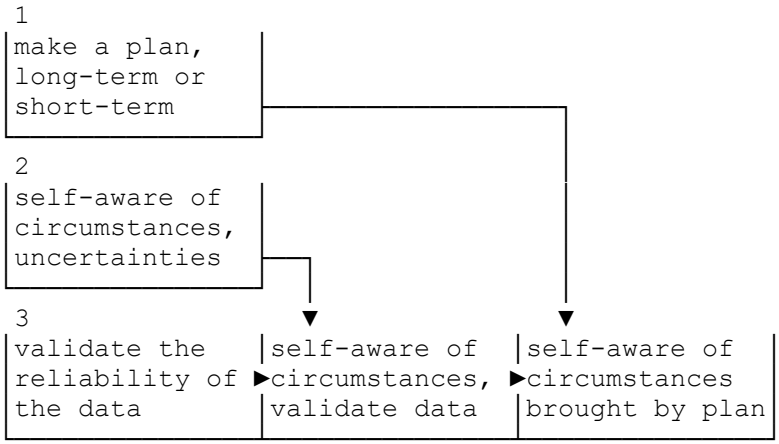

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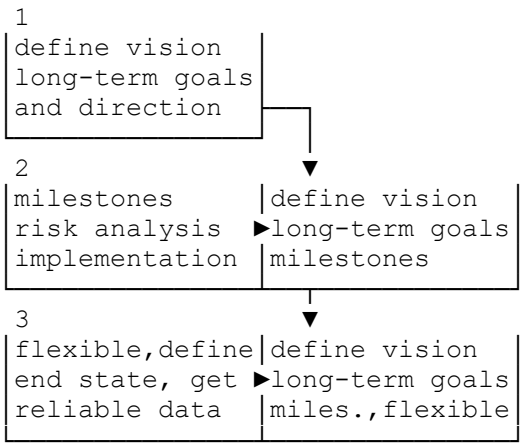

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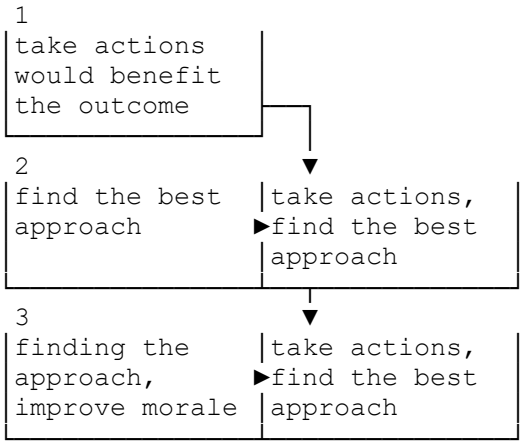

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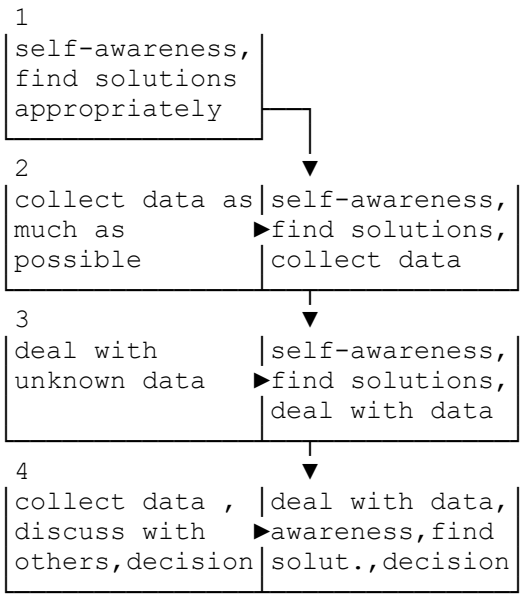

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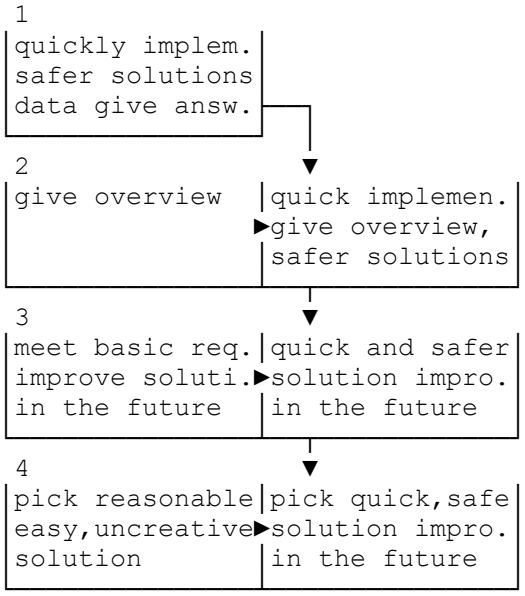

