A Dissertation

entitled

Exploring the Level of Conceptual Mastery in Computational Thinking Among Male Computer Science Teachers at Public Secondary Schools in Saudi Arabia

by

Abdulaziz A. Alfayez

Submitted to the Graduate Faculty as partial fulfillment of the requirements for the

Doctor of Philosophy Degree in

Curriculum and Instruction: Educational Technology

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An Abstract of

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In 2013, new Computer Science (CS) curricula were implemented by the Ministry of Education in Saudi Arabia (AlSabti, 2013). These CS curricula should be taught by male CS teachers (AlSabti, 2013). The lack of male CS teachers' conceptual mastery of the Computational Thinking (CT) was the reason behind this study. Based on the researcher's personal experience of teaching CS for secondary grades and other anecdotal evidence (e.g., O. Alsoby, personal communication, August 1, 2015), many male CS teachers in Saudi Arabia are unfamiliar with CT concepts or have not been trained on them. Therefore, this study explored the level of conceptual mastery in CT among male CS teachers who teach at public secondary schools that implement the Courses' Schooling System (CSS) in Riyadh, Saudi Arabia. In addition, the study investigated what approaches male CS teachers use to develop students' CT capabilities in terms of both pedagogical strategies and educational technologies, while also examining their confidence level of teaching CT skills. This study was a descriptive study, and an electronic questionnaire distributed to collect the data through three ways: email, Short Message Service (SMS), and WhatsApp. 55 male CS teachers filled out the questionnaire, and the collected data were analyzed using both descriptive statistics and qualitative coding techniques. The study concluded that most of the male CS teachers have a low conceptual mastery level of CT. Offering professional training for eight CT concepts out of ten were recommended (See Table 24 in Chapter Five regarding the eight CT and the type of professional training needed). Collaborative learning, problem solving, and active learning were determined as the most popular pedagogical strategies used by CS teachers to develop students' CT skills. Computers, projector, and smartboard were identified as the most popular technologies used by CS teachers to develop students' CT skills. Finally, 71.2% of the CS teachers felt confident in teaching CT skills because of having prior experiences in the field and familiarity with the subject (CT). 28.8% of the CS teachers felt not confident in teaching CT skills due to the lack of sufficient knowledge and professional development (training workshops).

Keywords: Computer Science Teachers, Computational Thinking Concepts, Pedagogical Strategies, Educational technology, Teachers Confidence, Decomposition, Abstraction, Algorithms Design, Automation, Data Collection, Data Analysis, Data Representation, Simulation, Parallelization, Generalization, and Generative Learning Theory

This work is dedicated:

- To my precious parents Abdullah Alfayez and Salwa Alyousef, who devoted their lives and sacrificed their comfort for creating a better and comfortable life for my sisters, my brothers, and me
- To my queen' wife Afnan Alrshed, who stood with me throughout my graduate studies (Master and Ph.D.) by her encouragement which made my efforts worthwhile
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Chapter One

Introduction

Saudi Arabia, like other countries around the world, is trying to provide a better education for its citizens. Saudi Arabia has gone through several phases in term of reforming the school system and its curricula. The most recent phase was the King Abdullah Education Development project (Ministry of Education, 2008) with a budget of $2.4 billion (Meemar, 2014), with the aim to "provide students with 21st century capabilities and attitudes that will help them grow into productive citizens who engage with the rest of the world positively" (Tatweer, 2011, p. 4). As a result of this project, the Ministry of Education in Saudi Arabia introduced a new schooling system called Courses Schooling System (CSS) and developed new curricula for all levels and across all subjects (Ministry of Education, 2008). The newly developed Computer Science (CS) curricula have been designed by the Ministry of Education to meet Saudi Arabian cultural and societal needs (Ministry of Education, 2008). The Computer Science curricula are based on US Computer Science Teachers Association (CSTA) K-12 Computer Science Standards (Al Salman, Al-Wakee, Mandurah, Aloraifi, & Al-Mubarak, 2013), which were developed using the existing K–12 computer curricula of the Advanced Placement (AP) computer content. The standards were established to produce "well-educated citizens" (p. ii) who have a clear comprehension of the principles and practices of CS (Deborah, Carey, Fuschetto, Lee, Moix, Owens, O'Grady-Cunniff, Stephenson, & Verno, 2011).

The CSTA K-12 Computer Science Standards offer a three-level framework for

CS. The first two levels of the CS curriculum have been designed for Elementary and Middle grades respectively. The third level has been designed for secondary grades; however, it contains three different courses including "CS in the Current Era," "CS Principles," and "Topics in CS" (Deborah et al., 2011). Through these three courses, students learn advanced CS concepts that can be used to explore real-life problems and apply computational thinking to obtain appropriate solutions.

Across all three levels, there are five complementary and essential standards: Computational Thinking (CT); Collaboration Learning (CL); Computing Practice and Programming (CPP); Computer and Communications Devices (CCD); and Community, Global, and Ethical Impacts (CGEI) (Deborah et al., 2011). Of these, the CT "is a fundamental skill for everyone…" (Wing, 2006, p. 33). Wing (2006) defines CT as a way of thinking that "involves solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science" (p. 33). More specifically it "is reformulating a seemingly difficult problem into one we know how to solve, perhaps by reduction, embedding, transformation, or simulation" (p. 33). A more detailed operational definition of CT has been developed by CSTA and the International Society for Technology in Education (ISTE) in collaboration with other leaders from higher education, industries, and K–12 institutions. According to CSTA and ISTE (2011a, p. 7), CT is a problem-solving procedure during which students learn the following skills: (1) to formulate problems in a way that allows learners to utilize a digital device to assist addressing these problems; (2) to organize and to analyze data logically; (3) to represent data through abstractions; (4) to use algorithmic design (a sequence of ordered steps) automatically to solve a problem; (5) to identify, to analyze, and to apply possible ways with the purpose of reaching the most effective and efficient combination of steps and resources; and (6) to generalize and to transfer this problem-solving procedure to a wide variety of problems.

Students need to learn CT concepts to increase their problem-solving skills that are critical for solving real-world issues (Deborah et al., 2011). Learning CT concepts enable students to recognize when a computer and its applications can assist them in addressing a problem. Students with CT abilities are also able to gather and manipulate large data sets to make decisions. Furthermore, CT concepts enable students to solve complex problems, build computer systems, and understand strengths and weaknesses of computing in the modern era.

A. Statement of the Problem and Significance of Study

In 2013, the Ministry of Education in Saudi Arabia implemented new CS curricula and required male CS teachers to teach the subject (AlSabti, 2013). However, there is a lack of conceptual mastery of CT among these teachers. Based on the researcher's personal experience of teaching CS for secondary grades and other anecdotal evidence (e.g., O. Alsoby, personal communication, August 1, 2015), many CS teachers in Saudi Arabia are unfamiliar with CT skills or have not been trained on these skills. Although the Ministry of Education recently created training workshops in cooperation with Tatweer Education Holding Company (Tatweer Education Holding Company, 2014), and CS teachers are required to attend these workshops. The content of these training workshops is limited to the general discussion about the new CS curricula subjects, and it does not focus on teachers' mastery of CT skills (O. Alsoby, personal communication, August 1, 2015).

There have been few studies conducted internationally to investigate teachers' conceptual mastery of CT skills, and no prior studies have investigated the level of conceptual mastery of CT skills for the Saudi male CS teachers. For instance, Bower, Lister, Mason, Highfield, and Wood (2015) surveyed teachers from a broad range of institutions and backgrounds in Australia about their understanding of CT. They concluded, "Many teachers had misconceptions about Computational Thinking constructs, adding to the challenge of developing students Computational Thinking capabilities. This indicates a pressing need for professional development and programs to support teacher implementation of Computational Thinking" (Bower et al., 2015, p. 14). Teachers need to have a solid conceptual mastery level of CT to be able to deliver CT skills to students. Curzon, McOwan, Plant, and Meagher (2014) stated that teachers in the United Kingdom (UK) also have lack of CT knowledge, and it is important that they have a thorough understanding of CT concepts to be able to develop their students' CT skills. Studying Saudi Arabian male CS teachers' levels of conceptual mastery of CT skills will determine whether teachers in this country are well prepared to teach the new CS curriculum or if they need additional professional development to improve their capabilities and confidence level of teaching CT.

Five primary beneficiaries will derive advantages from investigating the male CS teachers' level of conceptual mastery of CT skills. The first beneficiary is CS teachers themselves. They could realize that they have not fully understood the concept of CT, or that they have a misconception of CT concept. If the CS teachers realize this misconception, they may become motivated to learn about the CT concept. In addition, they may see the need for professional development that focuses on improving their confidence level when teaching CT. Secondly, CS supervisors will be able to guide and advise the CS teachers when they know their level of conceptual mastery of CT skills. Thirdly, all College of Education faculty who prepare CS teachers in Saudi Arabia will be able to revise their CS pre-service teacher programs to produce future CS teachers who can teach CT skills for students. Fourthly, studying the CS teachers' level of conceptual mastery of CT skills may offer some useful recommendations to the Ministry of Education regarding in-service CS teachers and their ability to teach the new CS curriculum based on their knowledge of CT. Finally, male students will benefit by having CS teachers who can deliver CT skills that will help them to be successful in their academic and career journey.

B. Purpose Statement

The purpose of this study was exploring the level of conceptual mastery in CT among male CS teachers who teach at public secondary schools that implement CSS in Riyadh, Saudi Arabia. In addition, the study investigated what approaches male CS teachers use to develop students' CT capabilities in terms of both pedagogical strategies and technologies, while also considering their confidence level of teaching CT skills.

C. Research Questions

The current study addressed the following research questions:

1. What is the level of conceptual mastery of CT among male CS teachers who teach at public secondary schools that implement CSS in Riyadh as measured by "Questionnaire of Computational Thinking (QCT)"?
2. What pedagogical strategies do male CS teachers who teach at public secondary schools that implement CSS in Riyadh report using to develop

students' CT skills?

3. What educational technologies do male CS teachers who teach at public secondary schools that implement CSS in Riyadh report using to develop students' CT skills?
4. What is the confidence level of male CS teachers who teach at public secondary schools that implement CSS in Riyadh in teaching CT skills?

Chapter Two

Research and Literature Review

A. Background on Saudi Arabia Schooling System

Since the unification of the Kingdom of Saudi Arabia in 1932 until the present time, Saudi Arabia has witnessed a number of developments in all fields including the field of education. The Saudi government has developed a comprehensive plan for its educational system to meet the need of its citizens and to keep pace with the technological development (Alghamdi, Hamdan, Abduljawad, & Nuraldin, 2002). The educational system in Saudi Arabia consists of general education and higher education. The general education consists of three primary levels: Elementary (six years), Middle (three years), and Secondary (three years); in addition to the kindergarten, which precedes the Elementary level (Alhamed, Ziadeh, Alotaibi, & Metwally, 2007). The secondary level, which is a crucial stage for students in general education, covers a critical period for students' growth, and is a bridge between general education and higher education. The secondary level is also a comprehensive and integrated preparation stage to provide students with fundamental knowledge, skills, and attitudes that develop their personalities and prepare them for academic and practical life. In secondary level, students study three years from the age of 15 to 18 years, and secondary schools use three different schooling systems. The first of these systems is the Annual Schooling System (ASS), also called the Traditional Schooling System. In the ASS, the academic year is divided into two semesters, and students need an average of six semesters to complete their diploma. In each year, students are required to take more than 17 courses and complete them all successfully to move into the next year (Faraj & Hussain, 2009). If a student does not pass a course, he has to retake the entire year (all courses). In addition, the first year in this schooling system is called a qualification year; students study all courses including science, mathematics, linguistics, and religion. The second and third years in this schooling system are specialization years; students have to choose a track between sciences and art (Alahmadi & Hassan, 2005). In fact, this system is on its way to extinction.

The second system is the Developed Schooling System, also called Courses Schooling System (CSS). In 2004, the Ministry of Education began to implement this schooling system gradually (Faraj & Hussain, 2009). This system depends on students completing a number of core and elective credit hours. To illustrate, students have to complete 200 credit hours in six semesters (Ministry of Education, 2012). This system will be further elaborated in the next section.

The third system is the Semester Schooling System (SSS). In 2014, the Ministry of Education introduced the SSS to replace ASS in secondary schools gradually (Alsharida, 2014). This system relies on six academic semesters, and in each semester, students have to study 14 courses or less. In this system, if a student fails to pass a course, he has to retake it the next semester. In addition, the first and second semesters are called general preparation semesters. After these two semesters, students have to choose a track between sciences and art, and they have to study a minimum of four semesters to obtain a secondary school diploma (Tysan & Bahli, 2014).

a. Courses Schooling System (CSS). The Courses Schooling System (CSS) is implemented to strengthen the Islamic faith and social value as well as to improve the political and educational goals of Saudi Arabia. CSS aims to achieve integration among academic courses or subjects through providing courses that have an equivalent weight of two courses or more in the Annual Schooling System (Ministry of Education, 2012). Also, CSS aims to reduce costs of time and money by decreasing the rate of academic failure and withdrawal from schools (Ministry of Education, 2012). CSS provides students with a sufficient amount of knowledge and skills based on systematic planning that takes into consideration characteristics of students. Furthermore, this system is designed to develop students' skills, such as making decisions, creative thinking, self-learning, cooperative learning, and communication skills.

The CSS relies on a number of complementary courses through designing a plan of study that contains a combination of core and elective courses. In each semester, students enroll in a maximum of seven courses, and each course weights five credits hours (Ministry of Education, 2012). This system is flexible enough; it allows students to enroll in a number of courses that they wish to study during the semester, and it also gives students the opportunity to add or withdraw courses at the beginning of each semester. CSS also allows students to study courses over the summer semester within the limitation offered by each school (Ministry of Education, 2012). In addition, schools that implement CSS offer students with academic guidance to direct their abilities and tendencies toward specialties that suit them.

The Courses Schooling System consists of three programs: General, Specialized, and Elective (Ministry of Education, 2012). The general program is required to be studied by all students with a total of 26 courses (130 credit hours) (Ministry of Education, 2012). The specialized program has two tracks: sciences and art. Each track has a total of twelve courses (60 credit hours), and students have the opportunity to choose the track that suits their abilities and competencies (Ministry of Education, 2012). The science track focuses on taking twelve scientific subjects, such as mathematics, chemistry, physics, and biology as well as English (Ministry of Education, 2012). While the art track focuses on taking twelve courses in various subjects, such as Islamic studies, Arabic language, English language, social science and administrative science (Ministry of Education, 2012). The elective program contains a number of advanced subjects among which students are required to study a minimum of two courses (ten credit hours) and maximum of five courses (25 credit hours) (Ministry of Education, 2012). This program has been found to prepare students for university life, and it also gives students the opportunity to raise their GPA (Ministry of Education, 2012). In CSS, the academic year consists of two core semesters and one optional semester (summer). Students need six semesters on average to complete their secondary education and obtain their diploma (Ministry of Education, 2012). In fact, some students can complete their secondary education in five semesters by registering for some courses in the summer semester.

Students' evaluation process is an important educational function in CSS that includes multiple methods and types aimed at detecting strengths and weaknesses in the current schooling system to improve the learning process (Ministry of Education, 2012). The CSS allows students to study the course, which they failed in a previous semester (Ministry of Education, 2012). To illustrate, if a student fails to pass a course, he is required to retake it next semester. In some cases, a student can study another course instead of the course that he failed. Furthermore, the grading policy is designed according to the requirements of each specialty and course objectives (Ministry of

Education, 2012). In fact, some courses are subject to continuous evaluation. CSS utilizes a Grade Point Average (GPA) system that calculates each semester; it represents the average of all course grades studied by a student during their secondary schooling (Ministry of Education, 2012).

A team of experts from the Ministry of Education has developed several curricula for secondary school within the Tatweer project, including the Computer Science curricula. The Computer Science (CS) curricula are important to enable students to absorb scientific facts and advanced technical skills as well as keeping pace with the global developments in the field of CS (Humans & Alzahrani, 2004; Secondary Education Course Schooling System-Shared Program, 2016). In CSS, more specifically in the shared program, students are provided with two CS courses: Computer 1 and Computer 2. The Computer 1 course is considered a prerequisite for the Computer 2 course. Also, in the elective program, students can take a Computer 3 course after completing Computer 1 and 2 courses (Ministry of Education, 2012). The experts have taken into consideration the latest trends and developments in the field of CS when designing curricula of Computer 1, 2, and 3 (Secondary Education Course Schooling System-Shared Program, 2016), basing the courses on the CSTA K-12 Computer Science Standards (Al Salman et al., 2013) as mentioned in Chapter One.

Implementing new CS curricula leads to raising the level of qualification for CS teachers. Whereas the role of the teacher is no longer limited to the delivery of information and knowledge to students, but it has been extended to help students to learn and to be active citizens. Therefore, the National Center for Assessment in Higher Education (2013) has developed a set of standards for CS teachers to ensure that CS teachers have sufficient capacities to teach CS curricula. CS teachers must have (1) a great interest in their field, (2) full understanding of facts and theories related to their field, (3) and an understanding of CS curricula and its applications (National Center for Assessment in Higher Education, 2013). In addition, CS teachers have to face the rapid and dramatic changes in technological progress, the information revolution, social media, and curricula to play an essential role in producing modern citizens (Mada, 2014).

B. Computer Science and its Importance

Computer Science (CS) can be defined as "the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society" (Tucker et al., 2006, p.2). CS has become essential for individuals today because we are living in a world that depends on CS in all fields. Also, CS has a great influence on the way that individuals live, think, and act. Therefore, students have to understand CS, not for the sake of living in this era, but to be able to develop future innovations. Computer Science graduates will have a significant impact on how the world is formed because they offer important information that can affect people's lives through designing services and systems in their societies. The future of innovation is at risk without active, engaged, intelligent computer scientists (Microsoft Corporation, 2008). Computer scientists can work with experts in other fields to build computer systems that support the functioning of modern society. For example, computer scientists and neuroscientists can cooperate in an attempt to understand the computational mechanisms the human brains utilizes to find a solution to such tasks.

The field of CS is currently not keeping pace with the development of the technological environment in schools for many reasons. One reason is the low number of

CS courses currently offered (Weinberg, 2013). This may result in fewer numbers of students passing CS introductory courses at the college level. Bennedsen and Caspersen (2007) examined the failure rates within introductory programming courses around the world, and they found that 33% of college students failed or dropped out of these courses. CS educators have evaluated why students find computing difficult to understand. Boulay (1986) mentions that the concepts of programming are difficult to comprehend by students because they do not understand the key features of their programs, and, at the same time, do not know how to control them when writing a code.

The knowledge of CS enables students to obtain the necessary intellectual skills to solve complex problems. Students should be exposed to CS concepts, including CT skills, before post secondary education (Deborah et al., 2011), and this is due to the majority of professions in the 21st century needs of understanding CS concepts (Tucker et al., 2006). Therefore, students needs to have the opportunities to develop CT skills and explore how computational competencies may encourage them toward careers of interest (CSTA, 2005, 2009). Computer Science curricula and teachers should be capable of providing students with CT skills. Computer Science curricula need to be developed along with preparing teachers to meet students' needs (Wilson, Sudol, Stephenson, & Stehlik, 2010). The researcher could not find empirical evidences indicating that mastering CT skills helps teachers to teach CS curriculum. However, CT movement can be a solid direction for a change because it would enable individuals to navigate today's society where technology is inevitable effectively.

C. Computational Thinking (CT)

a. Definition and characteristics. Papert (1996) mentioned the term of

Computational Thinking (CT), as a way to forge ideas and use computers to solve problems, which allows individuals to analyze problems better and explain solutions more accurately. CT can play a significant role in helping individuals to understand how, when, and where these technologies can be used to help in problem-solving (Barr, Harrison, & Conery, 2011). However, "Computational thinking is often mistakenly equated with using computer technology" (Yadav, Stephenson, and Hong, 2017, p. 57). Mishra and Yadav (2013) mentioned that CT goes beyond human digital device interactions and suggested that CT could move learners from being technology users to produce new ways of expression, design tools, and promote creativity.

Based on the literature, there is no universal definition of CT; however, many scholars made significant effort to come up with a general and operational definition of CT. Wing (2006) defined CT as "solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science" (p. 33), and more specifically it "is reformulating a seemingly difficult problem into one we know how to solve, perhaps by reduction, embedding, transformation, or simulation" (p. 33). This is currently the most commonly cited definition in literature but other scholars have come up with other definitions of CT. For instance, Lu and Fletcher (2009) defined CT as a conceptual method to "systematically, correctly, and efficiently process information and tasks" to address difficult problems (p. 261). Furthermore, CSTA and ISTE have collaborated with other leaders from higher education, industries, and K–12 institutions to generate an operational definition of CT, and they state that:

> " CT is a problem-solving process that includes (but is not limited to) the following characteristics:

• Formulating problems in a way that enables us to use a computer and other tools to help solve them

• Logically organizing and analyzing data

• Representing data through abstractions, such as models and simulations

• Automating solutions through algorithmic thinking (a series of ordered steps)

• Identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources

• Generalizing and transferring this problem-solving process to a wide variety of problems." (Conery et al., 2011a, p. 7)

This operational definition underwent a review process by Weinberg (2013). He surveyed over 700 experts from various disciplines including CS teachers and researchers. The results showed that "The vast majority of respondents (n = 697, 82%) indicated their agreement or strong agreement when asked if CSTA's definition captured the fundamental elements of computational thinking [CT], and a further 9% indicated that the definition was sufficient to use to build consensus in the computer science education community" (Weinberg, 2013, p. 18).

Some scholars and organizations have argued that CT is not only characterized by abilities and skills, but it also characterized by attributes and dispositions (see Table 1 below).

Table 1

CT Attributes and Dispositions

Scholars/Organizations	Attributes and Dispositions
Conery et al., (2011a, p. 7)	• Confidence in dealing with complexity • Persistence in working with difficult problems • Tolerance for ambiguity • The ability to deal with open-ended problems • The ability to communicate and work with others to achieve a common goal or solution
Weintrop et al., (2015, p. 133)	• Confidence in dealing with complexity • Persistence in working through challenging problems • Ability to deal with open-ended problems
Woollard (2016, p. 5)	• Creating • Tinkering • Debugging • Persevering • Collaborating

Based on all of the previous definitions, CT focuses on abilities, a set of skills, and dispositions needed to solve complex problems (Barr & Stephenson, 2011; Grover & Pea, 2013; Lee, Martin, Denner, Coulter, Allan, Erickson, Malyn-Smith, & Werner, 2011) with the help of technology (Grover & Pea, 2013; Lee et al., 2011; Wolz, Stone, Pearson, Pulimood, & Switzer, 2011). CT is a set of general skills that can benefit individuals because these skills will enhance their intellectual skills to work with complexity, ambiguity, and open-ended problems (Wing, 2010). It is critical that individuals learn CT skills because it provides endless opportunities for creatively solving problems. Also, learning these types of skills would produce problem solvers instead of software users. Wing (2006) stated several characteristics of CT, which themselves are distinguished from other skills. One characteristic is that CT is a

"Fundamental, not rote skill" (p. 35). Fundamental skills mean skills that everyone has to know to live in modern society. For example, individuals have to know how to take advantage of technology in problem solving. Rote skills mean skills that are driven from individuals' routines. Individuals tend to memorize some techniques based on repetition, such as mathematical equations. Another characteristic is a "way that humans, not computers, think" (p. 35). Human intelligence is greater than computer intelligence. Therefore, computers are merely tools and not substance. Humans use their intelligence and computing devices to address any problem they face.

b. Computational Thinking concepts. The concept of CT was relevant only for computer scientists and engineers until Wing (2006) introduced it as a "fundamental skill for everyone" (p. 33). Similarly, a National Research Council report (2010) stated that CT is a set of cognitive skills that the "average person in modern society is expected to possess" (p.13). Researchers have demonstrated that CT is universally applicable for everyone across all disciplines (Barr & Stephenson, 2011; Conery et al., 2011a, 2011b; Furber, 2012; Lu & Fletcher, 2009; Wing, 2008; Wing, 2006). CT refers to a number of intellectual skills, practices, and methods that are fundamental in solving difficult problems. These skills and methods involve a set of concepts and capabilities: Decomposition, Abstraction, Algorithms design, Automation, Data collection, Data analysis, Data representation, Simulation, Parallelization (Barr & Stephenson, 2011; Conery et al., 2011a, 2011b; Google For Education, 2010; Park & Jeon, 2015), and Generalization (Google For Education, 2010; Selby & Woollard, 2013).

Decomposition. Decomposition is "breaking down tasks into smaller, manageable parts" (Conery et al., 2011a, p. 8). Similarly, Csizmadia et al., (2015) defined decomposition as “ a way of thinking about artefacts [sic] in terms of their component parts” (p. 8). Decomposition is important because it allows individuals to solve small and minor problems, one at a time, instead of trying to deal with a complex problem. For example, individuals have been asked to create a presentation to demonstrate their understanding of a certain topic. To decompose the problem, they have to ask themselves some questions, such as what kind of presentation they want to create, who the target audience is, what type of media will be used, and what presentation software will be used. This list of questions would help students to break down the complex problem of formatting a presentation into small and manageable pieces.

Abstraction. Abstraction is “reducing complexity to define main idea [s]” (Conery et al., 2011a, p. 8). Abstract thinking is a type of thinking, which can be described as the “ability to recognize multiple meanings and patterns of concepts and generalize to new meanings, ideas, or contexts” (Moorhead, Johnson, Maas, & Swanson, 2013, p. 70). Wing (2008) defined abstraction as “process – deciding what details we need to highlight and what details we can ignore – underlies computational thinking” (p. 3718). Similarly, Csizmadia et al., (2015) mentioned, “Abstraction is the process of making an artefact more understandable through reducing the unnecessary detail” (p. 7). In other words, abstraction is the ability to identify general principles, which generate patterns of similarities. For example, individuals are thinking abstractly when they can identify symbols, themes, events, values, and key figures in the field after reading articles about a particular subject.

Algorithms design. Algorithms Design is a “series of ordered steps taken to solve a problem or achieve some end” (Conery et al., 2011a, p. 9). In other words, it is the ability to perform step-by-step instructions to solve a problem. Csizmadia et al., (2015) stated, "Algorithmic thinking is the ability to think in terms of sequences and rules as a way of solving problems or understanding situations" (p. 7). This component of CT is critical because it gives individuals a clear visual path that includes a set of rules on how the problem will be solved. For example, individuals have been asked to discuss their decision-making process for choosing a major field of study. They would create an algorithm that describes how the decision would be made. The algorithm will include some variables such as what students want to do in their lives, their financial aid, and what college they should attend. Following the designed algorithm would result in a suitable decision.

Automation. Automation is "having computers or machines do repetitive or tedious tasks" (Conery et al., 2011a, p. 9). Individuals operate by mechanizing their abstractions and relationships among them (Wing, 2008). Automation implies the need for some type of technology, such as a computer to interpret abstractions. However, CT does not require a machine because humans have the ability to process information and compute it (Wing, 2008). Human beings are better than digital devices at analyzing and explaining pictures; on the other hand, digital devices (e.g. computer) are much better at performing particular types of instructions more quickly and accurately than humans (Ahn, Blum, & Langford, 2004). Automation can be applied to perform tasks that would (1) take a very long time to complete or (2) be dangerous and complicated to perform by humans. For example, students can use a Mathway application to learn mathematics through offering step-by-step directions to address mathematical problems. For another example, medical students can use robotics to learn how to perform complicated medical procedures.

Data collection. Data collection is "the process of gathering appropriate information" (Conery et al., 2011a, p. 8). Individuals can engage in a data collection process through many ways, such as observing, designing a survey, searching the Internet, and visiting the library. For example, individuals would create a questionnaire to gather both qualitative and quantitative information to answer a particular research question.

Data analysis. Data Analysis is "making sense of data, finding patterns, and drawing conclusions" (Conery et al., 2011a, p. 8). Recognizing patterns means identifying similarities and differences between small pieces of the problem that have been decomposed to solve a complex problem more efficiently. It is extremely critical that individuals are able to find patterns because the more patterns they can identify, the easier and quicker their problem-solving task will be. Also, individuals can find patterns among different problems as well. For example, individuals may have been asked to find trends in a line graph titled the "Hourly Attendance Rates at Local Fitness Clubs," which may result in making a rational decision regarding the best club to join and the best time to workout that meets one's preferred schedule. Thus, problems are easier, quicker, and simpler to address when the problems share patterns because individuals can transfer the same solutions from one problem to the next. In fact, finding patterns allows individuals to make sense of collected data and represent a conclusion.

Data representation. Data Representation is "depicting and organizing data in appropriate graphs, charts, words, or images" (Conery et al., 2011a, p. 8). Computational representation is critical because it can reduce cost and enable storage and transition of data more efficiently. Individuals can present a solution to a particular problem in many ways. One way is by using charts; for example, individuals can display the data as a timeline chart or scatterplot to show historical relationships among events.

Simulation. Simulation is a "representation or model of a process" (Conery et al., 2011a, p. 9), which is a way of developing a model to duplicate real-world procedures. Simulations can make scientific ideas more reachable and promote individuals' knowledge about the phenomena (Fifield, Grusenmeyer, & Ford, 2014; Holbert, Brady, Holbert, & Soylu, 2015; Schwarz, Meyer, & Sharma, 2007). Simulation is a way to investigate problems and test possible solutions. For example, individuals can produce visual aids to show their knowledge of a process, such as how an airplane takes off or how eyes receive visual messages. In addition, simulation helps individuals to avoid dangerous situations. For instance, individuals can use a simulation to learn how to drive a vehicle because a simulation offers a real-life experience in a safe environment.

Parallelization. Parallelization is forming resources to simultaneously perform tasks to achieve a mutual goal (Conery et al., 2011a). In other words, it is working on small-decomposed parts of the problem simultaneously to reach a common goal efficiently. For example, individuals have been asked to design a video tutorial. In the beginning, they would determine the required tasks, such as writing the script and selecting appropriate media. Then, they would work in small groups: one group would be responsible for collecting pictures, while another group would be responsible for producing audio. These two groups must work at the same time because syncing pictures, sound, and deciding the timing of these elements are critical in designing a consistent and coherent video tutorial. Distribution of tasks and working together simultaneously would help in solving the problem more efficiently.

Generalization. Generalization is "a way of quickly solving new problems based on previous problems we have solved" (Curzon, Dorling, Ng, Seldy, & Woollard, 2014, p. 4). It is the ability to transfer prior knowledge of a solution to address a current problem that has similar patterns; in other words, it is the capacity to identify parts of solutions that have been used in working with a past problem and may be used in solving current and future problems (National Research Council, 2011). For example, individuals write generalized formulas using symbols instead of numbers, so that they can use these formulas to address problems containing different values in another situation.

D. Theoretical Framework

The Generative Learning Theory (GLT) was introduced by Wittrock (an American educational psychologist) in 1974 (Tobias, 2010), and it is used as a way to "integrate some of the research in cognitive development, human learning, human abilities, information processing, and aptitude-treatment interactions around the notion of transfer of experience and abilities" (Wittrock, 2010, p. 40). Wittrock theorized that learners are not the passive recipients of information; rather they are active participants in the learning process who construct meaningful understanding of information found in the environment (Spector, 2008). Wittrock (1974) stated, "although a student may not understand sentences spoken to him by his teacher, it is highly likely that a student understands sentences that he generates himself" (p. 182). Wittrock's theory of generative learning is based on the idea that individuals generate perceptions and meanings that depend on their prior experiences (Wittrock, 2010). Based on GLT, learning occurs when individuals try to make sense of presented materials by connecting new information to their prior knowledge (Fiorella & Mayer, 2015). In other words, a learner can generate meaningful knowledge by self-generation of relationships and understanding. Generative learning focuses on a series of mental processes: cognitive process, knowledge creation process, motivational process, and metacognitive process (Fiorella & Mayer, 2015).

a. Cognitive processes. The concept map in Figure 1 illustrates the connection between GLT and CT skills. Mayer (2010) stated, "learning is an active process in which the learner seeks to make sense of the presented material by engaging in active cognitive processing during learning" (p. 46). Meaningful learning is based on three cognitive processes of selecting, organizing, and integrating (Fiorella & Mayer, 2015). These three cognitive processes cannot occur if the learner does not collect data by watching, listening, or reading presented materials.

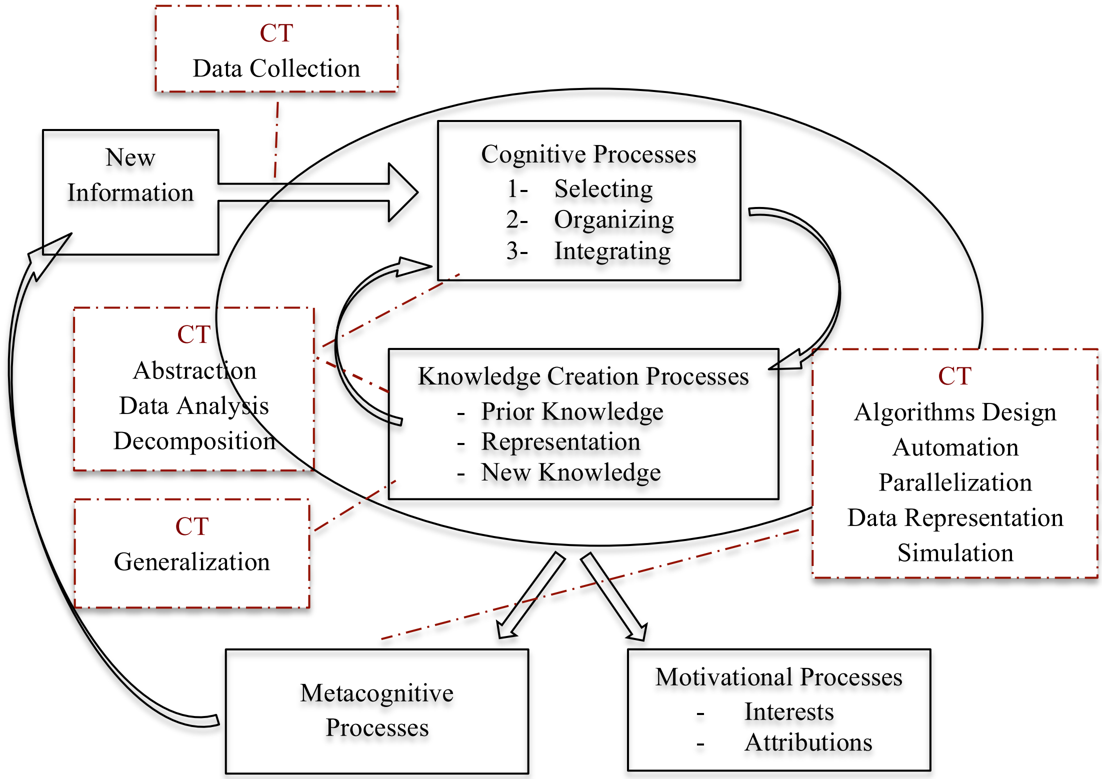

Figure 1: Conceptual Understanding of the Connection Between GLT and CT

For example, when learners have been asked to learn about block-based programming environments (e.g., Scratch), they may watch a video tutorial or read an instructional book (Data Collection). During the data collection process, learners will select some information that is related to block-based programming environments, and the selected information will temporarily be held as an exact copy in a sensory memory for further processing in the working memory (Fiorella & Mayer, 2016). Wittrock (1989) stated, "People ignore some information and actively attend to other information" (p. 348). Next, in the working memory, internal connections will be made between elements of the selected information to construct a new coherent mental representation (Fiorella & Mayer, 2016). Wittrock (1989) mentioned that generative learning involves "active generation of relations among parts of the text [or presented materials]" (p. 349). Then, the learners' brains will activate the long-term memory to bring the relevant prior knowledge and to integrate it with the new mental representation constructed in working memory (Fiorella & Mayer, 2016). Generative learning involves "active generation of . . . relations between the text [or presented materials] and [prior] knowledge or experience[s]" (Wittrock, 1989, p. 349).

Abstraction, data analysis, and decomposition are all related to each other and to the three cognitive processes: selecting, organizing, and integrating. For example, when reading a book, learners will select what data they need to highlight and what data they need to ignore (abstraction) (Wing, 2008). The learner will then analyze the selected information and activate their prior knowledge to understand the material. They might look for patterns between their existing and the new knowledge and eventually, this will enable the learner to better organize the information in their memory to create a new representation (data analysis). Finally, when a situation demands the recall of stored information to solve a new problem, learners can use abstract thinking and data analysis to divide a complex problem into small and manageable parts (decomposition) (Conery et al., 2011a). Based on Fiorella and Mayer (2016), the processes of organizing and integrating data are called generative processing because it consists of constructing a new mental representation based on learners' existing knowledge. Cognitive processing allows learners to develop meaningful knowledge that they can use in new situations.

b. Knowledge creation processes. Wittrock (1974) stated, "People tend to generate . . . meanings that are consistent with their prior knowledge" (p. 88). It means that learning depends on both presented materials and learners' experiences. In other words, learners must construct relations between presented materials and their past knowledge in order to learn. Creating meaningful knowledge "is a process of generating . . . associations between stimuli and stored information" (Wittrock, 1974, p. 89). In generative learning, there are three critical steps in the knowledge creation process: selecting data for further processing, constructing internal connections among them to form a coherent representation, and building external connections with other representations in a systematic way (Fiorella & Mayer, 2015). GLT enables learners to transform the incoming information such as pictures and words into meaningful and practical knowledge such as mental models and schemes. As learning occurs, individuals develop sophisticated schemas, and this is what makes a novice become an expert in the field (Sorden, 2005). In addition, Norman (1993) mentioned that mental models enable individuals to understand their prior knowledge and also assist them to respond to future situations (generalization). This means that obtaining new knowledge, organizing and analyzing that information, and finally, creating new mental models, will enable learners to transfer their knowledge to address a new problem that has similar patterns.

c. Metacognitive and motivational processes. Harris and Hodges (1995) defined metacognition as "an awareness and knowledge of one's mental processes such that one can monitor, regulate and direct them toward the desired end" (p. 153). Metacognitive processes allow individuals to identify which information is needed, which prior knowledge to activate, and what types of knowledge need to be structured (Fiorella & Mayer, 2015). According to Flavell (1979), metacognition includes both metacognitive knowledge (i.e., the acquired knowledge that can be applied to regulate cognitive processes) and metacognitive regulation (i.e., the use of learning strategies to control cognitive activities and to guarantee that a cognitive outcome will be obtained). These procedures assist individuals to regulate their learning by performing cognitive activities and achieving desired outcomes. A self-questioning strategy can be used to guarantee that the cognitive goal of comprehension is obtained (Livingston, 2003). To illustrate, imagine you have been given a problem in a scenario form. After reading the scenario, you may question yourself about the presented problem in the scenario. In this case, the cognitive goal is to understand the problem. If you can answer the questions that you have generated, that means you have met the cognitive goal by understanding the problem.

Fiorella and Mayer (2016) stated, "generative learning depends on the ability to accurately evaluate one's own understanding of the material and to select appropriate learning strategies that prime selecting, organizing, and integrating" (p. 719). Clearly, understanding problems helps individuals to (1) develop step-by-step instructions to solve a problem (algorithms design), (2) determine the need for incorporating technology to address a problem (automation), and (3) distribute tasks and to collaborate in groups simultaneously to address the problems more efficiently (parallelization). Furthermore, after understanding a particular problem and finding the appropriate solution, individuals need to find a way to depict and organize results (data representation). In some cases, individuals need to test the solution by developing a model to imitate the solution processes (simulation).

Fiorella and Mayer (2016) mentioned that individuals have to be motivated to begin and maintain generative processing even if they have strong metacognitive skills. Motivation is defined as "a cognitive state that initiates, energizes, and maintains goaldirected behavior" (Fiorella & Mayer, 2015, p. 388). In other words, individuals have to be willing to invest cognitive effort toward understanding presented materials during learning. In fact, many aspects, such as the individual's interests, beliefs, objectives, and attributions, could impact motivation. To generate knowledge, individuals need both solid metacognitive skills and motivation to initiate, maintain, regulate, and direct suitable cognitive processing during learning (Fiorella & Mayer, 2016).

E. Integrating CT Concepts in K-12 Education

a. The importance of integrating CT concepts in K-12 education. As mentioned earlier in the Computational Thinking concepts section, CT skills are fundamental skills for everyone (Csizmadia, Curzon, Dorling, Humphreys, Ng, Selby, & Woollard, 2015; Wing, 2008; Wing, 2006). Wing (2006) has stated, "To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability" (p. 33). Also, she has argued that the use of CT concepts, methods and tools would change every discipline, profession, and sector (Wing, 2016). Many scholars, like Wing, believe that CT is a revolutionary concept, and that it is integral to a solid educational foundation as are reading and writing (Bundy, 2007; Day, 2011). Chioccariello, Dettori, Ferrari, Engelhardt, and Punie (2016) summarized two main trends that emerge regarding the rationale of integrating CT concepts into compulsory education: " [1] developing CT skills in children and young people to enable them to think in a different way, express themselves through a variety of media, solve real-world problems, and analyse [sic] everyday issues from a different perspective; [2] fostering CT to boost economic growth, fill job vacancies in ICT [Information and Communication Technology], and prepare for future employment" (p. 25).

CT offers many possible applications in a wide range of disciplines. Bundy (2007) noted that CT knowledge has been used in various disciplines through problem-solving methods, and it is essential that individuals are able to think computationally in every discipline. For instance, some CT concepts (Data analysis and abstraction) could be implanted in social studies by finding trends in population data and concluding general principles from facts (Barr & Stephenson, 2011). Therefore, a number of scholars have called for teaching CT concepts in early stages (Fletcher & Lu, 2009; Qualls & Sherrell, 2010; Wing, 2008; Yadav, Mayfield, Zhou, & Hambrusch, 2014). Studies on embedding CT concepts in K-12 begin to emerge, and they suggests that students who are exposed to CT concepts would show significant improvement in their problem-solving and critical-thinking skills (Yadav et al., 2017). For example, Calao, Moreno-Leon, Correa, and Robles, (2015) stated that integrating CT concepts in a sixth-grade mathematics class has resulted in significant improvement in students' understanding of mathematics processes. It is no longer adequate to wait until students are in college to introduce CT skills because all students are living a life heavily influenced by computing (Barr & Stephenson, 2011). More specifically, Barr and Stephenson (2011) have argued for the need to focus on "algorithmic problem solving practices and applications of computing across disciplines, and help integrate the application of computational methods and tools across diverse areas of learning" (p. 49). In fact, some teachers are already unintentionally implementing some CT concepts in their lessons.

For example, students are learning about the Roman Empire in a social studies class. They have been asked to compare the events in an ancient Roman child's life to their own life experience. By applying CT concepts, students would break down the problem into small pieces (decomposition and abstraction). After decomposing the problem, students would follow logical steps to address it (algorithm design). For the first step, students should identify the lifestyle of ancient Roman children (data collection). In the second step, students should compare the identified lifestyle to their own (patterns recognition). For the final step, students should logically organize and analyze data to represent their findings (data analysis and representation).

b. Initiatives of integrating CT concepts in K-12 education. Integrating CT concepts into K–12 curricula undoubtedly present significant challenges, and it will be a gradual and evolutionary process. Integrating CT skills into K–12 requires efforts in two directions: educational policy change and teachers' resources (Barr & Stephenson, 2011; Fletcher & Lu, 2009; Yadav, Stephenson, & Hong, 2017). For more illustration, educational policy makers need to be aware of the nature and the importance of CT concepts as well as its connections to learning goals. Also, teachers need resources that explain how to integrate CT concepts suitably and more efficiently. Teachers' resources should first be tied to their pedagogical knowledge, and later into their classroom practices (Barr & Stephenson, 2011). In addition, embedding CT concepts in K-12 education requires teachers to be well prepared (Yadav et al., 2017). More specifically, teacher preparation programs need to equip teachers with the knowledge of CT concepts and instructional strategies needed to incorporate CT into their curricula. In other words, teachers of each subject area should be able to support their students' understanding of CT concepts.