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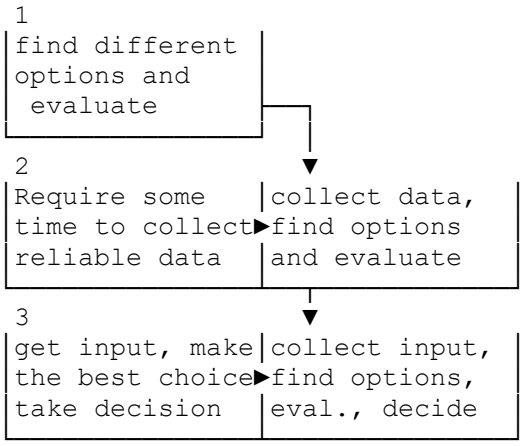

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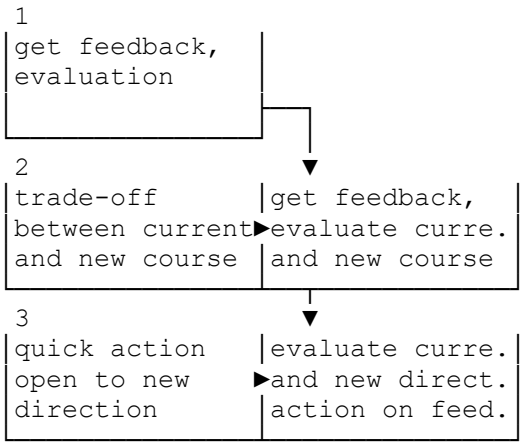
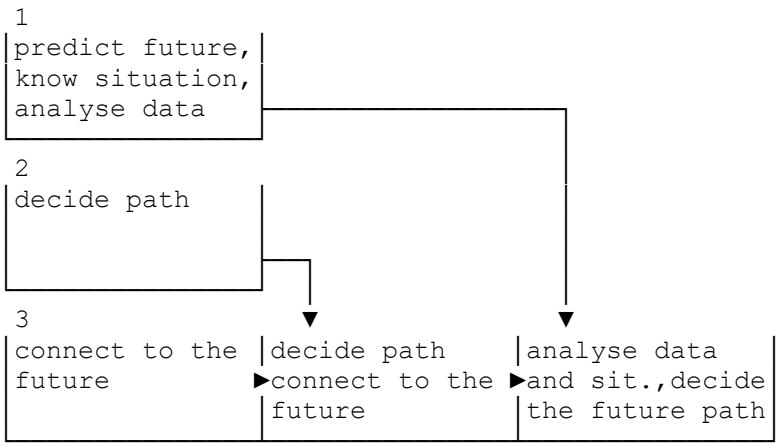
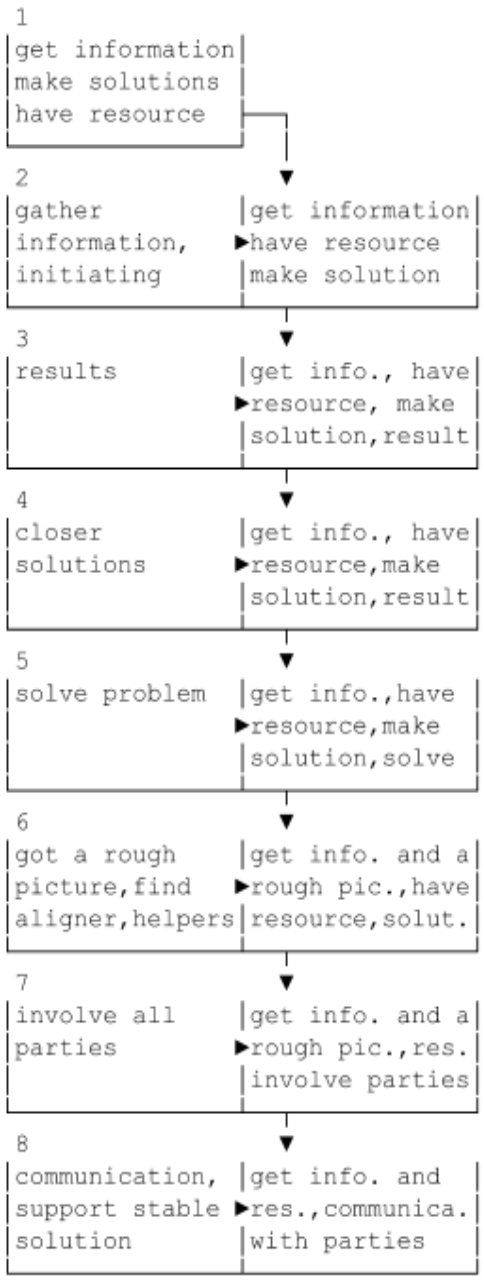