Barr and Stephenson (2011) mentioned several strategic areas that are critical in implanting CT concepts in K-12 education. One of these strategic areas is teachers' professional training. In the United States, President Obama's "Computer Science for All" initiative aims to prepare K-12 students with CT concepts, so that they could be active participants in this modern world (Becker, Freeman, Hall, Cummins, & Yuhnke, 2016; Wing, 2016). Becker et al., (2016) stated that "States will receive $4 billion in funding and school districts $100 million to expand training programs for teachers as well as access to high-quality instructional materials" to embed CT concepts within K-12 education (p. 30). Another strategic area is to ask professional education associations to embrace CT concepts in their workshops, conferences, and professional trainings (Barr & Stephenson, 2011). For example, the Society for Information Technology & Teacher Education (SITE) holds an annual conference that contains Special Interest Groups (SIGs) in CT (SITE & AACE, 2017). For another example, in 2010 the National Science Foundation designed a program called Computing Education for the 21st Century (CE21) to help K-12 students and their teachers to develop CT competencies (Wing, 2014).

Commercial institutions are also endorsing the importance of CT for all. In 2006, Carnegie Mellon University, with support from Microsoft and Google, organized summer workshops for secondary school teachers called Computer Science For High School (CS4HS) (Grover & Pea, 2013; Wing, 2014). The purpose of these workshops is to provide a message that there is more to CS than programming (Wing, 2014). By 2013, these workshops under the sponsorships of Google have spread to serve "…63 schools in the United States, 20 in China, 12 in Australia, 3 in New Zealand, and 28 in Europe, the Middle East and Africa" (Wing, 2014, p. 5). Furthermore, a number of associations and corporations, including scientific societies and non-profit organizations, collaborated to establish "Computing in the Core" initiative. This initiative was founded by Google, Microsoft, Association for Computing Machinery (ACM), CSTA, Computing Research Association (CRA), National Center for Women and Information Technology (NCWIT), and Anita Borg Institute to promote CS education to a core academic subject in K-12 education (Wing, 2014; Code.org, 2017). Later, Computing in the Core initiative merged with Code.org, which is also another initiative is funded by Allen and Company, Google, Amazon, JPMorgan Chase and Co., Juniper Networks, Microsoft, LinkedIn, and Salesforce (Wing, 2014). Code.org shares similar values and goals of Computing in the Core, which is the need for professionals trained in computing skills. Code.org offers many educational materials and tools that can be incorporated into many devices such as smart phones and tablets to teach computing skills (Wing, 2014; Code.org, 2017). Moreover, one of the goals of Code.org is to disseminate knowledge internationally by organizing an annual Hour of Code event (Code.org, 2017). This event has involved ten percent of all students from all around the world, and it offers the leading curriculum for K-12 CS in the largest school districts in the United States, such as Columbus City School District (Columbus, OH), Chicago Public Schools (Chicago, IL), Miami-Dade County Public Schools (Miami, FL), Denver Public Schools (Denver, CO), and Los Angeles Unified School District (Los Angeles, CA) (Code.org, 2017).

The Next Generation Science Standards (NGSS) has identified CT concepts as essential skills for K-12 students; more specifically, for scientific and engineering practices (National Research Council, 2012). The NGSS proposed that K-12 students should explore data sets using CT concepts and mathematical tools (National Research Council, 2012). The project, "Growing Up Thinking Scientifically" (GUTS) is an example of integrating CT concepts in science classrooms. The project highlights what

CT concepts look like for students by using three domains: Game Design, Simulation, and Robotics (Lee, Martin, Denner, Coulter, Allan, Erickson, Malyn-Smith, & Werner, 2011; Yadav, Stephenson, & Hong, 2017). The project GUTS focuses on three of CT concepts: Abstraction, automation, and analysis, and the helps students deepen their acquisition of CT concepts in the context of science learning throughout a use-modify-create learning progression (Lee et al., 2011).

Integrating CT concepts into K-12 education has also spread internationally. In 2012, the British Royal Society published a report called *Shut down or restart? The way forward for computing in UK schools* that recommended “Every child should have the opportunity to learn Computing at school” (The Royal Society, 2012, p. 6). After this report, United Kingdom (UK) Department of Education developed a new national curriculum for computing (UKEd13) with the goal by Fall 2014 all K-12 students in the UK being exposed to ideas in CS suitable for their grade level (Wing, 2014; Wing, 2016).

In 2016, the College Board organization in the United States has developed a new CS curriculum for high schools called *Computer Science Principles* concentrating on exposing students to CT concepts and applications (Yadav et al., 2017). This curriculum developed to go beyond programming and to focus on CT practices to "help students coordinate and make sense of knowledge to accomplish a goal or task" (College Board, 2017, p. 6). Moreover, CoolThink@JC is a four-year initiative that has been launched by collaboration among the following: MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL), City University of Hong Kong, and the Education University of Hong Kong (School of Engineering, 2016). The aim of the CoolThink@JC initiative is to empower primary school teachers and students with CT skills (School of Engineering, 2016). This initiative's goal is to offer training for over 16,000 students at 32 primary schools across the city of Hong Kong, and the training would include tools and expertise to boost CT knowledge (School of Engineering, 2016).

c. CT concepts and teachers of K-12 education. Students could learn about CT skills and concepts by observing teachers (National Research Council, 2010). The NRC report states that teachers could guide students to use thinking strategies, such as CT skills, independently. Thus, teachers have a great responsibility to develop and guide students' thinking abilities, including CT. However, there are many challenges that teachers face in teaching CT, such as being unfamiliar with CT concepts or having misconceptions regarding CT concepts (Bower et al., 2015). Often times, teachers feel nervous and worried throughout preparation programs, especially when being exposed to new or unfamiliar content (Paul Curzon, McOwan, Cutts, & Bell, 2009).

Students in K-12 would have greater exposure to CT concepts when future teachers have been prepared to present subjects by using ideas from CT concepts (Yadav, Zhou, Mayfield, Hambrusch, & Korb, 2011). Consequently, teachers need to be well prepared and trained to integrate CT concepts into their discipline and teaching practices (Blank, Pottenger, Sahasrabudhe, Li, Wei, & Odi, 2003; British Computer Society, 2010; National Research Council, 2010). The first step toward teachers' preparation is to begin from the basis of pre-service teacher knowledge (Teacher Education Programs). Bower, Lister, Mason, Highfield, and Wood (2015) have surveyed teachers from a broad range of institutions and backgrounds in Australia about their understanding of CT. They concluded, "Many teachers had misconceptions about Computational Thinking constructs, adding to the challenge of developing students Computational Thinking capabilities. This indicates a pressing need for professional development and programs to support teacher implementation of Computational Thinking" (Bower et al., 2015, p. 14).

Yadav, Zhou, Mayfield, Hambrusch, and Korb (2011) have designed a one-week CT module for an undergraduate course that is complementary for all elementary and secondary majors to enroll in. The purpose of this module is to expose students (pre-service teachers) to computing (CT concepts) as well as to show how computing can be used in their future teaching. They found that pre-service teachers are more likely to integrate CT principles in their future teaching when they have been exposed to relevant information about CT concepts (Yadav et al., 2011). Overall, the CT module has improved pre-service teachers' understanding of CT knowledge; it helped them to realize that they can demonstrate CT ideas in K-12 classrooms without using digital devices, such as computers, and they also can incorporate CT concepts across all disciplines (Yadav et al., 2011). In another study, Yadav, Mayfield, Zhou, and Hambrusch (2014) concluded that exposing pre-service teachers to CT concepts early in their teacher preparation may permit them to realize the importance of CT in their own disciplines (Yadav, Mayfield, Zhou, & Hambrusch, 2014).

The second step toward teachers' preparation is training and professional development for in-service teacher level. Blum and Cortina (2007) offered workshops for high school CS teachers, and they introduced CT concepts during workshops for the purpose of increasing CS teachers' awareness of CT. They found that the workshops have improved CS teachers' understanding of CT as well as their knowledge of the importance of CT in all aspects of life. In a similar study, Curzon et al., (2014) have developed five workshops to train teachers on CT concepts by using unplugged storytelling activities. The researchers found that the workshops helped teachers to be familiar with CT concepts and to build their confidence in teaching CT knowledge (P. Curzon et al., 2014). Morreale and Joiner (2011) studied high school CS teachers' perceptions of CS as a learning tool to solve complex problems. They found that teachers' perceptions have changed due to exposure to CT concepts (Morreale & Joiner, 2011). These findings recommend that familiarizing teachers on CT concepts can change their behavior towards computing. Therefore, it is critical to offer all teachers with significant CT knowledge and skills to integrate them into academic disciplines (Yadav et al., 2014).

F. Approaches and Technologies to Develop Students' CT Skills

To develop students' CT skills, teachers are required to use a variety of different teaching methods (Guzdial, 2008). In fact, a wealth of strategies, approaches, tools, and resources are found to help teachers and educators to develop students' CT skills and also to obtain ideas on how to incorporate them into their daily lives. Philips (2009) stated, "learning activities that allow students to discover and explain scientific relationships, predict events, and learn procedural skills will enable them to better understand these subjects [academic subjects], to predict behavior, and to build computational thinking skills" (p. 2). Technology is a substantial support and help regarding developing students CT skills; however, some teachers find that using technology is challenging. Therefore, the following section will illustrate some ideas that could be appropriate for developing students' CT skills without technology (Technology-Free).

a. Technology-free activities. Some teachers are not comfortable with or have access to technology in their classrooms. The rapid development of technologies creates a significant challenge for CS teachers in teaching CS curricula at K-12 setting (Gal-Ezer & Stephenson, 2009). To address this challenge, CS teachers can incorporate educational activities that support teaching CT concepts without technology. Therefore, it is reasonable to think about the technology-free options because these options would serve many classroom teachers, especially those who are not technologically savvy, those who lack the appropriate training on using technology, and those who do not have access to technology for all students (Weinberg, 2013). The following are materials and ideas that can be appropriate for all K-12 students.

The National Center for Women and Information Technology (NCWIT) developed *Computer Science-in-a-box: Unplug Your Curriculum* with the purpose of demonstrating that CS is about more than programming (National Center for Women & Information Technology, 2011). It contains a number of free activities, such as Minimal Spanning Trees, Graph Coloring, and Parity and Error Detection, to introduce students to the fundamental concepts in CS, including CT, without the use of a computer (Bell, Fellows, & Witten, 2002; Bell, Alexander, Freeman, & Grimley, 2009; National Center for Women & Information Technology, 2011). Furthermore, it includes lessons that teach how computers work while simultaneously addressing mathematics and science concepts (National Center for Women & Information Technology, 2011). Rodriguez (2015) studied the effectiveness of using CS Unplugged activities, such as Minimal Spanning Trees, in teaching CT skills. The researcher found that the CS Unplugged activities can be used to enhance students' CT abilities and achieve satisfying mastery level (Rodriguez, 2015). The *Computer Science-in-a-box: Unplug Your Curriculum* is available and free to download, for both personal and educational use through www.csunplugged.com.

In a similar initiative, Cozzens, Kehle, Garfunkel, Bradley, and Weinberg (2010) with the support from National Science Foundation, began a project called the *Value of Computational Thinking across Grade Levels* (*VCTAL*). The project offers twelve instructional modules that have been designed to engage secondary school teachers and students in the process of applying CT concepts to problem solving in a variety of scientific contexts. These modules and lessons are activity-based, and they can be used in many disciplines, such as Computer Science, Natural Science, and Mathematics (Cozzens et al., 2010). In fact, the process of integrating a physical activity (unplugged activity) makes learning CT concepts energetic and engaging (Chioccariello, Dettori, Ferrari, Engelhardt, & Punie, 2016; Curzon, McOwan, Plant, & Meagher, 2014). Curzon et al., (2014) developed five workshops that contain many unplugged storytelling activities to train teachers on CT concepts. They found that using unplugged storytelling activities to introduce CT concepts is inspiring and confidence building (P. Curzon et al., 2014).

Collaboration learning (working in groups) is one of the learning strategies that could be used to promote students' CT abilities (Bower et al., 2017, 2015; Bower & Falkner, 2015; Conery et al., 2011; Goode & Chapman, 2011), more specifically data collection, data analysis, and data representation (Mannila et al., 2014). Bower, Lister, Mason, Highfield, and Wood (2015) surveyed teachers to measure their attitudes towards CT concepts and also their knowledge of pedagogies and technologies that could be used to improve students CT abilities. They found that teachers use the following approaches to develop their student CT skills: Problem-Based Learning, collaboration, and scaffolding. One of the collaboration learning activities is role-playing, which Conery et al., (2011) have suggested to use to develop CT skills, more specifically the skills of data collection, data analysis, and generalization. Some teachers mentioned that they could use role-playing to develop their students' CT abilities (Bower et al., 2015).

Conery et al., (2011) recommended some useful unplugged learning strategies, such as questioning strategy. Bower et al., (2015) stated that some teachers could use questioning strategy to develop students CT capabilities. In fact, teachers can ask their students questions to get them to think about the subject more deeply, which would lead students to find patterns and connections among the collected data. In other words, questioning strategy could help students to develop CT abilities, such as the skills of data collection, data analysis, data representation, and algorithmic design (Brennan & Resnick, 2012; Conery et al., 2011a).

b. Technology involvement. Technology's presence in the field of education has become important in allowing the field to keep pace with developments in other areas, such as engineering, medicine, defense, and modern sciences. The importance of technology increases over time in education. The field of education has witnessed a great growth in university research, teaching methods, and curriculum development in the late twentieth century, and has become more developed at the beginning of this century. The development of technologies has led to the emergence of a generation called *Net Generation.* As Berk (2010) describes, this generation "…never knew a world without computers and the Internet." In the *Net Generation*, learners use technologies in their daily lives. Over 94 percent of *Net Generation* owns computers, laptops, and smart devices (Junco & Mastrodicasa, 2007). Besides, 99 percent of them are using the Internet for researching information (Pryor et al., 2009). Learners who belong to this generation have particular characteristics. They are technology savvy, can multitasks, interested in multimedia, rely on search engines for data, learn by inductive discovery, communicate visually, favore teamwork and collaboration, and obtain feedback (Berk, 2009). Furthermore, the educational setting differs between generations; classrooms today have more equipment especially after the wide spread of technology.

Grover and Pea (2013) mentioned that digital devices can be used to promote CT concepts to solving problems. Bower et al., (2017) found similar results when they conducted a study that aims to improve teachers' CT capabilities. More specifically, Bower and his colleagues want "to measure teachers' understanding of and attitudes towards computational thinking…" (p. 57). They offered workshops to develop teachers' CT knowledge, and the researchers also used pre and post surveys as tools for data collection method. Bower et al., (2017) found that 91 responses showed "agreeing technological devices could support the development of computational thinking. Devices like personal computers, iPads, mobile phones, laptops, interactive whiteboards, interactive televisions, digital cameras, etc. were referenced by teachers" (p. 62).

Flipped classroom. Teachers can use a flipped classroom approach to develop students' CT skills. A flipped classroom is reversing the traditional way of teaching: lecture, through the use of videos will be done at home, and assignments and critical thinking, discussion and reflection will be done in the classroom. In this case, the classroom is used for producing an active learning environment: students interact with their classmates and teacher (Shriya, Ashwini, & Archana, 2015). Flipped classrooms could be applied through using many technologies, such as video tutorials and social media tools. Teachers can create or choose existing video tutorials in which students can watch them outside classrooms. Teachers could use YouTube or TED-Ed as ways to share the video tutorials. At home, students could watch the video tutorials, and they would use CT skills, such as problem decomposition, abstraction, and data collection. In the classroom, the teacher could promote students CT skills by dividing the students into groups and engaging them in active learning (Bower & Falkner, 2015). Each group will be given a problem to solve based on the video tutorials that they have watched at home. In each group, students would decompose the problem, analyze the collected data, and assign tasks to each member in the group to perform a small-decomposed part of the problem simultaneously to find the solution more efficiently. Then, groups are required to present their solutions by using one of the presentation tools, such as PowerPoint or Google Slides. Through this scenario, the teacher could develop students' CT skills.

Game Based Learning (GBL). Teachers could use a Game Based Learning (GBL) approach to design learning activities (games and playing) that could develop students' CT skills (Bower & Falkner, 2015). GBL broadly refers to the utilization of games to encourage learning processes through students' engagement (Pho & Dinscore, 2015). GBL enables teachers to create learning activities that could introduce concepts and direct students to achieve desired learning objectives. Teachers could use games that tell a story to develop students' creative writing, and also, they could use puzzle games to develop students' problem-solving skills. Teachers also could use GBL to reach students' interests and facilitate collaborative learning as well as enhance the problem-solving process. For example, teachers could ask students to play a racing game and record the lap times. Then, the students could work in small groups and use the collected data to learn how to calculate the mean, mode, and median. There are many useful games that teachers could adopt to facilitate the learning process and develop students' CT skills.

For example, teachers could use Second Life (SL), an online virtual world that users can log into with their virtual avatars and explore digital spaces through field trips and visit any world attractions, such as exhibitions and museums (McKay, Van Schie, & Headley, 2008). Chien, Davis, Slattery, Keeney-kennicutt, and Hammer (2013) have used SL to develop students' self-reflection and self-understanding regarding teaching and learning. The researchers used two types of virtual exhibitions: war and ecology, and Chien, et al., (2013) found that participants have the chance to apply critical thinking skills and to conduct multiple conversations. Also, this study concluded that using exhibitions in SL enables participants to develop a self-understanding, which in turn helps them to reconstruct their knowledge. Based on the previous study, the reader can realize that SL assists participants to collect data, represent data, think abstractly, and use technology (automation), which are four critical aspects of CT concepts.

Another useful game that could be used to enhance students' CT abilities is Minecraft, which is also called a sandbox game. Based on the Minecraft site (2016), Minecraft is a game available on multiple platforms (e.g. smartphone, computer, tablets, PlayStation and X Box) where players go through many adventures by placing blocks, exploring generated worlds, and constructing objects such as homes and airports. Chambers (2014) used Minecraft to teach students logic gates (e.g., AND/NOT and OR gates). Logic gates are digital circuits that have two inputs and one output. Minecraft users could use logic gates to make different objects, such as clocks. Chambers (2014) noticed that there is a high possibility of combining GBL and flipped classroom approaches. He mentions that it would be engaging if the students tried using Minecraft at home. Then, they share their projects in class and have a group discussion about them. Bower et al., (2017) surveyed a number of teachers after offering workshops about CT concepts, and they found that more than 30 responses suggested that games, such as Kodu and Minecraft, could be used to teach students CT skills.

Coding and programming. The two terms *Coding* and *Programming* are frequently used interchangeably to indicate the process of writing instructions for a computer to perform (Chioccariello et al., 2016). However, programming refers to many activities, such as analyzing a problem, designing a solution, and implementing a solution (Chioccariello et al., 2016). Coding refers to the stage of implementing solutions in one of the programming languages (Chioccariello et al., 2016). Some scholars have mentioned that CT and programming are not overlying sets of skills. Wing (2006) mentioned, "Thinking like a computer scientist means more than being able to program a computer" (p. 34). In fact, programming could be used as a learning tool to teach CT concepts or explore other domains of self-expression through the creation of videogames (Chioccariello et al., 2016).

Teachers, especially CS teachers, could use visual programming to develop students CT skills. Lye, Hwee, and Koh (2014) stated that visual programming languages could facilitate CT concepts in K-12 contexts "…because unnecessary syntax is reduced (e.g., the use of semi colon and curly brackets) and the commands are closer to spoken English. Students usually need only to drag and snap the command blocks" (p. 53). In fact, visual programming tools, such as Scratch, help reduce students' cognitive load, and allow them "…to focus on the logic and structures involved in programming rather than worrying about the mechanics of writing programs" (Kelleher & Pausch, 2005, p. 131). Additionally, students would have the opportunity to focus on creating and experimenting with problem-solving instead of thinking about how to work with coding in a textual language (Chioccariello et al., 2016). Therefore, some teachers have used visual coding and programming platforms, such as Scratch, Raspberry pie etc., to develop students' CT skills (Bower et al., 2017, 2015; Bower & Falkner, 2015). Conery et al., (2011) have recommended using Scratch to develop students CT skills; more specifically, data representation, automating, and generalization. Similar studies found that teachers prefer using onscreen blocks (i.e., Tangible program language, specifically designed to program a robot's behavior) and game-play to teach CT concepts to K-12 students (Wang & Chen, 2010; Kazakoff & Bers, 2012). Furthermore, block-based programming environments (e.g. Kodu, Scratch, Agentsheets, and StarLogo TNG simulation software) can be used to provide animated storytelling activities, in which students have to perform valuable practices of CT concepts (Bauer, Butler, & Popovi, 2015; Bienkowski, Snow, Rutstein, & Grover, 2015; Brennan & Resnick, 2012; Chioccariello et al., 2016; Israel, Pearson, Tapia, Wherfel, & Reese, 2015; Li, 2016; Sneider, Stephenson, Schafer, & Flick, 2014; Weese & Feldhausen, 2016).

G. Teachers Confidence in Teaching CT Skills

To the best of the researcher's knowledge, there are few studies that have explored teachers' confidence level in teaching CT skills. Bower et al. (2015) stated that some Australian teachers do not feel confident in teaching CT skills due to the lack of CT knowledge as well as the lack of support from schools or districts. Bower and his colleagues (2017) conducted another study; where this time they offered workshops to develop Australian teachers' CT knowledge and to build their confidence in teaching these capacities. Bower et al., (2017) concluded "teachers felt more confidence to develop their students' computational thinking abilities after the workshops" (p. 64). This finding showed that it is possible for teachers to enhance their CT knowledge and to promote their confidence level of teaching these capabilities by attending workshops.

Curzon et al., (2014) mentioned that UK teachers have a lack of conceptual understanding of CT knowledge. Therefore, they offered several workshops to introduce CT concepts and to build teachers confidence in teaching CT. After the training, teachers stated that workshops are engaging, inspiring, and confidence building; for example, one of the teachers stated, "the best thing about the workshop: 'realising [sic] the approachableness of computer science. It is now less daunting to teach'" (Curzon et al., 2014, p. 92). In another study, Sentance and Csizmadia (2017) surveyed over 300 teachers in the UK to describe these teachers' viewpoints on challenges and strategies of computing in curricula. The survey contained questions about teachers' confidence level regarding computing (CT) skills. The results showed that most teachers are confident in delivering CT knowledge, and some teachers still need training to raise their confidence level in pedagogical skills regarding computing (Sentance & Csizmadia, 2017). In fact, the lack of research in this area indicates further investigation of teachers' confidence level in teaching CT skills.

H. Summary

This study aims to investigate the level of conceptual mastery in CT among male CS teachers who teach at public secondary schools that implement CSS in Riyadh, Saudi

Arabia. In addition, this study will explore what approaches CS teachers use to develop students' CT capabilities regarding both pedagogical strategies and technologies, while also considering their confidence level of teaching CT skills. The literature review was discussed in several main sections. The first section introduced Saudi Arabia schooling system and illustrated its types. The second section focused on the importance of the Computer Science field on individuals' lives. The third section reviewed CT definitions, characteristics, and concepts. The fourth section discussed the study's theoretical framework and described Generative Learning Theory and its connection to CT concepts. The fifth section reviewed previous studies about integrating CT concepts in K-12 Education. The sixth section reviewed previous studies about approaches and technologies have been used to develop students' CT skills. The last section reviewed previous studies about teachers' confidence level in teaching CT skills. There was a lack of studies that explored this area, which makes the current study valuable to address the gap in the literature. The following Chapter will describe the methodological aspects of the current study including research design, instrumentation, data collection procedures, and data analysis procedures.

Chapter Three

Methodology

A. Research Design

a. Type of non-experimental design

The purpose and the research questions implied a non-experimental design. Specifically, they indicated a descriptive design because the focus is on exploring male CS teachers' current conceptual mastery in CT. Based on the traditional classification of non-experimental research, the current study used a survey design. Creswell (2012) stated, "survey research designs are procedures in quantitative research in which investigators administer a survey to a sample or to the entire population of people to describe the attitudes, opinions, behaviors, or characteristics of the population" (p. 376). In this study, the level of conceptual mastery of CT represents teachers' knowledge, while pedagogical strategies and technologies that CS teachers report they use to develop students' CT skills represent behavioral data. The researcher collected these data through distributing a single questionnaire to address the following research questions:

1. What is the level of conceptual mastery of CT among male CS teachers who teach at public secondary schools that implement CSS in Riyadh as measured by "Questionnaire of Computational Thinking (QCT)"?
2. What pedagogical strategies do male CS teachers who teach at public secondary schools that implement CSS in Riyadh report using to develop students' CT skills?
3. What educational technologies do male CS teachers who teach at public secondary schools that implement CSS in Riyadh report using to develop

students' CT skills?

4. What is the confidence level of male CS teachers who teach at public secondary schools that implement CSS in Riyadh in teaching CT skills?

b. Population, sample, and sampling procedure

In non-experimental studies, researchers frequently select a sample from a target population, which is a group of individuals with the same feature that the researcher identifies in a study (Creswell, 2012). The target population of the current study was male CS teachers who teach at public secondary schools that implement CSS in Riyadh, Saudi Arabia. As such, three inclusion criteria used. Every member of the target population was a CS teacher, a male, and teaching at a public secondary school that implements CSS in Riyadh.

According to the Ministry of Education's Statistical Cards for the year 2015- 2016 there are 42 public secondary schools serving male students that implement CSS in Riyadh. The researcher contacted the director of the Computer Department of the General Administration for Education in Riyadh via email to determine the size of the target population. The researcher found that the target population size is 101 CS teachers. The director has provided a list of the CS teachers who teach in public secondary schools that implement CSS, including their contact information. Given that the target population size was small and finite, the entire target population was studied. This theoretically means that the researcher used non-probability sampling defined as selecting individuals "because they are available, convenient, and represent some characteristic the investigator seeks to study" (Creswell, 2012, p. 145). Specifically, the researcher used non-probability sampling called census sampling. The researcher attempted to receive responses from all CS teachers who teach at public secondary schools that implement CSS in Riyadh, Saudi Arabia.

B. Variables

To answer the research questions, four variables have been measured. These variables were as follows: (1) level of conceptual mastery of CT, (2) pedagogical strategies used to develop students' CT skills, (3) technologies used to develop students' CT skills, and (4) level of confidence in teaching CT. The first variable was continuous variables, and the rest of the variables were categorical variables. A more detailed discussion of these variables was included in the instrumentation section below.

C. Instrumentation

a. Questionnaire development

To collect data on the variables in the study, a questionnaire was developed and administered using a free online questionnaire tool (Qualtrics). The questionnaire was named "Questionnaire of Computational Thinking (QCT)," and it was offered with two languages: English and Arabic (Appendix C and F). The questionnaire was a closed-ended survey with some open-ended questions. The questionnaire contained 37 questions that distributed over five sections as follows:

Section one: demographic information. This section concentrates on the demographic information of CS teachers. This section has eight closed-ended questions that ask participants about their age, educational level, years of experience, etc. The data obtained from this section was used to describe the questionnaire's participants.

Section two: computational thinking skills and its concepts. This section has 22 multiple-choice questions with five options, and one of these five options is correct.

Each question weighs one point, which means that the highest score that a participant can obtain is 22 point. These questions use to get the participants' conceptual mastery level of CT. For example, participants have been asked if Computational Thinking is a fundamental skill for: (1) everyone, (2) teachers and students, (3) Computer scientists including programmers, (4) Engineers, or (5) Psychologists. The data obtained from this section was used to answer research question Number One. Furthermore, the researcher conducted a pilot study on 40 participants to establish reliability of this section (see Chapter Four) and to design a grading scale. In the pilot study, the mean score of participants was 9.9 with standard deviation of 3.855. Based on the pilot study result, the score between 22 and 18 (100-80%) is "High"; the score between 17 and 14 (79-60%) is "Acceptable"; while the score 13 and below (59-0%) is considered "Low."

Section three: pedagogical strategies. This section has two open-ended questions that ask participants about pedagogical strategies used to develop students' Computational Thinking skills. For example, participants have been asked, "What pedagogical strategies do you use to develop your students' computational thinking skills?" The data obtained from this section was used to answer research question Number Two.

Section four: classroom educational technologies. This section also has two open-ended questions that ask participants about classroom educational technologies used to develop students' CT skills. For example, participants have been asked, "What educational technologies are available in your classroom?" The data obtained from this section was used to answer research question Number Three.

Section five: confidence level. This section contains a Yes/No question and two open-ended questions that ask participants about their confidence level of teaching Computational Thinking skills. For example, participants have been asked; "Are you confident in teaching Computational Thinking skills?" If the answer was "Yes," the participant has to answer the following question: "What are some reasons that make you confident in teaching Computational Thinking skills?" While if the answer was "No," the participant has to answer the following question: "Why do you not feel confident in teaching Computational Thinking skills?" The data obtained from this section was used to answer research question Number Four.

b. Questionnaire translation

As mentioned earlier, the target population was Saudi CS teachers who speak Arabic as a mother language. Therefore, there was a need to translate the questionnaire from English to Arabic. The researcher translated the questionnaire, and then he obtained translation approval from the Department of Foreign Languages at University of Toledo (Appendix D).

D. Data Collection Procedures

The questionnaire was distributed by the researcher to CS teachers through e-mail, Short Message Service (SMS), and/or smart devices' communication applications, such as WhatsApp (an instant messaging application broadly used in Saudi Arabia), at the end of fall of 2017 semester. An electronic data collection method has been chosen because web surveys allow for effective and economical surveying of the whole population as well as promoting a high response rate (Creswell, 2012). To further enhance the latter, the researcher contacted the CS teachers up to three times by –mail, SMS, and WhatsApp asking for their participation in the study.

Prior to the study, the researcher obtained permission from the University of Toledo's Institutional Review Board (IRB) (UT IRB Guidance Form, 2008), because this research study involves interaction with human subjects as well as collecting information that is not available in a public source or commercial provider (NHS Determination Form, 2015; UT IRB Guidance Form, 2008). The researcher explained how the study's design and procedures will "minimize harms and risks and maximize benefits; respect human dignity, privacy, and autonomy; take special precautions with vulnerable populations; and strive to distribute the benefits and burdens of research fairly" (Resnik, 2011, p. 4). Specifically, the researcher explained that the harms and risks will be minimal and that the researcher was not involving a vulnerable population. Further, participants were not affected by participation even if they scored poorly on the assessment of QCT because the Ministry of Education and the public already hold negative perceptions about the public schools due to the lack of equipment and limited budget (Alhakami, 2014; Alshammari, 2012). In addition, participants' names kept confidential; there is no way that the Ministry of Education could identify participants' scores. The researcher further protected participants' anonymity and confidentiality through storing their identifying information on a computer that only the researcher has exclusive access to. Finally, the researcher asked the participants to complete an online Informed Consent Form before filling out the questionnaire (Appendix B and E). The Informed Consent Form was used to inform teachers about the "…nature and implications of the research and that participation [is] voluntary" (Homan, 2001, p. 330), which implied that teachers had the right to make decisions for themselves - either to complete the questionnaire or withdrawing from the study.

E. Data Analysis Procedures

Descriptive statistics were run to analyze the data. Frequencies, means, standard deviations, and percentages were reported for each research question and displayed in tabular and graph forms. In addition, qualitative coding techniques were used to analyze the open-ended responses. The researcher used classification to determine the initial analytical categories, and also an axial coding was used to determine emergent themes and modify the initial categories. It is possible that the current study has a greater total of responses than the number of participants in the open-ended questions because each participant may provide multiple responses that were coded in more than one category. Furthermore, descriptive statistics were used to report the demographic characteristics of participants in this study. In Table 2, the researcher presented research questions, data collection methods for each question, and how each question was analyzed.

Table 2

Research Questions, Data Collection Methods, and Data Analysis

Research Questions	Data Collection Methods	Data Analysis
Q1: What is the level of conceptual mastery of CT among male CS teachers who teach at public secondary schools that implement CSS in Riyadh as measured by "Questionnaire of Computational Thinking (QCT)"?	Section Two in QCT	Descriptive statistics

Research Questions	Data Collection Methods	Data Analysis
Q2: What pedagogical strategies do male CS teachers who teach at public secondary schools that implement CSS in Riyadh report using to develop students' CT skills?	Section Three in QCT	Qualitative coding techniques
Q3: What educational technologies do male CS teachers who teach at public secondary schools that implement CSS in Riyadh report using to develop students' CT skills?	Section Four in QCT	Qualitative coding techniques
Q4: What is the confidence level of male CS teachers who teach at public secondary schools that implement CSS in Riyadh in teaching CT skills?	Section Five in QCT	Descriptive statistics and Qualitative coding techniques

Chapter Four

Results

This Chapter covers all findings that are related to present study including the validity and the reliability of the developed instrument. In this Chapter, the researcher used Statistical Package for Social Science (SPSS) 23 to analyze the data of the present study. The researcher also used descriptive statistics to describe participants' characteristics, such as age, years of experience, and educational level. In addition, the researcher presents the findings of the present study based on the study research questions, and this would be as follows:

- The participants' level of conceptual mastery in CT has been presented to answer the research question Number One.
- The pedagogical strategies that participants reported using to develop students' CT skills have been presented to answer the research question Number Two.
- The classroom educational technologies that participants reported using to develop students' CT skills have been presented to answer the research question Number Three.
- The participants' confidence level of teaching CT skills has been presented to answer the research question Number Four.

A. Instrument

a. Questionnaire validity

A valuable research study requires paying attention to instruments' validity and reliability. Cohen (2000) defined validity as "a demonstration that a particular instrument in fact measures what it purports to measure" (p. 133). To validate the developed questionnaire, the researcher obtained both face and content validity. For this process, the researcher used "Survey/Interview Validation Rubric for Expert Panel - VREP©" developed by Marilyn Simon and Jacquelyn White to measure face, content, and construct validity (Appendix G and H). The VREP© contains the following criteria for reviewing the developed questionnaire: clarity, negative wording, wordiness, overlapping responses, balance use of jargon, appropriateness of response listed, use of technical language, application to praxis, relationship to problem, and measure of constructs (i.e., CT concepts, pedagogical strategies and educational technologies used to develop students' CT skills, and teachers' confidence level in teaching CT skills).

The researcher has electronically sent the questionnaire and VREP© to a panel of five experts (two from the United States and three from Saudi Arabia) in the Educational Technology field to ensure the validity of the content as well as face and cultural validity of the Arabic version. The experts provided positive feedback and some recommendations for improvement on all of the following criteria: clarity, negative wording, overlapping responses, use of jargon, and use of technical language. Furthermore, most of the experts mentioned that the measure of constructs meets expectations; which provides evidence that the developed questionnaire has face and content validity. The researcher took into considerations experts' critical feedback and revised the developed questionnaire. Consequently, the final vision of the questionnaire reflects experts' recommendations.

b. Questionnaire reliability

As mentioned earlier, the QCT contains five sections: Demographic Information, Computational Thinking Skills and its Concepts, Pedagogical Strategies, Classroom Educational Technologies, and Confidence Level. The researcher is only required to report the reliability of Section Two because this section represents a single construct, which is Computational Thinking, while the rest of the sections (One, Three, Four, and Five) do not need any type of reliability since the researcher is not trying to measure any other constructs. In fact, the items in Section One will be used to describe the study's participants, and the items in sections Three, Four, and Five will be used to report how participants are utilizing CT concepts.

To establish reliability of the developed questionnaire, the researcher conducted a pilot study on 40 participants after obtaining permission from the University of Toledo's Institutional Review Board (IRB) (Appendix A). The pilot study was also conducted to review, critique, and comment on the questionnaire's items because it is critical that the participants and the questionnaire designer (in this case the researcher) have a similar understanding of the questionnaire's items. In other words, participants on the pilot study helped the researcher in checking the clarity of the items' wording and suitability of response options.

Muijs (2004) stated, "Reliability then refers to the extent to which test scores are free of measurement error" (p. 71). In addition, Creswell (2012) mentioned, "scores from an instrument are reliable and accurate if an individual's scores are internally consistent across the items on the instrument" (p. 161). The researcher used Cronbach's alpha to measure the internal consistency of the second section items in the QCT, which is Computational Thinking Skills and its Concepts. The internal consistency is a form of reliability that is "…only applicable to instrument[s] that have more than one item as it refers to how homogenous the test items of a test are or how well they measure a single construct" (Muijs, 2004, p. 74). Furthermore, this form of reliability can be computed by using Cronbach's alpha. Cohen, Manion, and Morrison (2011) stated, “The Cronbach alpha provides a coefficient of inter-item correlations, that is, the correlation of each item with the sum of all the other relevant items, and is useful for multi-item scales. This is a measure of the internal consistency among the items (not, for example, the people)” (p. 201). In other words, the Cronbach's alpha measures the extent to which the items in an instrument are correlated.

The researcher used Statistical Product and Service Solution (SPSS) version 23 software to compute the Cronbach's alpha. The Coefficient of Cronbach’s alpha ranges from 0 to 1.00, and when the value of Cronbach’s alpha approaches 1.00, it indicates that instrument has high internal consistency between its items (Gliem & Gliem, 2003; Wells & Wollack, 2003; and Davoodzadeh & Sadeghi, 2015). Moreover, the widely cited criterion for internal consistency reliability for psychological and educational studies are: 0.70 for acceptable, 0.80 for satisfactory, and 0.90 for adequate (Nunnally, 1978). As presented in Table 2, the internal consistency reliability coefficients (Cronbach’s alpha) for Computational Thinking Skills and its Concepts section was 0.703 in the acceptable range as Nunnaly (1978) categorized.

Table 3

Internal Consistency Reliability Coefficients in Cronbach’s Alpha

Scales	No. of Responses (N)	No. of Items	Cronbach’s Alpha
Computational Thinking Skills and its Concepts (Section two in QCT)	40	22	0.703

B. Participants' Characteristics

81 male CS teachers participated in the present study from 42 public secondary schools that implement CSS in Riyadh, Saudi Arabia. This number of participants represents 80.2% response rate. However, the researcher excluded 26 participants from the data analysis due to not completing all questionnaire questions, which reduces the response rate to be 54.6% (n = 55). The participants' characteristics in the present study covered participants' ages, educational level, and years of experience. Furthermore, participants' responses provided some primary results concerning whether or not participants were hired based on their competency test score (i.e., employment requirement), the number of workshops that participants had attended regarding teaching Computer Science courses, more specifically Computer 1 and 2 courses, and finally whether or not participants had heard of the term, "Computational Thinking."

a. Age, educational level, and years of experience

As shown in Table 4, there were no participants between 22 to 25 years old, 10.9% were between 26 to 30 years old, 40% were between 31 to 35 years old, 39.5% were between 36 to 40 years old, 10.9% were between 41 to 45 years old, and 3.6% were over 46 years old (see Figure 2). 87.3% of the participants held a Bachelor's degree, 10.9% of the participants held a Master's degree, and 1.8% of the participants held a Doctoral degree (see Figure 3). 1.8% of the participants had less than five years of experience, 43.6% of the participants had between 6 to 10 years of experience, 36.4% of the participants had between 11 to 15 years of experience, 9.1% of the participants had between 16 to 20 years of experience, 7.3% of the participants had between 21 to 25 years of experience, and 1.8% of the participants had more than 26 years of experience (see Figure 4). Finally, 56.4% of the participants were hired based on their competency test scores, while 43.6% of the participants were not hired based on this factor (see Figure 5).

Table 4

Participants' Age, Educational Level, Years of Experience, and Employment Requirement

Participants' Characteristics	N	%
Age (Figure 2)		
22 – 25	0	0
26 – 30	6	10.9
31 – 35	22	40
36 – 40	19	34.5
41 – 45	6	10.9
Over 46	2	3.6
Total	55	100
Educational Level (Figure 3)		
Bachelor	48	87.3
Master	6	10.9
Doctorate	1	1.8
Other	0	0
Total	55	100
Years of Experience (Figure 4)		
Less than 5 years	1	1.8
6 – 10	24	43.6
11 – 15	20	36.4
16 – 20	5	9.1
21 – 25	4	7.3
More than 26	1	1.8
Total	55	100

Participants' Characteristics	N	%
Hired Based on Competency Test Score (Figure 5)		
Yes	31	56.4
No	24	43.6
Total	55	100

* *N* = 55

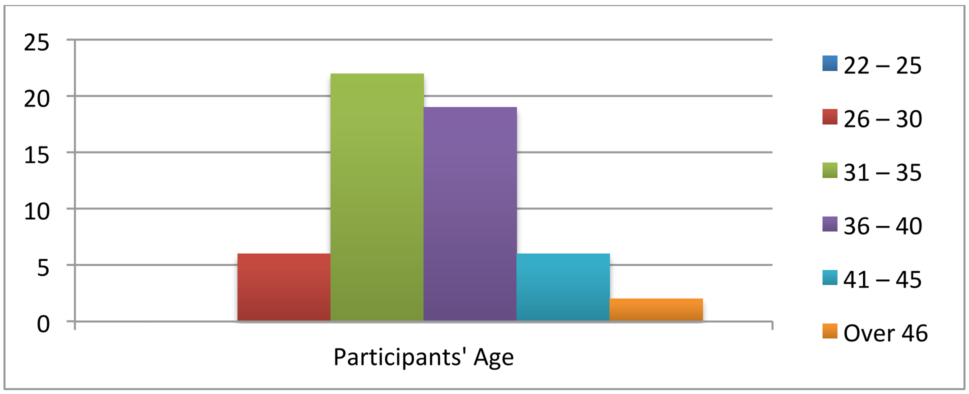

Figure 2: Participants' Age

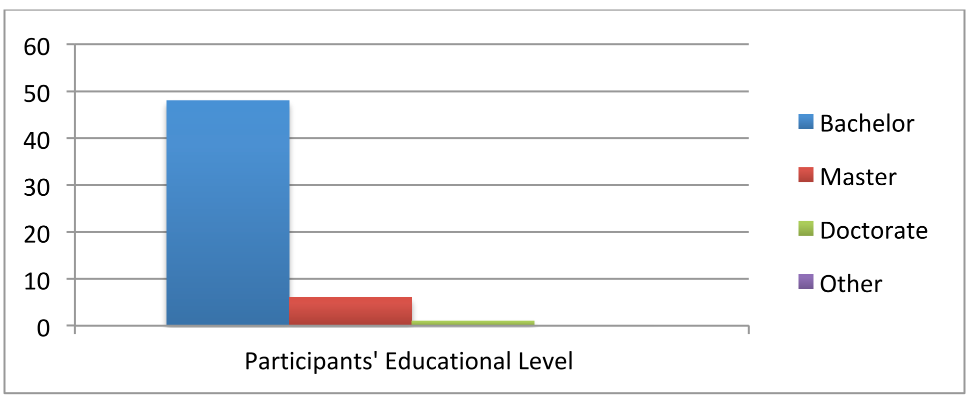

Figure 3: Participants' Educational Level

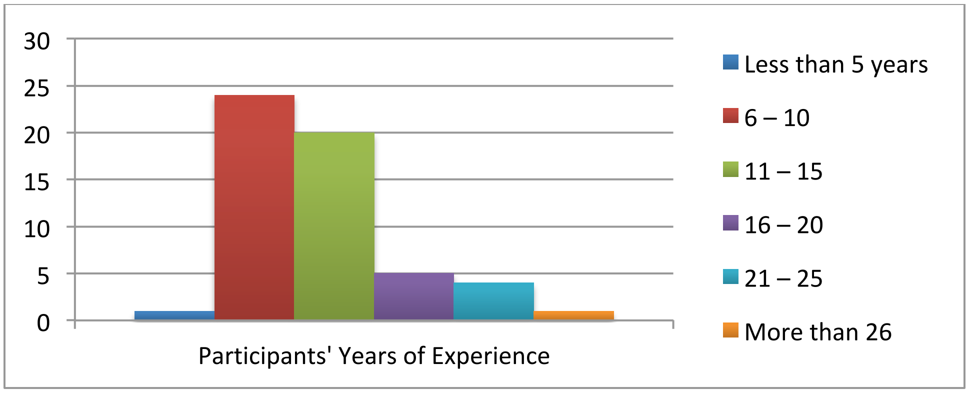

Figure 4: Participants' Years of Experience

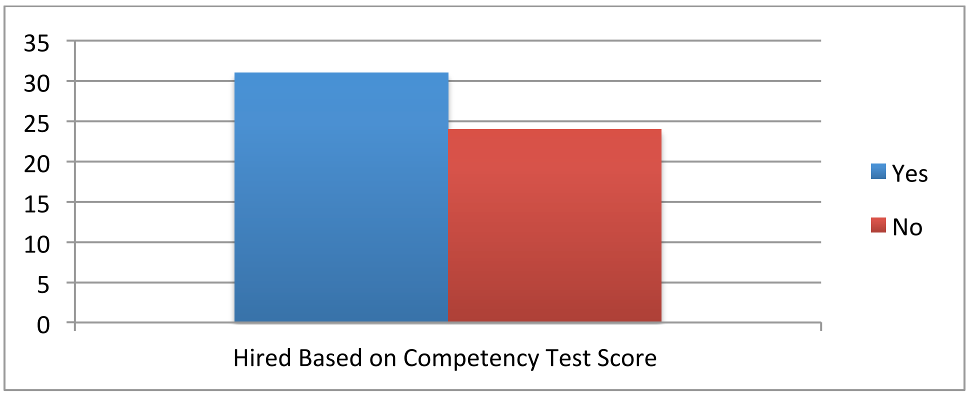

Figure 5: Participants' Employment Requirement

b. Workshops on teaching computer science courses

As shown in Table 5, 5.5% of the participants did not attend any workshop related to teaching CS courses, 60% of the participants attended between one to five workshops related to teaching CS courses, 23.6% of the participants attended between six to ten workshops related to teaching CS courses, and 10.9% of the participants attended more than 11 workshops related to teaching CS courses (see Figure 6). In addition, 69.1% of the participants attended workshops related to a teaching a Computer 1 Course, while 30.9% of the participants did not (see Figure 7). Also, 74.5% of the participants attended to workshops related to teaching a Computer 2 Course, while 25.5% of the participants did not (see Figure 8). Finally, 34.5% of the participants had heard about the term, "Computational Thinking," while 65.5% of the participants had not heard the term (see Figure 9).