Pertex Analysis Result of P10



Pertex Analysis Result of P11



Pertex Analysis Result of P12

Appendix E: Score Distribution of the Second and Third Interview Questions

Table 1 Scores of the Importance of the Fifteen Elements from Students

Element	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**Sum**
Analytical	4	3	5	4	5	5	4	4	5	39
Creative	5	2	4	1	5	5	3	3	3	31
Conceptual	4	3	3	3	4	5	5	2	3	32
Context Oriented	4	4	5	2	5	5	4	5	3	37
Divergent	5	4	3	5	4	3	5	1	5	35
Flexible	5	3	4	2	5	4	5	5	5	38
Future Oriented	4	5	4	4	4	4	3	2	5	35
Holistic	3	3	4	4	5	4	4	4	2	33
Integrative	5	3	4	5	5	5	5	4	3	39
Intuitive	4	5	3	4	3	2	2	2	4	29
Process Oriented	5	4	3	4	5	4	4	3	5	37
Reflective	5	3	4	3	5	5	5	4	5	39
Synthetic	5	3	4	5	4	5	4	4	3	37
Systematic	4	3	3	3	5	4	5	3	4	34
Visionary	4	4	4	4	5	4	4	5	3	37

Table 2 Scores of the Frequency of the Fifteen Elements Used by Students

Element	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**Sum**
Analytical	1	1	1		1	1		1	1	7
Creative	1					1		1		3
Conceptual	1	1			1		1	1		5
Context Oriented	1		1		1			1		4
Divergent	1	1			1		1		1	5
Flexible	1						1	1	1	4
Future Oriented	1							1	1	3
Holistic	1							1		2
Integrative	1			1	1			1		4
Intuitive	1							1		2
Process Oriented	1				1			1	1	4
Reflective	1				1		1	1	1	5
Synthetic	1			1				1		3
Systematic	1							1		2
Visionary	1				1		1	1		4

Table 3 Scores of the Importance of the Fifteen Elements from Professionals

Element	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	Sum
Analytical	4	5	4	5		5	5	5	5	4	4	5	51
Creative	3	3	3	5		3	4	3	5	5	4	4	42
Conceptual	4	3	4	5		5	3	4	4	2	4	4	42
Context Oriented	5	4	5	4		3	5	3	5	4	3	4	45
Divergent	4	3	3	5		4	4	4	4	5	5	3	44
Flexible	4	3	5	5		3	5	3	5	5	4	3	45
Future Oriented	4	5	4	5		4	4	3	5	5	5	5	49
Holistic	5	5	5	5		4	5	3	4	1	5	5	47
Integrative	4	4	4	5		3	4	2	4	5	3	5	43
Intuitive	3	3	3	4		2	3	2	3	3	3	3	32
Process Oriented	2	4	4	5		4	3	3	4	3	4	4	40
Reflective	5	3	5	5		5	5	4	5	5	4	3	49
Synthetic	4	4	3	4		3	4	3	4	5	5	4	43
Systematic	5	4	5	4		4	4	3	4	2	4	4	43
Visionary	5	5	5	5		5	4	2	4	1	5	3	44

Table 4 Scores of the Frequency of the Fifteen Elements Used by Professionals

Element	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	Sum
Analytical	1	1		1		1	1	1	1	1		1	9
Creative	1	1		1		1			1	1		1	7
Conceptual				1		1		1				1	4
Context Oriented	1	1		1		1			1	1		1	7
Divergent	1			1		1		1	1	1	1	1	8
Flexible	1	1	1	1		1			1	1		1	8
Future Oriented	1	1		1		1			1	1	1	1	8
Holistic	1	1	1	1		1	1		1		1	1	9
Integrative		1		1		1			1	1		1	6
Intuitive				1									1
Process Oriented		1		1		1						1	4
Reflective	1		1	1		1	1	1	1	1		1	9
Synthetic		1		1		1			1	1	1	1	7
Systematic	1	1		1		1			1			1	6
Visionary		1	1	1		1					1		5