Table 5

Attendance of Participants' at Workshops on Teaching Computer Science Courses

Participants' Characteristics	N	%
Number of workshops That participants' had attended related to teaching CS courses (Figure 6)		
0	3	5.5
1 – 5	33	60
6 – 10	13	23.6
More than 11	6	10.9
Total	55	100
Attended workshops related to teaching Computer 1 course (Figure 7)		
Yes	38	69.1
No	17	30.9
Total	55	100
Attended workshops related to teaching Computer 2 course (Figure 8)		
Yes	41	74.5
No	14	25.5
Total	55	100
Heard About CT Term (Figure 9)		
Yes	19	34.5
No	36	65.5
Total	55	100

* $N = 55$

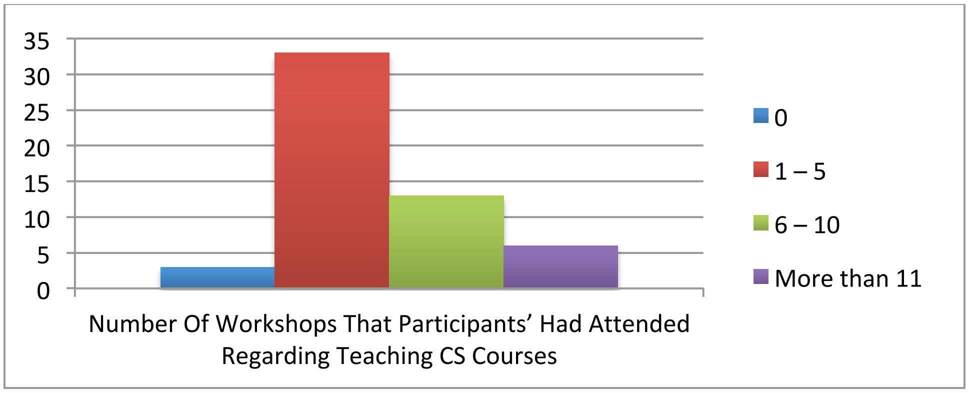

Figure 6: Number Of Workshops That Participants' Had Attended Regarding Teaching CS Courses

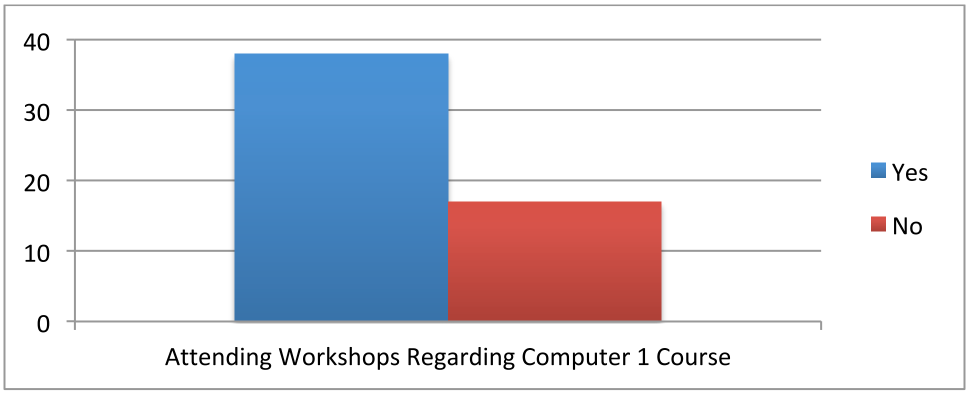

Figure 7: Attending Workshops Regarding Computer 1 Course

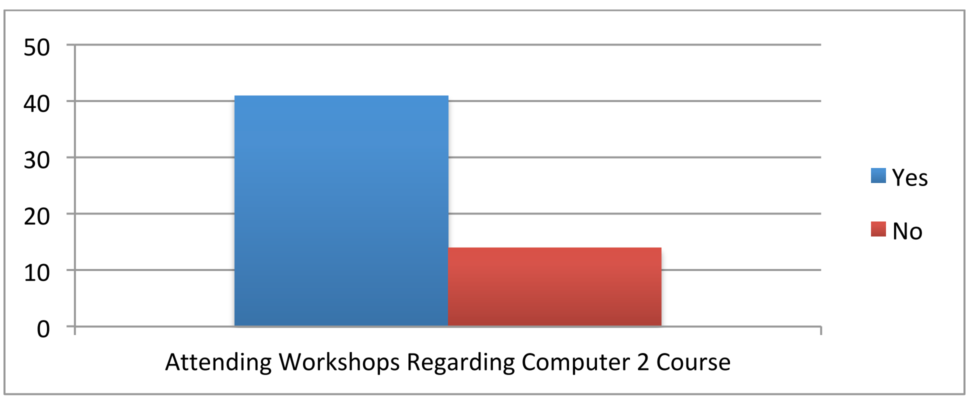

Figure 8: Attending Workshops Regarding Computer 2 Course

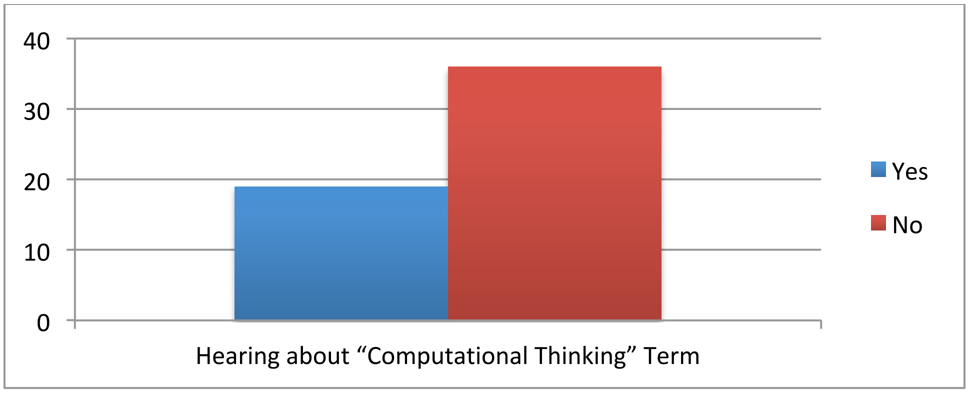

Figure 9: Hearing about "Computational Thinking" Term

C. Research Question Number One

a. CT in general

As shown in Table 6 and Figure 10, 65.5% of the participants were aware that CT is a fundamental skill for everyone, while 34.5% of the participants were not. 34.5% of the participants chose the most appropriate definition of CT, while 65.5% of the participants did not. Overall, 50% of the participants were able to identify the term, "Computational Thinking" in general, while 50% of the participants were not.

Table 6

Descriptive Statistics of Participants' Conceptual Mastery in CT in General

Statements of CT and its Concepts	Correct Answer		Wrong Answer			
	N	%	N	%	M	SD
CT in General (Figure 10)						
CT is a fundamental skill for…	36	65.5	19	34.5	.65	.480
Definition	19	34.5	36	65.5	.35	.480
Total	55	50	55	50		

* $N = 55$

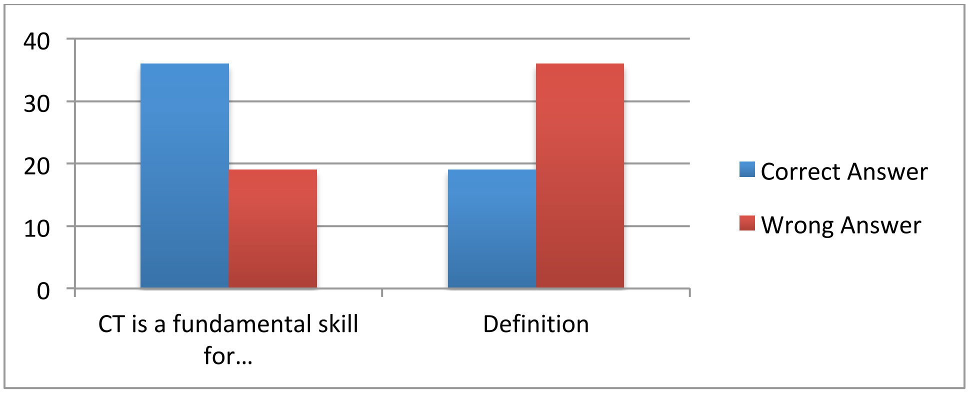

Figure 10: Participants' Conceptual Mastery in CT in General

b. CT concepts

*Decomposition***.** As shown in Table 7 and Figure 11, 45.5% of the participants chose the correct definition of decomposition concept, while 54.5% of the participants did not. 69.1% of the participants were able to identify the benefit of decomposition concept on individuals, while 30.9% of the participants were not. 50.9% of the participants were capable of recognizing the decomposition concept through an example, while 49.1% of the participants were not. Overall, 55.15% of the participants were able to recognize the decomposition concept, while 44.85% of the participants were not.

Table 7

Descriptive Statistics of Participants' Conceptual Mastery of the Decomposition Concept

Statements of CT and its Concepts	Correct Answer		Wrong Answer			
	N	%	N	%	M	SD

Statements of CT and its Concepts	Correct Answer		Wrong Answer			
	N	%	N	%	M	SD
Decomposition (Figure 11)						
Definition	25	45.5	30	54.5	.45	.503
Individuals decompose a complex problem to...	38	69.1	17	30.9	.69	.466
An example of decomposition	28	50.9	27	49.1	.51	.505
Total	91	55.15	74	44.85		

* $N = 55$

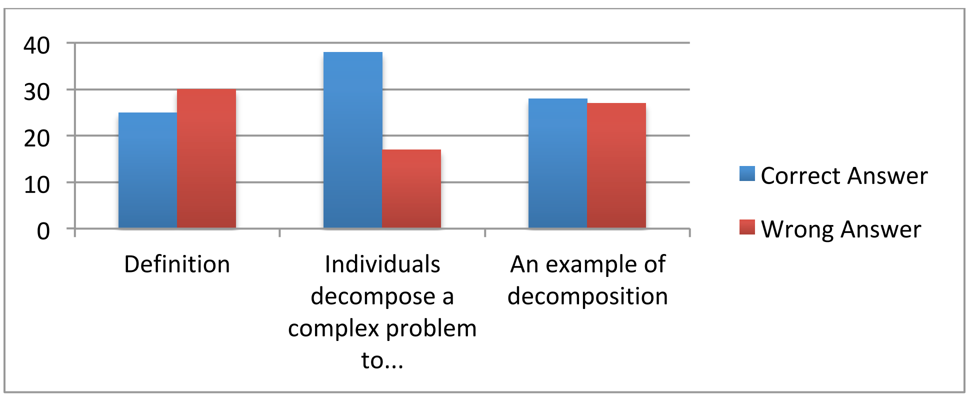

Figure 11: Participants' Conceptual Mastery in Decomposition Concept

Abstraction. As shown in Table 8 and Figure 12, 36.4% of the participants chose the correct definition of the abstraction concept, while 63.6% of the participants did not. 61.8% of the participants were able to think abstractly and find a general characteristic of laptops, while 38.2% of the participants were not. 69.1% of the participants were capable of recognizing the abstraction concept through an example, while 30.9% of the participants were not. Overall, 55.76% of the participants were able to recognize the abstraction concept, while 44.24% of the participants were not.

Table 8

Descriptive Statistics of Participants' Conceptual Mastery of the Abstraction Concept

Statements of CT and its Concepts	Correct Answer		Wrong Answer			
	N	%	N	%	M	SD
Abstraction (Figure 12)						
Definition	20	36.4	35	63.6	.36	.485
A general characteristic of laptops	34	61.8	21	38.2	.62	.490
An example of the abstraction	38	69.1	17	30.9	.69	.466
Total	92	55.76	73	44.24		

* *N* = 55

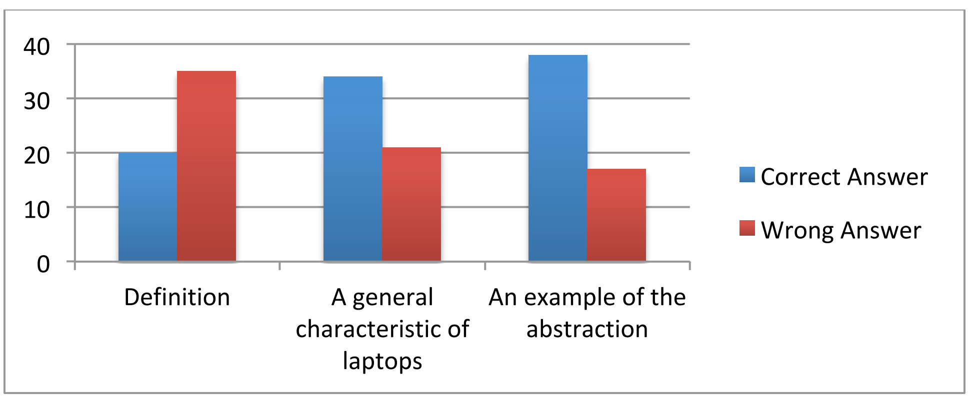

Figure 12: Participants' Conceptual Mastery in Abstraction Concept

Algorithm Design. As shown in Table 9 and Figure 13, 72.3% of the participants chose the correct definition of the algorithm design concept, while 27.3% of the participants did not. 3.6% of the participants were able to identify how an algorithm can be represented, while 96.4% of the participants were not. Overall, 38.18% of the participants were able to recognize the algorithm design concept, while 61.82% of the participants were not.

Table 9

Descriptive Statistics of Participants' Conceptual Mastery of the Algorithm Design Concept

Statements of CT and its Concepts	Correct Answer		Wrong Answer			
	N	%	N	%	M	SD
Algorithm Design (Figure 13)						
Definition	40	72.3	15	27.3	.73	.449
An algorithm can be represented by...	2	3.6	53	96.4	.04	.189
Total	42	38.18	68	61.82		

* $N = 55$

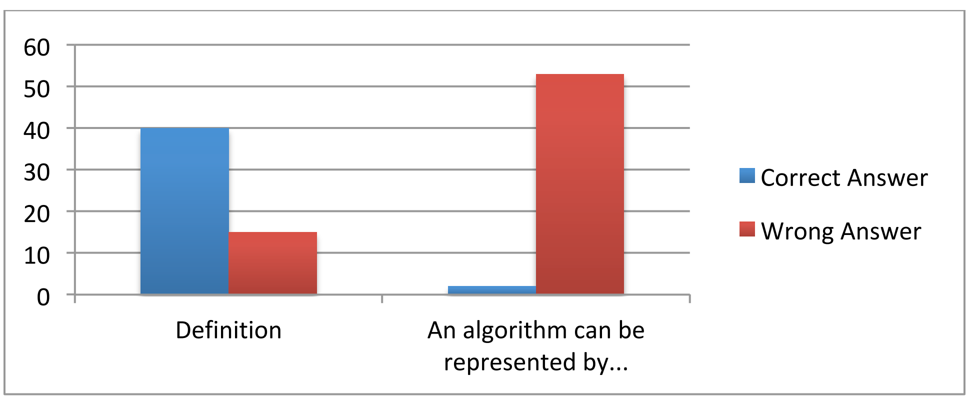

Figure 13: Participants' Conceptual Mastery in Algorithm Design Concept

Automation. As shown in Table 10 and Figure 14, 49.1% of the participants chose the correct definition of the automation concept, while 50.9% of the participants did not. Consequently, 49.1% of the participants were able to recognize the automation concept, while 50.9% of the participants were not.

Table 10

Descriptive Statistics of Participants' Conceptual Mastery of the Automation Concept

Statements of CT and its Concepts	Correct Answer		Wrong Answer			
	N	%	N	%	M	SD
Automation (Figure 14)						
Definition	27	49.1	28	50.9	.49	.505
Total	27	49.1	28	50.9		

* *N* = 55

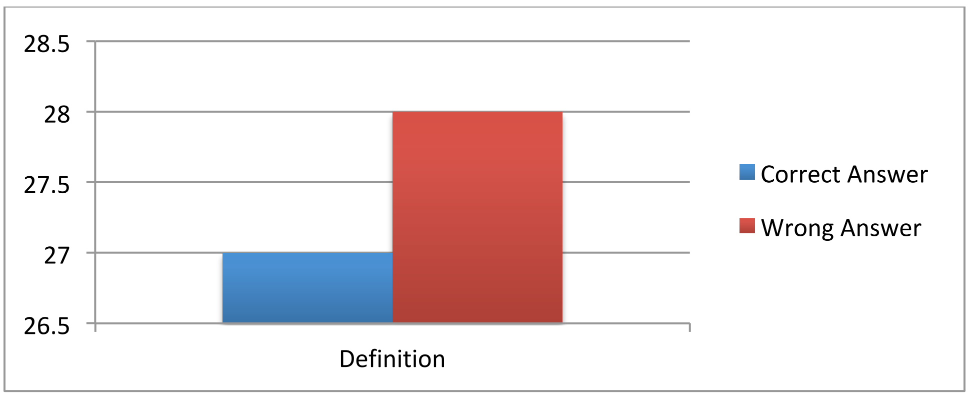

Figure 14: Participants' Conceptual Mastery in Automation Concept

Data collection. As shown in Table 11 and Figure 15, 27.3% of the participants chose the correct definition of the data collection concept, while 72.7% of the participants did not. Consequently, 27.3% of the participants were able to recognize the data collection concept, while 72.7% of the participants were not.

Table 11

Descriptive Statistics of Participants' Conceptual Mastery of the Data Collection Concept

Statements of CT and its Concepts	Correct Answer		Wrong Answer			
	N	%	N	%	M	SD
Data collection (Figure 15)						
Definition	15	27.3	40	72.7	.27	.449
Total	15	27.3	40	72.7		

* *N* = 55

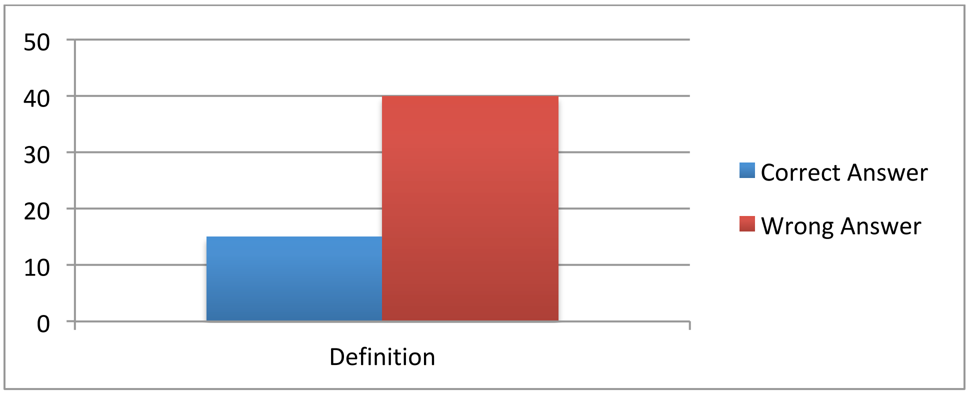

Figure 15: Participants' Conceptual Mastery in Data Collection Concept

*Data analysis***.** As shown in Table 12 and Figure 16, 52.7% of the participants chose the correct definition of the data analysis concept, while 47.3% of the participants did not. 56.4% of the participants were able to identify the benefit of analyzing data appropriately, while 43.6% of the participants were not. 54.5% of the participants were capable of recognizing the patterns concept, while 45.5% of the participants were not. Overall, 54.55% of the participants were able to recognize the data analysis concept, while 45.45% of the participants were not.

Table 12

Descriptive Statistics of Participants' Conceptual Mastery of the Data Analysis Concept

Statements of CT and its Concepts	Correct Answer		Wrong Answer			
	N	%	N	%	M	SD
Data analysis (Figure 16)						
Definition	29	52.7	26	47.3	.53	.504
Based on CT, analyzing data appropriately will result in ...	31	56.4	24	43.6	.56	.501
Which of following statements contains a pattern...	30	54.5	25	45.5	.55	.503
Total	90	54.55	75	45.45		

* $N = 55$

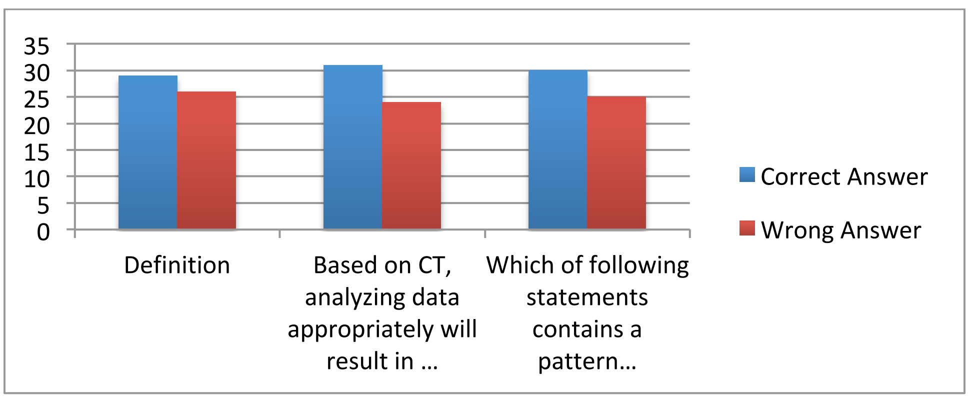

Figure 16: Participants' Conceptual Mastery in Data Analysis Concept

Data representation. As shown in Table 13 and Figure 17, 49.1% of the participants chose the correct definition of the data representation concept, while 50.9% of the participants did not. Consequently, 49.1% of the participants were able to recognize the data collection concept, while 50.9% of the participants were not.

Table 13

Descriptive Statistics of Participants' Conceptual Mastery of the Data Representation Concept

Statements of CT and its Concepts	Correct Answer		Wrong Answer			
	N	%	N	%	M	SD
Data representation (Figure 17)						
Definition	27	49.1	28	50.9	.49	.505
Total	27	49.1	28	50.9		

* *N* = 55

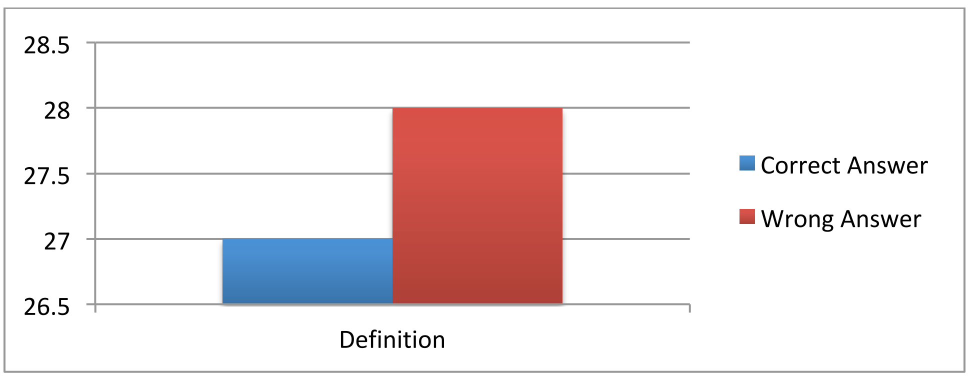

Figure 17: Participants' Conceptual Mastery in Data Representation Concept

Simulation. As shown in Table 14 and Figure 18, 69.1% of the participants chose the correct definition of the simulation concept, while 30.9% of the participants did not. 60% of the participants were able to correctly identify how running simulations helps individuals, while 40% of the participants were not. Overall, 64.55% of the participants were able to recognize the simulation concept, while 35.45% of the participants were not.

Table 14

Descriptive Statistics of Participants' Conceptual Mastery of the Simulation Concept

Statements of CT and its Concepts	Correct Answer		Wrong Answer			
	N	%	N	%	M	SD
Simulation (Figure 18)						
Definition	38	69.1	17	30.9	.69	.466
Running simulations helps individuals to...	33	60	22	40	.60	.494
Total	71	64.55	39	35.45		

* *N* = 55

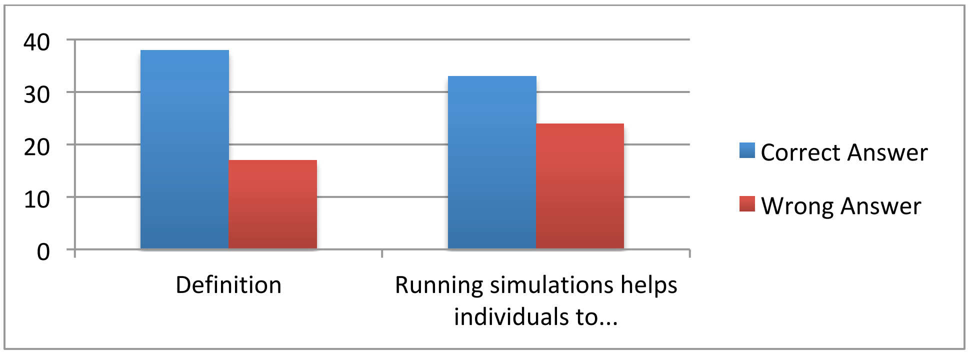

Figure 18: Participants' Conceptual Mastery in Simulation Concept

Parallelization. As shown in Table 15 and Figure 19, 25.5% of the participants chose the correct definition of the simulation concept, while 74.5% of the participants did not. 47.3% of the participants were capable of recognizing the parallelization concept through an example, while 52.7% of the participants were not. Overall, 36.36% of the participants were able to recognize the parallelization concept, while 63.64% of the participants were not.

Table 15

Descriptive Statistics of Participants' Conceptual Mastery of the Parallelization Concept

Statements of CT and its Concepts	Correct Answer		Wrong Answer			
	N	%	N	%	M	SD
Parallelization (Figure 19)						
Definition	14	25.5	41	74.5	.25	.440
An example of the parallelization	26	47.3	29	52.7	.47	.504
Total	40	36.36	70	63.64		

* $N = 55$

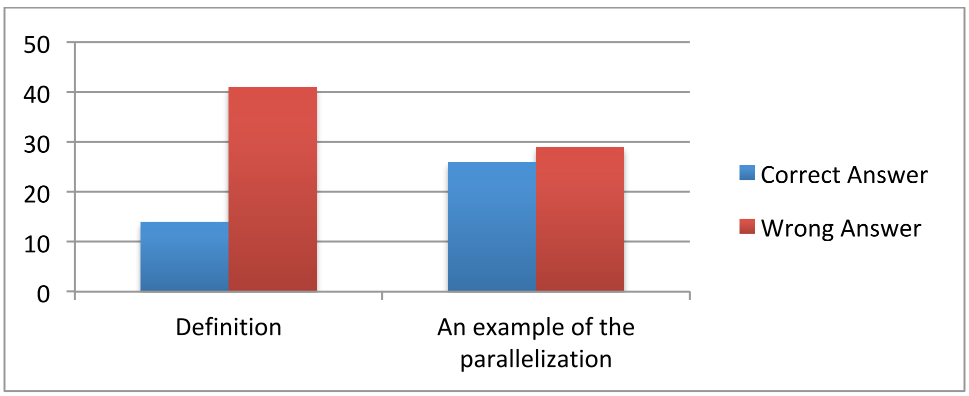

Figure 19: Participants' Conceptual Mastery in Parallelization Concept

Generalization. As shown in Table 16 and Figure 20, 27.3% of the participants chose the correct definition of the generalization concept, while 72.7% of the participants did not. 47.3% of the participants were able to correctly identify what the generalization process allows individuals to do, while 52.7% of the participants were not. Overall, 37.27% of the participants were able to recognize the generalization concept, while 62.73% of the participants were not.

Table 16

Descriptive Statistics of Participants' Conceptual Mastery of the Generalization Concept

Statements of CT and its Concepts	Correct Answer		Wrong Answer			
	N	%	N	%	M	SD
Generalization (Figure 20)						
Definition	15	27.3	40	72.7	.27	.449
Based on CT, Generalization process allows individuals to ...	26	47.3	29	52.7	.47	.504
Total	41	37.27	69	62.73		

* *N* = 55

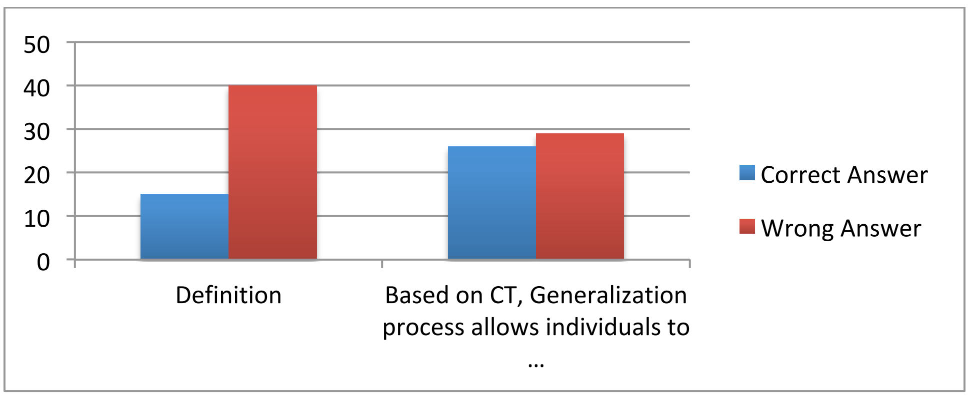

Figure 20: Participants' Conceptual Mastery in Generalization Concept

c. Conceptual mastery score of CT

As shown in Table 17, 55 CS teachers participated in answering 22 multiple-choice questions that were used to collect the participants' level of conceptual mastery of CT. The overall mean for participants' scores of Computational Thinking Skills and Its Concepts was 10.75 with a standard deviation of 3.622. The participants' scores ranged between 2 to 18.

Table 17

Descriptive Statistics of Participants' Conceptual Mastery Score of CT

Scale	N	No. of Items	M	SD	Range	Minimum	Maximum
CT Score	55	22	10.75	3.622	16	2	18

As mentioned in Chapter Three (Questionnaire Development section), the researcher presented the grading scale as follows: the score between 22 and 18 is high; the score between 17 and 14 is acceptable; while the score below 14 is considered low. Table 18 and Figure 21 show more details regarding the participants' scores, 1.82% of the participants scored "High" (N = 1); 23.64% of the participants scored "Acceptable" (N = 13); and 74.54% of the participants scored "Low" (N = 41). This result shows that most of the participants have low conceptual mastery level of CT.

Table 18

Participants' Score of CT Skills and its Concepts

Participants' Scores	N	%
2	1	1.82
4	1	1.82
5	3	5.45
6	2	3.64
7	4	7.27
8	4	7.27
9	7	12.73
10	5	9.09
11	1	1.82

Participants' Scores	N	%
12	7	12.73
13	6	10.9
14	5	9.09
15	5	9.09
16	2	3.64
17	1	1.82
18	1	1.82
Total	55	100

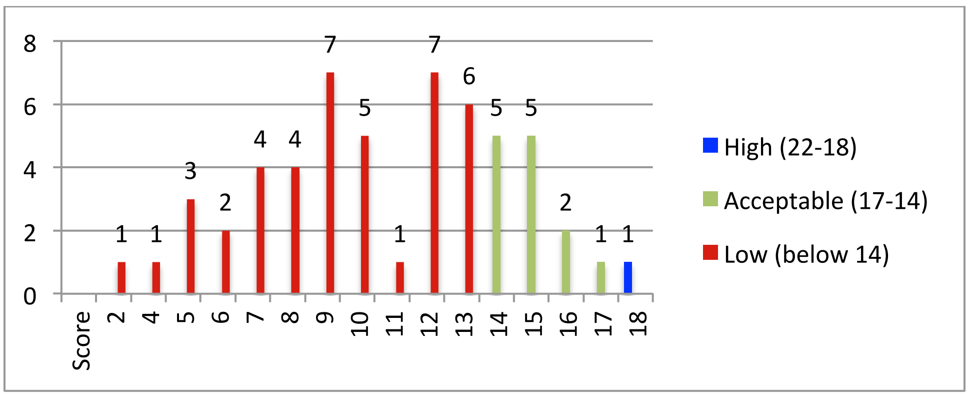

Figure 21: Participants' Score of CT Skills and its Concepts

D. Research Question Number Two

There were 51 male CS teachers who chose to respond to the following two questions: "What pedagogical strategies do you use to develop your students' Computational Thinking skills?" and "Which pedagogical strategies do you most frequently use to teach Computational Thinking skills?" Table 19 summarizes participants' responses into a number of categories that emerged from coding the data.

Table 19

Summary of Pedagogical Strategies Used to Develop Students' CT Skills

Pedagogical Strategies	N
Collaborative learning	24
Problem Solving	15
Active learning	12
Brainstorming	9
Discussion	8
Lecturing	6
Problem Solving using technologies	3
Self-learning	3
Conceptual Mapping	2
Unplugged activities	1
Questioning	1
Six Thinking Hats	1
Creative thinking	1
Flipped classroom	1
Inductive reasoning	1
Coaching	1
Role Playing	1
Trial and Error	1

* $N = 51$

The most popular pedagogical strategies used by CS teachers to develop students' CT skills were "Collaborative learning" (N = 24), "Problem Solving" (N = 15), "Active Learning" (N = 12), and "Brainstorming" (N = 9) respectively. In addition, eight participants reported using "Discussion" to develop students' CT skills, while others used "Lecturing" (N = 6). Three participants associated problem solving with using technologies to develop students' CT skills, while others reported using "Self-learning"

(N = 3). "Conceptual Mapping," "Unplugged Activities," "Questioning," "Six Thinking Hats," "Creative Thinking," "Flipped Classroom," "Inductive Reasoning," "Coaching," "Role Playing," and "Trial and Error" were less commonly pedagogical strategies teachers used for developing students' CT skills.

E. Research Question Number Three

There were 50 male CS teachers who chose to respond to the following two questions: "What educational technologies are available in your classroom?" and which "Educational technologies do you most frequently use to teach Computational Thinking Skills?" Table 20 summarizes participants' responses into a number of categories that emerged from coding the data.

Table 20

Summary of Available Classroom Technologies and the Most Frequently Used Educational Technologies for Developing Students' CT Skills

Educational Technologies	N
Computers	34
Projector	33
Smartboard	20
Internal Network (Local Area Network - LAN)	11
Whiteboard	6
Applications; including programming languages	5
Internet; including Web 2.0 tools	4
Smartphone	1

* *N* = 50

The most popular technologies used by CS teachers to develop students' CT skills were "Computers" (N = 34), "Projector" (N = 33), and "Smartboard" (N = 20) respectively. In addition, 11 participants reported using "Internal Network (Local Area Network - LAN)" in the school computer lab to develop students' CT skills, while others used "Whiteboard" (N = 6). Five participants reported using some applications including programming languages software to develop students' CT skills, while four participants mentioned using "Internet including Web 2.0 tools." Using "Smartphone" (N = 1) was less technology commonly used to develop students' CT skills.

F. Research Question Number Four

There were 52 male CS teachers who chose to respond to the following question: "Are you confident in teaching Computational Thinking skills?" As shown in Table 21 and Figure 21, 71.2% of the participants were confident in teaching CT. 28.8% of the participants were not confident in teaching CT. This result indicates that most of the CS teachers feel confident in teaching their students CT skills.

Table 21

Descriptive Statistics of Participants' Confidence Level in Teaching CT

Statement	N	%
Are you confident in teaching Computational Thinking skills? (Figure 21)		
Yes	37	71.2
No	15	28.8
Total	52	100

* *N* = 52

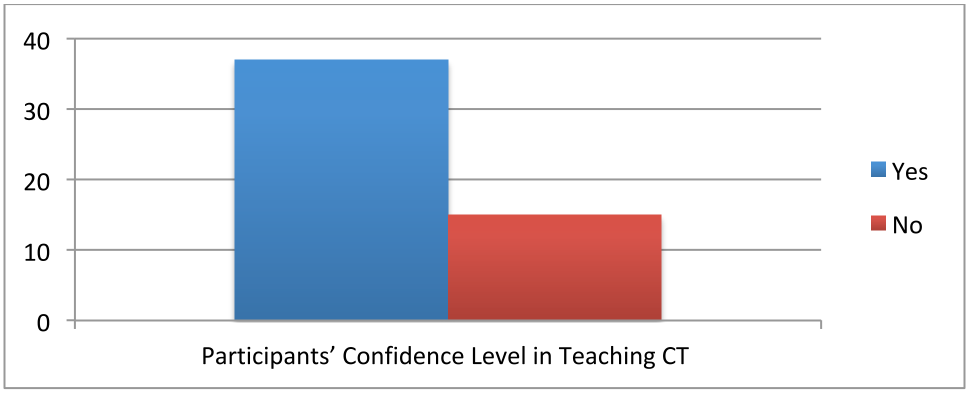

Figure 21: Participants' Confidence Level in Teaching CT

As shown in Table 22, the most popular reason that made CS teachers feel confidence in teaching CT skills was their prior experiences in the field and familiarity with CT (N = 16). Seven participants mentioned that the ability to learn on their own was the reason behind feeling confidence in teaching CT skills. Furthermore, having high self-confidence in teaching and thinking abilities (N = 5) and having outstanding students (N = 5) were listed as reasons that caused CS teachers to felt confident in teaching CT skills. The desire and interest in teaching students new skills (N = 2) and receiving professional training (N = 1) were less frequently stated reasons for why participants felt confident in teaching CT skills. Ultimately, a surprising result was that two participants do not know why they felt confident in teaching CT skills.

Table 22

Reasons That Caused Participants to Feel Confident in Teaching CT

Reasons	N
Prior experiences in the field and familiarity with the subject (CT)	16
I have the ability to learn on my own	7
I have high self-confidence in my teaching and thinking abilities	5
Having high quality students (Outstanding students)	5
My desire and interest of teaching students new skills	2
I do not know	2
Receiving some professional training (workshops)	1

N = 37

As shown in Table 23, the most common reason that made CS teachers feel a lack of confidence in teaching CT skills was the lack of sufficient knowledge (N = 6). Five participants mentioned that they need more professional training to feel more confident in teaching CT skills. Furthermore, three participants stated that the lack of technological equipment was the reason behind feeling less confident in teaching CT skills. Ultimately, the lack of time for professional training (N = 1) was less frequently listed as the reason why the participants felt less confident in teaching CT skills.

Table 23

Reasons That Caused Participants to Feel Less Confident in Teaching CT

Reasons	N
Lack of sufficient knowledge	6
Lack of professional development (training workshops)	5
Lack of technological equipment	3
Lack of time for professional training	1

N = 15

G. Summary

This chapter showed the validity and reliability of the developed questionnaire that the researcher used to collect the data. It also described the participants' characteristics and responses through presenting some descriptive statistics. Furthermore, this chapter presented the findings of the study based on the research questions of the current study. The researcher used descriptive statistics in analyzing research question Number One, while qualitative coding techniques were used in analyzing research questions Number Two and Three. Both descriptive statistics and qualitative coding techniques were used in analyzing research questions Number Four. In the next chapter, discussion and conclusions related to these findings will be addressed.

Chapter Five

Discussion and Recommendations

The study contributes to our knowledge of Saudi education, more specifically, the ability of male CS teachers who teach at public secondary schools that implement CSS in Riyadh, Saudi Arabia. The purpose of this study is to explore the level of conceptual mastery in CT among those teachers. In addition, the study investigates what approaches male CS teachers use to develop students' CT capabilities in terms of both pedagogical strategies and technologies, while also considering their confidence level of teaching CT skills. As mentioned in both Chapter One and Two, there are relatively few studies conducted to explore the level of conceptual mastery of CT among teachers. Therefore, there is a need for further research in this area, and the current research study assists to fill in this gap.

The current study focused on four dependent variables: (1) level of conceptual mastery of CT, (2) pedagogical strategies used to develop students' CT skills, (3) technologies used to develop students' CT skills, and (4) level of confidence in teaching CT. A descriptive design was used, and an electronic questionnaire was distributed to collect data. Both descriptive statistics and qualitative coding techniques were used to analyze the obtained data. The study attempted to examine these variables through answering four research questions, and the findings were presented in the previous chapter. This chapter contains the following sections: discussion of major findings, limitations and delimitations, conclusion, recommendations, and future research.

A. Discussion of Major Findings

a. Research question number one (RQ1); what is the level of conceptual mastery of CT among male CS teachers who teach at public secondary schools that implement CSS in Riyadh as measured by "Questionnaire of Computational Thinking (QCT)"?

Data included 55 male CS teachers from 42 secondary schools that implemented Courses Schooling System (CSS) at Riyadh in Fall 2017. Descriptive statistics were utilized to analyze the participants' responses of the Computational Thinking Skills and Its Concepts section. This section contained 22 multiple-choice questions, and each question had one correct answer. Each question weighed one point, which means that the highest score that a participant could obtain was 22 points. The researcher designed a grading scale based on a conducted pilot study (see Chapter Three) as follows: the score between 22 and 18 (100-80%) is high; the score between 17 and 14 (79-60%) is acceptable; while the score 13 and below (59-0%) is considered low.

The study revealed that 36 of CS teachers were able to recognize that CT is a fundamental skill for everyone. However, 41 of the CS teachers scored low on this section of the questionnaire (See Table 18 and Figure 21 in Chapter Four). Also, the study showed that 13 of the CS teachers had acceptable scores, while only one CS teachers had a high score. In other words, 74.54% of CS teachers have low conceptual mastery level of CT, and 23.64% of the CS teachers have an acceptable knowledge of CT. This is not a surprising finding when taking into consideration the participants' characteristics that showed: 65.5% of CS teachers (N = 36) had never heard about the term, "Computational Thinking", while 34.5% of the CS teachers (N= 19) had heard about it (see Table 5 and Figure 9 in Chapter Four). In addition, most CS teachers (N = 36) were not able to define CT correctly (see Table 6 in in Chapter Four). This finding shows similar results as those of Curzon, McOwan, Plant, and Meagher (2014) indicating that UK teachers also had a lack of CT knowledge. Furthermore, this finding indicates that most CS teachers most likely were not exposed to CT knowledge during the workshops that they had attended for teaching CS courses (i.e., these workshops were offered by the Saudi Ministry of Education; see Table 5 in in Chapter Four). The researcher made this inference based on Generative Learning Theory (GLT), where learning occurs when individuals try to connect new information to their prior knowledge (Fiorella & Mayer, 2015). CS teachers' scores on the Questionnaire of Computational Thinking (QCT) would be high or acceptable if the contents of the offered workshops included CT knowledge. In other words, CS teachers should have generated an adequate understanding of CT if they were exposed to CT skills during the offered workshops. However, this inference is tentative given that information is not available on the offered workshops. Therefore, the researcher recommends analyzing the content of the offered workshops for the inclusion of CT skills. This implication can help the researcher to obtain more accurate and adequate evidence for this inference.

The surprising finding is that five of the CS teachers who had heard about the "Computational Thinking" term scored low on this section of the questionnaire; which means that approximately 9% of the CS teachers have a misconception about CT. Wing (2006) defined CT as "reformulating a seemingly difficult problem into one we know how to solve, perhaps by reduction, embedding, transformation, or simulation" (p. 33). The five CS teachers defined CT as either "logical and creative thinking" or "using technologies to solve problems;" both of these two definitions are not correct. If those teachers had an accurate conception of CT, they would choose "Reformulating a seemingly difficult problem into one easy to solve" as a definition. The researcher believes that the modernity of the CT term, only introduced in 2006, has contributed to the occurrence of this misconception. 45.4 % of the CS teachers (N = 25) had ten years of experiences or less in teaching CS (see Table Four). In other words, those teachers were hired at the time that Wing introduced the CT term means that these teachers were not exposed to the term during their teacher preparation program. Moreover, this finding concurs with Bower, Lister, Mason, Highfield, and Wood (2015) in which they found that teachers in Australia had misconceptions about CT constructs.

Table 24 illustrates how CS teachers understand CT concepts. As shown in Table 24, CS teachers were able to correctly identify both the definitions and relevant practices of the concept, Data Analysis and Simulation. CS Teachers were only able to identify the appropriate definition of the concept, Algorithm Design. On the concept, Decomposition and Abstraction, teachers were able to determine only the relevant practices. CS teachers were not able to identify a definition for the concepts, Decomposition, Abstraction, Automation, Data Representation, and Data Collection. Nevertheless, CS teachers were able to determine the relevant practices for these concepts. Parallelization and Generalization were the only CT concepts that CS teachers were not able to identify both its appropriate definitions and relevant practices. Therefore, the study concluded that CS teachers need professional training for eight CT concepts out of ten, and these concepts are: Algorithm Design, Decomposition, Abstraction, Automation, Data Representation, Data Collection, Parallelization, and Generalization.

Table 24

Participants' Findings Regarding Conceptual Mastery of CT concepts Based on Definitions and Relevant Practices

Definition & Relevant Practices Were Identified	Only Definition was Identified	Only Relevant Practices Were Identified	Only Definition was **NOT** Identified	Definition & Relevant Practices Were **NOT** Identified
Data Analysis Simulation	Algorithm Design	Decomposition Abstraction	Decomposition Abstraction Automation Data Representation Data Collection	Parallelization Generalization

Computational thinking offers many possible applications in a wide range of disciplines. Bundy (2007) noted that CT knowledge has been used in various disciplines through problem-solving methods, and it is essential that individuals are able to think computationally in every discipline. CT is a set of general skills that can benefit students because these skills will enhance their intellectual skills to work with complexity, ambiguity, and open-ended problems (Wing, 2010). Additionally, the National Research Council report (2010) stated that CT is a set of cognitive skills that the "average person in modern society is expected to possess" (p.13). Researchers have demonstrated that CT is universally applicable for everyone across all disciplines (Barr & Stephenson, 2011; Conery et al., 2011a, 2011b; Furber, 2012; Lu & Fletcher, 2009; Wing, 2008; Wing, 2006). Therefore, students need to learn CT concepts to increase their problem-solving skills that are critical for solving real-world issues (Deborah et al., 2011). Students with CT abilities are able to gather and manipulate large data sets to make decisions. It is critical that students learn CT skills because it provides endless opportunities for creatively solving problems.

To develop students' CT knowledge, it is realistic that teachers have a high conceptual mastery level of CT. The National Research Council (2010) report states that teachers could guide students to use thinking strategies, such as CT skills, independently. Thus, teachers have a great responsibility to develop and guide students' thinking abilities, including CT. Consequently, teachers need to be well prepared and trained to integrate CT concepts into their discipline and teaching practices (Blank, Pottenger, Sahasrabudhe, Li, Wei, & Odi, 2003; British Computer Society, 2010; National Research Council, 2010).

Developing students' CT knowledge will be challenging if teachers have a low conceptual mastery level of CT. Based on the current study findings, CS teachers need to raise their conceptual mastery level of CT. The researcher recommends providing CS teachers with training workshops to introduce CT concepts to increase CS teachers' awareness of CT and to improve their understanding of CT knowledge. This implication corresponds to other studies (Blum & Cortina, 2007; Bower et al., 2017; Curzon et al., 2014; Yadav, Zhou, Mayfield, Hambrusch, & Korb, 2011), in which they all offered training workshops to improve teachers CT knowledge. Providing all teachers with CT concepts and integrating these concepts into academic disciplines are critical (Yadav et al., 2014).

b. Research question number two (RQ2); what pedagogical strategies do male CS teachers who teach at public secondary schools that implement CSS in Riyadh report using to develop students' CT skills?

Data included 51 CS teachers' responses, and a qualitative coding technique was used to analyze the data obtained from the Pedagogical Strategies section of the questionnaire. This section contained two open-ended questions that ask participants about pedagogical strategies used to develop students' CT skills. The researcher observed four notes during the coding process. The first note is that the total number of responses was greater than the number of participants, and that was expected (as mentioned in Chapter Three) because some participants provided multiple responses that were coded in more than one category.

The second note is that most of the participants reported pedagogical strategies used to develop students' CT skills in general terms. For example, collaborative learning and problem solving were the most popular pedagogical strategies used by CS teachers to develop students' CT skills (see Table 19 in Chapter Four). This finding corresponds to other studies (Bower et al., 2015, 2017; Bower & Falkner, 2015; Conery et al., 2011; Goode & Chapman, 2011), in which collaborative learning was used to promote students' CT skills. Bower, Lister, Mason, Highfield, and Wood (2015) also found that Australian teachers used both problem-based and collaborative learning to develop students' CT skills. At the same time, only five CS teachers reported using some specific pedagogical strategies to develop their students' CT skills, such as Numbered Head Together and Listening Triangle, both of which are forms of collaborative learning and active learning strategies. Furthermore, only two CS teachers reported using Hot Seat strategy to develop their students' CT skills, and this specific pedagogical strategy can be categorized under Active Learning pedagogical strategies.

The third note is that some responses were ambiguous and complicated to classify. For example, a participant mentioned, "[pedagogical strategies were:] Raising students' sense of using computer technology to solve mathematical problems... and using applications [software] that help solving algorithmic problems." However, the researcher addressed this response through reporting that this participant used the pedagogical strategy of Problem Solving Using Technologies to develop students' CT skills. This pedagogical strategy was one of the emerging categories found during the coding process.

The fourth note was surprising in that no participants reported using coding or game-based learning as pedagogical strategies to develop students' CT skills. However, this finding is similar to Bower and Falkner (2015) where they found only one pre-service teacher who reported using writing code as a strategy to develop students' CT skills. At the same time, there were many studies indicating that coding and game-based learning pedagogical strategies can be used to develop students' CT skills. For example, some teachers have used visual coding and programming platforms, such as Scratch, Raspberry pie etc., to develop students' CT skills (Bower et al., 2015, 2017; Bower & Falkner, 2015). Furthermore, some teachers were found to prefer using onscreen blocks (i.e., Tangible program language, specifically designed to program a robot's behavior) and game-play to teach CT concepts to K-12 students (Kazakoff & Bers, 2012; Wang & Chen, 2010). In fact, some Australian teachers suggested using games such as Kodu and Minecraft, to develop students CT skills (Bower et al., 2017).

There is a wealth of strategies, approaches, tools, and resources are found to help teachers and educators to develop students' skills and also to obtain ideas on how to incorporate them into their daily lives. Teachers need to be knowledgeable on how to use a variety of different teaching methods to develop students' CT skills. The finding of RQ2 showed that most of CS teachers used "collaborative learning" and "problem solving" as pedagogical strategies to develop students' CT skills (see Table 19 in Chapter Four). However, these two pedagogical strategies were mentioned in general terms. In other words, the researcher does not know how those teachers are using these pedagogical strategies to develop students' CT skills. Therefore, the researcher recommends interviewing CS teachers to understand how they are using the reported pedagogical strategies to develop students' CT knowledge in more details. This implication would give the researcher a deeper understanding of CS teachers' CT knowledge and its relevant pedagogical strategies. Furthermore, the researcher recommends providing CS teachers with training workshops to introduce coding and game-based learning as pedagogical strategies to develop students' CT skills. This implication is associated with the surprising finding of RQ2; where no CS teacher reported using coding or game-based learning as pedagogical strategies to develop students' CT skills. Also, this implication is supported by many studies that indicate coding and game-based learning pedagogical strategies can be used to develop students' CT skills (Bower et al., 2015, 2017; Bower & Falkner, 2015; Kazakoff & Bers, 2012; Wang & Chen, 2010).

c. Research question number three (RQ3); what educational technologies do male CS teachers who teach at public secondary schools that implement CSS in Riyadh report using to develop students' CT skills?

Data included 50 CS teachers' responses, and a qualitative coding technique was used to analyze the data obtained from Classroom Educational Technologies section of the questionnaire. This section contained two open-ended questions that ask participants about classroom educational technologies used to develop students' CT skills. Throughout the coding process, the researcher noticed that there was a lack of educational equipment available in classrooms. Computers, Projector, Smartboard, and Internal Network (i.e. Local Area Network - LAN) were the most popular technologies that were frequently reported as technologies available in classrooms and used to develop students' CT skills (see Table 20 in Chapter Four). This finding is similar to (Bower et al., 2017; Grover & Pea, 2013), in which they found that devices such as computers and interactive whiteboards were used to develop students' CT skills.

As mentioned in Chapter Two, visual programming languages could facilitate the learning of CT concepts in K-12 contexts (Lye, Hwee, & Koh, 2014). The researcher was surprised that only five responses reported using applications such as programming languages and none of them mentioned specific programming languages. Furthermore, these responses were short and lacked details on how these applications could be applied to develop and promote students' CT skills. For instance, a participant mentioned using the "NetSupport School" application to develop his students' CT skills, but the participant did not explain how this application is being used. Surprisingly, one respondent reported using a smartphone as a technology to develop students' CT skills because students are not allowed to use their smartphone within the perimeter of the school in Riyadh. Moreover, most if not all secondary public schools are not equipped with digital devices, such as iPads and tablets.

As mentioned in Chapter Two, the development of technologies has led to the emergence of a generation called *Net Generation.* This generation of learners relies on technology in their daily lives (Berk, 2010; Junco & Mastrodicasa, 2007; Pryor et al., 2009). Therefore, teachers need to take full advantage of technology to develop students' skills in general and CT skills in particular. Teachers can use digital devices, such as personal computers, mobile phones, laptops, interactive whiteboards to promote CT concepts (Bower et al., 2017; Grover & Pea, 2013). Based on the discussion of RQ3, the responses of CS teachers regarding using technology to develop students' CT skills were short and lacked details on how these technologies have being used to develop and promote students' CT skills. Consequently, the researcher recommends interviewing CS teachers to understand how they are using the reported technologies to develop students' CT knowledge in more details.

In the discussion of RQ2, the researcher recommends offering CS teachers with training workshops to introduce coding and game-based learning as pedagogical strategies to develop students' CT skills. In fact, these two pedagogical strategies (coding and game-based learning) require particular technologies such as computers and programming application (e.g., Scratch). Therefore, the researcher suggests adding instruction of how to use relevant technologies to the recommended training workshops. This implication would provide teachers with sufficient knowledge on how to use coding and game-based learning pedagogical strategies and its relevant technologies, such as Scratch (Bower et al., 2017, 2015; Bower & Falkner, 2015) and Minecraft (Chambers, 2014) to develop students' CT skills.

d. Research question number four (RQ4); what is the confidence level of male CS teachers who teach at public secondary schools that implement CSS in Riyadh in teaching CT skills?

Data included 52 CS teachers' responses, and both descriptive statistics and a qualitative coding technique was used to analyze the data collected from the Confidence Level section of the questionnaire. This section contained a Yes/No question and two open-ended questions that asked participants about their level of confidence for teaching CT skills. The study showed that most CS teachers felt confident in teaching CT (N = 37), while fewer CS teachers did not feel confident in teaching CT (N = 15) (see Table 21 in Chapter Four). This finding concurs with the study of Sentance and Csizmadia (2017) in which they found most teachers in the UK were confident in delivering CT knowledge while some still needed more training in pedagogical strategies to raise their confidence levels for teaching CT.

After coding the two open-ended questions, the finding revealed that CS teachers felt not confident of teaching CT skills because of lack of sufficient knowledge and professional development (training workshops) (See Table 23 in Chapter Four). This finding comes in agreement with (Bower et al., 2015); where they found that some Australian teachers do not feel confident in teaching CT skills due to the lack of CT knowledge as well as the lack of support from schools or districts. Furthermore, this finding comes in agreement with the finding of RQ1; where most of CS teachers have a low conceptual mastery level of CT. As mentioned earlier in the discussion of RQ1, the researcher recommends providing those teachers with training workshops to raise and improve their conceptual level of CT. This implication would give those teachers the required knowledge of CT, which will make them feel confident in teaching CT. This implication is supported by many studies: where offering workshops did result in developing teachers' CT knowledge and building their confidence in teaching these competencies (Bower et al., 2017; Curzon et al., 2014).

As mentioned earlier in the discussion of RQ1, the study's findings of the Computational Thinking Skills and Its Concepts section revealed that 74.54% of CS teachers have a low conceptual mastery level of CT. This finding seems contradictory to the result that most CS teachers (N = 37) feel confident in teaching CT. One possible reason for this contradiction is that some teachers may engage their students in educational activities to teach CT concepts without fully understanding the accurate names for these concepts (e.g., algorithm, decomposition, or generalization). This seems a reasonable conclusion considering that one of the concepts; Decomposition was one that most CS teachers were not able to appropriately define. However, they seemed to understand the relevant practices that can be used to teach the concept. In other words, most CS teachers know how to develop students' decomposition skill, but they are not able to identify the actual name for this concept. Further investigation is needed to identify the reasons why some teachers feel confident in teaching CT skills while they have a lack of knowledge about these skills.

B. Limitations and Delimitations

As mentioned earlier, the target population of this study was 101 CS teachers who teach at public secondary schools that implement Courses' Schooling System (CSS) in Riyadh, Saudi Arabia. One of the limitations of the current study is that the findings may not be generalizable to all CS teachers in Saudi Arabia or in other locations around the world. In addition, the response rate and response bias may compromise validity of the inferences or conclusions. To avoid overgeneralization, the researcher reported the response rate and acknowledged any possible response bias.

The study was delimited to male CS teachers because they are the only teachers who teach the new CS curricula (Computer 1 and 2) that contain CT skills. Only male teachers and only those who teach at public secondary schools that implement the CSS characteristics were included for three reasons: (1) females and males teach in separate schools, and (2) the new CS curricula have only been implemented at secondary schools for males (Al Salman et al., 2013), and (3) the researcher could not identify the CS teachers who taught these skills in the private sector.

C. Conclusion

This study concluded that most of the male CS teachers, who teach at public secondary schools that implement Course Schooling System (CSS) in Riyadh, Saudi Arabia, have a low conceptual mastery level of CT, and few of them (28.8%) were not confident in teaching CT skills. 71.2% of the CS teachers felt confident in teaching CT skills because of their prior experiences in the field and familiarity with the subject (CT) (as reported in Table 22, Chapter Four). It is surprising that those teachers felt confident in teaching CT skills while they have low conceptual mastery level of CT. Therefore, further investigation is needed to identify the reasons why those teachers feel confident in teaching CT skills while they have lack of CT knowledge.

CT is a set of general skills that can benefit students because these skills will enhance their intellectual skills to work with complexity, ambiguity, and open-ended problems (Wing, 2010). It is a set of cognitive skills that the "average person in modern society is expected to possess" (National Research Council report, 2010, p.13). CT is universally applicable for everyone across all disciplines (Barr & Stephenson, 2011; Conery et al., 2011a, 2011b; Furber, 2012; Lu & Fletcher, 2009; Wing, 2008; Wing, 2006). The National Research Council (2010) report states that teachers could guide students to use thinking strategies, such as CT skills, independently. Thus, teachers have a great responsibility to develop and guide students' thinking abilities, including CT. It is realistic that teachers have a high conceptual mastery level of CT to be able to develop students' CT knowledge. Consequently, teachers need to be well prepared and trained to integrate CT concepts into their discipline and teaching practices (Blank, Pottenger, Sahasrabudhe, Li, Wei, & Odi, 2003; British Computer Society, 2010; National Research Council, 2010). Therefore, the current study recommends providing CS teachers with training workshops to raise their conceptual mastery level of CT and their confidence in teaching CT.

This study determined that collaborative learning, problem solving, and active learning were the most popular pedagogical strategies used by CS teachers to develop students' CT skills. Computers, projector, and smartboard were the most popular technologies used by CS teachers to develop students' CT skills. The researcher does not know if CS teachers use the reported pedagogical strategies and technologies in a way that can develop students' CT skills due to the shortness and lack of details in the participants' responses. In other words, CS teachers reported using pedagogical strategies and technologies in general (i.e., reporting only the names of the used pedagogical strategies and technologies), which make it difficult for the researcher to know CS teachers' knowledge of these pedagogical strategies and how these technologies work to develop students' CT skills. Therefore, the researcher recommends interviewing CS teachers to comprehend how they are using the reported pedagogical strategies and technologies to develop students' CT knowledge in more details. This implication would give the researcher a deeper understanding of CS teachers' CT knowledge and its relevant pedagogical strategies and technologies.

Overall, the Saudi Arabia Ministry of Education should intervene to save the learning process and ensure its quality. The continuation of the current situation in the state of computational thinking as discovered in this study (i.e., CS teachers have a low conceptual mastery level of CT) will lead to producing students who are unable to think computationally; which means they will not be adequately able to solve real-life problems. In other words, students without CT skills will be technology or software users instead of problem solvers. CT skills could move students from being technology users to produce new ways of expression, design tools, and promote creativity (Mishra & Yadav, 2013). On a broader scale, by not adequately preparing individuals who possess and can use their knowledge of CT might tend to make Saudi Arabia less competitive in the global marketplace in fields related to CT. This is especially true since CT is universally applicable for everyone across all disciplines (Barr & Stephenson, 2011; Conery et al., 2011a, 2011b; Furber, 2012; Lu & Fletcher, 2009; Wing, 2008; Wing, 2006).

Therefore, the Ministry of Education should offer professional training (workshops) for CS teachers to increase their CT knowledge and their confidence in teaching CT skills. In addition, the researcher needs to interview CS teachers to comprehend how they are using the reported pedagogical strategies and technologies to develop students' CT knowledge in more details to ensure that they are using effective pedagogical strategies and useful technologies. If the researcher finds that CS teachers are not effectively using pedagogical strategies or technologies, the Ministry of Education should offer training workshops for those teachers to train them on how to use pedagogical strategies and technologies to teach CT concepts effectively. It is an integral process that the CS teacher must have adequate knowledge of CT as well as effective pedagogical strategies and technologies to be able successfully to develop students' CT concepts.

D. Recommendations and Future Research

This study recommends offering some professional training (workshops) on CT skills and how to integrate CT concepts into CS curricula for male CS teachers, and this professional training should be introduced gradually. CS teachers need to grow in their knowledge of (1) conceptual mastery of CT knowledge and (2) pedagogical strategies on how to develop students' CT skills including using technology, and then they should be trained on how to incorporate CT skills into the CS curriculum. This can be done through taking advantage of what some developed countries such as the United States are doing to develop and train its CS teachers with CT skills. Computer Science for All (Becker, Freeman, Hall, Cummins, & Yuhnke, 2016; Wing, 2016), Computing Education for the 21st Century-CE21, and Code.org (Wing, 2014) are examples for popular initiatives to develop K-12 students' and teachers' CT knowledge.

This study also recommends analyzing the contents of teacher preparation programs, their courses, and curriculum in Saudi universities for the inclusion of CT skills in order to provide pre-service teachers (future teachers) with an appropriate and sufficient CT knowledge. Based on Generative Learning Theory (GLT), individuals generate perceptions and meanings depending on their prior experiences (Wittrock, 2010); learning occurs when individuals try to make sense of presented materials by connecting new information to their prior knowledge (Fiorella & Mayer, 2015). If the contents of teacher preparation courses do not include CT knowledge, pre-service teachers will not be able to generate accurate and adequate understanding of CT skills, an as a result, will not be able to teach these skills to their students. Furthermore, this implication supports Yadav, Zhou, Mayfield, Hambrusch, and Korb (2011, 2014) who argued that students in K-12 would have greater exposure to CT concepts when future teachers have been prepared to present subjects by using ideas from CT concepts. They also found that exposing pre-service teachers to CT concepts early in their teacher preparation might allow them to realize the importance of CT in their disciplines. Furthermore, this implication corresponds with others (Blank, Pottenger, Sahasrabudhe, Li, Wei, & Odi, 2003), (British Computer Society, 2010), and (National Research Council, 2010) who recommend that teachers need to be well prepared and trained to integrate CT concepts into their discipline and teaching practices.

The current study has provided several opportunities for future research studies that can investigate more related issues and variables. A possible further research study is a qualitative study to explore in depth what type of professional training workshops are needed to develop CS teachers' CT knowledge. In addition, the researcher encourages future researchers to explore in depth reasons why male CS teachers felt confident in teaching CT concepts while they lacked sufficient knowledge of these concepts.

Further research study could also help us understand how CS teachers are utilizing pedagogical strategies and educational technologies to develop CT skills. More specifically, future researchers could focus on investigating how CS teachers implement particular pedagogical strategies, such as collaborative learning and problem solving, to develop students' CT skills. Also, they could explore how CS teachers use some technologies, such as computers and particular applications including programming languages software to promote students' CT abilities.

Further, researchers could replicate the current study in other settings, such as studying teachers in middle schools because CT concepts offer many possible applications in a wide range of disciplines. In fact, CT knowledge has been used in various disciplines that require problem-solving approaches, which makes this knowledge fundamental for all individuals to think computationally in every discipline (Bundy, 2007). Calao, Moreno-Leon, Correa, and Robles (2015) found that integrating CT knowledge in a sixth-grade mathematics class significantly results in improvement in students' understanding of mathematics procedures. Furthermore, some CT concepts (Data analysis and abstraction) could be integrated in social studies by finding trends in population data and concluding general principles from facts (Barr & Stephenson, 2011). These examples show why a number of scholars have called for developing CT knowledge in students even in the very early grades (Fletcher & Lu, 2009; Qualls & Sherrell, 2010; Wing, 2008; Yadav, Mayfield, Zhou, & Hambrusch, 2014).

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Appendix A

IRB APPROVAL LETTER

The University of Toledo
Department for Human Research Protections
Social, Behavioral & Educational Institutional Review Board
Office of Research, Rm. 2300, University Hall
2801 West Bancroft Street, Mail Stop 944
Toledo, Ohio 43606-3390
Phone: 419-530-2844 Fax: 419-530-2841
(FWA00010686)

To: Judy Lambert, Ph.D. and Abdulaziz A Alfayez
Department of Curriculum & Instruction

From: Walter Edinger, Ph.D., Chair
Patricia Case, Ph.D., Vice Chair
Wesley A. Bullock, Ph.D., Chair Designee
Nilgun Sezginis, MPH, RHA, Chair Designee

Signed: Wesley A. Bullock, Ph.D. **Date:** 06/28/17

Subject: IRB #202137
Title: **Exploring the Level of Conceptual Mastery in Computational Thinking among Male Computer Science Teachers who Teach at Public Secondary Schools That Apply Courses□ Schooling System in Riyadh, Saudi Arabia**

On 06/28/17, the above research was reviewed and approved as Exempt (Category #2a) by the Chair and Chair Designee of the University of Toledo (UT) **Social Behavioral & Educational** Institutional Review Board (IRB). The requirement to obtain a signed consent form has been waived as this research is determined to be minimal risk and a signed consent document would be the only record linking the subject to the data. It was determined that this waiver for signed consent will not adversely affect the rights and welfare of the participants. This action will be reported to the committee at its next scheduled meeting.

Items Reviewed: IRB Application Requesting Exempt Review
Consent Form
Survey(s):

- Questionnaire of Computational Thinking - Arabic
- Questionnaire of Computational Thinking - English

Designated as EXEMPT RESEARCH on: 06/28/17

Please read the following attachment detailing Principal Investigator responsibilities.

Appendix B

ADULT RESEARCH - INFORMED CONSENT INFORMATION – ENGLISH VERSION

ADULT RESEARCH - INFORMED CONSENT INFORMATION
Exploring the Level of Conceptual Mastery in Computational Thinking (CT) Among Male Computer Science (CS) Teachers who Teach at Public Secondary Schools That Apply Courses' Schooling System (CSS) in Riyadh, Saudi Arabia

Principal Investigator: Abdulaziz Abdullah Alfayez (Doctoral Candidate- Curriculum and Instruction: Educational Technology Program at the University of Toledo), 620-757-6116

Purpose: You are invited to participate in the research project entitled, Exploring the Level of Conceptual Mastery in Computational Thinking (CT) Among Male Computer Science (CS) Teachers who Teach at Public Secondary Schools That Apply Courses' Schooling System (CSS) in Riyadh, Saudi Arabia. This research is under the supervision of Dr. Judy Lambert, University of Toledo. The purpose of this study is to explore the level of conceptual mastery in CT among male CS teachers who teach at public secondary schools that apply CSS in Riyadh, Saudi Arabia. In addition, the study will investigate what approaches male CS teachers use to develop students' CT capabilities in terms of both pedagogical strategies and technologies as well as will examine their confidence level of teaching CT skills.

Description of Procedures: This research will take place in 42 public secondary schools that apply CSS in Riyadh, Saudi Arabia from the Fall 2017 to the Spring 2018. The researcher will use a primary data; that will be obtained through administrating an online questionnaire. The questionnaire will be distributed by the researcher to male CS teachers through e-mail or smart devices' communication applications, such as WhatsApp (an instant messaging application broadly used in Saudi Arabia), at the end of the school year in the Fall of 2017. This questionnaire is part of my doctoral research, and it asks you questions regarding your ability to teach Computational Thinking skills to your students. The questionnaire contains 36 questions and should take no longer than 10-15 minutes to complete. Thank you for your willingness to share this information! It will help me to understand what kind of training teachers need to be better prepared to teach Computational Thinking skills.

Potential Risks: There are no known risks at this time to participation in this study. Your response is anonymous and no one will have access to the data other than myself.

Potential Benefits: As a participant in this research study, there will be no direct benefit for you; however, information from this study may benefit other people now or in the future.

Confidentiality: The researchers will make every effort to prevent anyone who is not on the research team from knowing that you provided this information, or what that information is. ***ALL INFORMATION THAT YOU PROVIDE WILL BE KEPT CONFIDENTIAL***. Although we will make every effort to protect your confidentiality, there is a low risk that this might be breached.

Voluntary Participation: Your refusal to participate in this study will involve no penalty or loss of benefits to which you are otherwise entitled and will not affect your relationship with your school or your district. *Your participation in this survey is completely voluntary. Your decision to participate will not affect your relationship with the school or your district.* In addition, you may discontinue participation at any time without any penalty or loss of benefits.

Contact Information: Before you decide to accept this invitation to take part in this study, you may ask any questions that you might have. If you have any questions at any time before, during or after your participation you should contact me *Abdulaziz Alfayez,* email: Abdulaziz.Alfayez@rockets.utoledo.edu*, phone**: 620-757-6116** or **+966546344900**.* If you have questions beyond those answered by the research or your rights as a research subject or research-related injuries, please feel free to contact the IRB Chair at (419) 530-2844.

THE UNIVERSITY OF TOLEDO SOCIAL, BEHAVIORAL & EDUCATIONAL INSTITUTIONAL REVIEW BOARD
The research project described in this consent has been reviewed and approved as EXEMPT
By the University of Toledo SBE IRB
SBE IRB #: 202137 Project Start Date: 06/28/17

By clicking on to the next page and beginning the survey, you are stating that you have read and accept the information above and are giving your consent to participate in this research. You are also confirming that you are 18 years old or over.

Appendix C

QUESTIONNAIRE OF COMPUTATIONAL THINKING (QCT) – ENGLISH VERSION

Questionnaire of Computational Thinking (QCT)

Section One: Demographic Information
This section asks about demographic characteristics of Computer Science teachers. Please click on the box that describes your characteristics.

Q1 Please specify your age group

○ 22 – 25

○ 26 – 30

○ 31 – 35

○ 36 – 40

○ 41 – 45

○ Over 46

Q2 Please specify your Educational level

○ Bachelor

○ Master

○ Doctorate

○ Other: ____

Q3 Please specify your years of experience

○ Less than 5 years

○ 6 – 10

○ 11 – 15

○ 16 – 20

○ 21 – 25

○ More than 26

Q4 Have you been hired based on your competency test score?

○ Yes

○ No

Q5 Please specify the number of workshops that you attended regarding teaching Computer Science courses?

○ 0

○ 1 – 5

○ 6 – 10

○ More than 11

Q6 Have you attended 'Training on topics of computer science courses for computer 1'?

○ Yes

○ No

Q7 Have you attended 'Training on topics of computer science courses for computer 2'?

○ Yes

○ No

Q8 Have you ever heard of ‘Computational Thinking’?

○ Yes

○ No

Section Two: Computational Thinking Skills and its Concepts
This section contains 22 multiple-choice questions that ask you about your knowledge of Computational Thinking skills and your ability to teach these skills to your students. Please choose an answer that you feel best fit the statement.

Q9 Computational Thinking is a fundamental skill for ...

- ○ A. Everyone
- ○ B. Teachers and Students
- ○ C. Computer scientists including programmers
- ○ D. Engineers
- ○ E. Psychologists

Q10 Computational Thinking can be defined as ...

- ○ A. Mentally computing problems
- ○ B. Reformulating a seemingly difficult problem into one easy to solve
- ○ C. Writing programs or coding constructs
- ○ D. Using technologies to solve problems
- ○ E. Logical and creative thinking

Q11 Based on Computational Thinking, Decomposition concept can be defined as ...

- ○ A. Adding details to make a problem more complex
- ○ B. Ignoring unnecessary details to make a problem easier
- ○ C. Collecting necessary details and characteristics to make a problem easier
- ○ D. Ignoring unnecessary characteristics to make a problem easier

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◯ E. Breaking down a problem into smaller, manageable parts

Q12 Individuals decompose a complex problem to ...

◯ A. Make a problem easier to solve

◯ B. Change the problem they have

◯ C. Make a problem manageable

◯ D. Spend less time to solve it

◯ E. Work in-group to solve it

Q13 Which of these is an example of decomposition concept?

◯ A. Finding out how a computer works by looking in detail to the computer internal parts and how each part works

◯ B. Looking at different types of computers in order to find similarities among them

◯ C. Watching a technician repair a computer

◯ D. Collecting sufficient information about a computer to understand how it works

◯ E. Watching a video tutorial on how to dismantle a smart phone, such as iPhone 7, parts

Q14 Based on Computational Thinking, Abstraction concept can be defined as ...

◯ A. The process of representing essential features

◯ B. The process of hiding the needed and relevant information

◯ C. The process of filtering out unnecessary details

◯ D. The process of filtering out unnecessary characteristics

○ E. The process of filtering out unnecessary characteristics and details

Q15 Which of the following is a general characteristic of laptops?

○ A. Most laptops have two USB ports

○ B. This laptop has a USB port

○ C. My laptop has Bluetooth

○ D. This laptop is black

○ E. This laptop has big screen

Q16 To design an effective presentation based on Computational Thinking, which of the following characteristics is necessary to know about?

○ A. When you will present it

○ B. Where you will present it

○ C. The audiences' outfit

○ D. Target audience of the presentation

○ E. The room's design that the presentation will take place in

Q17 Based on Computational Thinking, an Algorithm Design concept can be defined as...

○ A. Series of ordered steps taken to solve a problem or achieve some end (1)

○ B. A programming language

○ C. Patterns and directions used to solve a problem

○ D. A way to solve a problem using charts

5

E. A way to present the right solution to a particular problem

Q18 An algorithm can be represented by ...

A. Charts

B. Images

C. A flowchart

D. Pseudocode

E. A flowchart or pseudocode

Q19 Based on Computational Thinking, Automation concept can be defined as ...

A. Using computer to solve problems

B. Having computers or machines do repetitive or tedious tasks

C. Using Internet-based applications to solve problems

D. Using smart devices to solve problem

E. Using smart device applications to solve problem

Q20 Based on Computational Thinking, Data collection concept can be defined as ...

A. The process of gathering appropriate information

B. The process of gathering general information

C. The process of gathering qualitative data

D. The process of gathering quantitative data

E. The process of gathering qualitative and quantitative data

6

Q21 Based on Computational Thinking, Data analysis concept can be defined as ...

- A. Breaking down a problem into smaller, manageable parts
- B. Making sense of data, finding patterns (similarities), and drawing conclusions
- C. Constructing models from patterns
- D. Applying statistical tests
- E. The process of decision making

Q22 Based on Computational Thinking, analyzing data appropriately will result in ...

- A. Reaching correct and efficient solution to a problem
- B. Reaching correct solution to a problem
- C. Reaching efficient solution to a problem
- D. Applying multiple statistical tests
- E. Displaying the solution in a tabular format

Q23 Which of following statements contains a pattern ...

- A. My computer is black
- B. My friend's computer has two USB ports
- C. My laptop has Bluetooth
- D. This computer has built-in speaker
- E. All computers have memory

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Q24 Based on Computational Thinking, Data representation concept can be defined as ...

- A. A way to describe and encode information
- B. Depicting and organizing information in appropriate graphs, charts, words, or images
- C. Developing a model to imitate real-world processes
- D. A way to collect appropriate data to solve a problem
- E. A way to select relevant information to solve a problem

Q25 Based on Computational Thinking, Simulation concept can be defined as ...

- A. Imitating real-world processes
- B. A way to display a possible solution to a particular problem
- C. A process that allows individuals to find solutions to problems
- D. The process of representing essential features
- E. Finding patterns to make sense of data and drawing conclusions

Q26 Running simulations helps individuals to ...

- A. Demonstrate specific ideas and obtain an in-depth understanding of problem
- B. Find a solution to a problem
- C. Break down and analyze a problem correctly
- D. Reach correct solution to a problem
- E. Choose the appropriate statistical test

8

Q27 Based on Computational Thinking, Parallelization concept can be defined as ...

◯ A. Solving two problems simultaneously

◯ B. A new way to solve problems quickly based on prior experiences of similar problems

◯ C. Arranging encoded information in parallel form

◯ D. Simultaneously processing of smaller tasks from a larger task to more efficiently reach a common goal

◯ E. Viewing solution of problem in parallel form

Q28 Based on Computational Thinking, Which of these is an example of the parallelization concept when producing a video tutorial?

◯ A. Using a pre-designed templates to produce the new video tutorial

◯ B. Dividing the processes of producing a video tutorial into smaller tasks that will be performed by a group simultaneously

◯ C. Dividing the processes of producing a video tutorial into smaller tasks that will be performed by a group asynchronously

◯ D. Dividing the processes of producing a video tutorial into smaller tasks that will be performed by a group sequentially

◯ E. Individual produces a video tutorial in a systematic manner; writing script, collecting relevant images, design the video ... etc.

Q29 Based on Computational Thinking, Generalization concept can be defined as...

◯ A. A new way to solve problems quickly based on prior experiences of similar problems

◯ B. Organizing resources to simultaneously perform tasks to achieve a common goal

◯ C. Making sense of data, finding patterns, and drawing conclusions

٥

◯ D. Taking one or a few facts and making a broader, more universal statement

◯ E. Broad statement or idea that applies to a lot of people or situations

Q30 Based on Computational Thinking, Generalization process allows individuals to ...

◯ A. Create models, rules, principles, or theories of observed patterns

◯ B Transfer prior knowledge of a solution to address a current problem that has similar patterns

◯ C. Find patterns and make sense of data

◯ D. Produce universal statement

◯ E. Investigate problems and test possible solutions

Section Three: Pedagogical Strategies
This section contains two open-ended questions that ask you about pedagogical strategies used to develop your students' Computational Thinking skills. Please answer the following questions by writing a paragraph or more.

Q31 What pedagogical strategies do you use to develop your students' computational thinking skills?

Q32 Which pedagogical strategies do you most frequently use to teach Computational Thinking Skills?

Section Four: Classroom Educational Technologies
This section contains two open-ended questions that ask you about classroom educational technologies used to develop your students Computational Thinking skills. Please answer the following questions by writing a paragraph or more.

Q33 What educational technologies are available in your classroom?

Q34 Which educational technologies do you most frequently use to teach Computational Thinking Skills?

Section Five: Confidence Level
This section contains a multiple-choice question and two open-ended questions that ask you about your confidence level of teaching Computational Thinking skills. Please answer the following questions by clicking on the box that describes your confidence level and by writing a paragraph or more.

Q35 Are you confident in teaching Computational Thinking skills?

- Yes
- No

Q36 Why do you not feel confident in teaching Computational Thinking skills?

Q37 What are some reasons that make you confident in teaching Computational Thinking skills?

Thank you for your participation!
I really appreciate that!

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Appendix D

TRANSLATION APPROVAL LETTER FOR BOTH (ADULT RESEARCH - INFORMED CONSENT FORM AND QUESTIONNAIRE OF COMPUTATIONAL THINKING (QCT) - ARABIC VERSION)

THE UNIVERSITY OF TOLEDO 1872

September 6, 2017

To Whom it May Concern,

This is to certify that I approve the attached Arabic translation of the "Adult Research – Informed Consent Information" and of the "Questionnaire of Computational Thinking (QCT)" The Arabic translation reflects an accurate translation of the attached English questionnaire.

Gaby Semaan

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Appendix E

ADULT RESEARCH - INFORMED CONSENT INFORMATION – ARABIC VERSION

ADULT RESEARCH - INFORMED CONSENT INFORMATION

استكشاف مستوى اتقان **مفاهيم التفكير الحاسوبي** (CT) بين معلمي الحاسب الآلي الذكور (CS) الذين يدرسون في المدارس
الثانوية العامة التي تطبق نظام الوحدات التعليمية (CSS) في الرياض، المملكة العربية السعودية

الباحث الرئيسي: عبدالعزيز عبدالله الفائز (مرشح للحصول على درجة الدكتوراه - في برنامج المناهج و طرق التدريس : تقنيات التعليم، جامعة توليدو)، ٠٠١٦٢٠٧٥٧٦١١٦

الغرض: أنت مدعو للمشاركة في هذا البحث بعنوان" استكشاف مستوى اتقان **مفاهيم التفكير الحاسوبي** (CT) بين معلمي الحاسب الآلي الذكور (CS) الذين يدرسون في المدارس الثانوية العامة التي تطبق نظام الوحدات التعليمية (CSS) في الرياض، المملكة العربية السعودية؛ هذا البحث تحت إشراف الدكتوره جودي لامبرت من جامعة توليدو .الغرض من هذه الدراسة هو استطلاع مستوى اتقان مفاهيم مهارات التفكير الحاسوبي بين معلمي الحاسب الآلي الذكور الذين يدرسون في المدارس الثانوية العامة التي تطبق نظام الوحدات التعليمية في الرياض، المملكة العربية السعودية .وبالإضافة إلى ذلك، يبغي البحث معرفة الاستراتيجيات التربوية و التقنيات التي يستخدمها معلمي الحاسب الآلي لتطوير مهارات التفكير الحاسوبي لطلابهم، وكذالك هذه الدراسة ستستطلع مستوى ثقة معلمين الحاسب الآلي في تدريس هذه المهارات.

وصف الإجراءات: هذا البحث سوف يُطبق على ٤٢ مدرسة ثانوية عامة تطبق نظام الوحدات التعليمية في الرياض، المملكة العربية السعودية من خريف ٢٠١٧ إلى ربيع ٢٠١٨ .سيستخدم الباحث بيانات أولية-من خلال استبيان عن طريق الإنترنت . سيتم توزيع الاستبيان من قبل الباحث على معلمي الحاسب الآلي من خلال البريد الإلكتروني أو أحد تطبيقات الأجهزة الذكية، مثل واتس اب (تطبيق الرسائل الفورية المستخدمة على نطاق واسع في المملكة العربية السعودية)، في نهاية العام الدراسي، خريف عام ٢٠١٧ .هذا الاستبيان هو جزء من متطلبات الحصول على درجة الدكتوراه، و هو يطرح اسئلة بشأن قدرتك على تدريس مهارات التفكير الحاسوبي لطلابك .يحتوي الاستبيان على ٣٦ سؤالا، و لاستكمال هذه الاستبانة تحتاج إلى ١٠-١٥ دقيقة .شكرا لكم على استعدادكم للمشاركة في هذه الدراسة ! مشاركتكم ستُمكنُني من اقتراح برنامج تدريب لتطوير مهارات معلمي- الحاسب الآلي ليكونوا على أتم الاستعداد لتدريس مهارات التفكيرالحاسوبي.

المخاطر المحتملة: في الوقت الحالي لا توجد مخاطر معروفة للمشاركة في هذه الدراسة .إجاباتك على اسألة الاستبيان ستكون مجهول الهوية، ولن يتمكن أحد من الوصول إلى البيانات غير الباحث الرئيسي.

الفوائد المحتملة: كمشارك في هذه الدراسة البحثية، لن يكون هناك فائدة مباشرة بالنسبة لك .ومع ذلك، فإن المعلومات التي تقدمها في هذه الدراسة قد تفيد الآخرين في الوقت الحالي أو في المستقبل.

السرية: سيبذل الباحثون كل جهد ممكن لمنع أي شخص ليس من فريق البحث من معرفة أنك قدمت هذه المعلومات، أو ما هي تلك المعلومات .**جميع المعلومات التي تقدمها سوف تكون سرية و ستحفظ في مكان آمن .**على الرغم من أننا سوف نبذل قصارى جهدنا لحماية سرية معلوماتك، هناك خطر منخفض من أن هذا المعلومات قد يتم اختراقها.

المشاركة تطوعية: إن رفضك للمشاركة في هذه الدراسة لن يعود عليك بأي عقوبة أو خسارة، ولن يؤثر على علاقتك مع مدرستك أو الإدارة التعليمية التابعة لها .**مشاركتك في هذه الدراسة الإستطلاعية تطوعية تماما .لن يؤثر قرار المشاركة من**

عدمها على علاقتك بالمدرسة أو بالإدارة التعليمية التابعة لها .وبالإضافة إلى ذلك، يمكنك التوقف عن المشاركة في أي وقت دون أي عقوبة أو فقدان أي مزايا تتمتع بها حالياً .

معلومات الاتصال: قبل أن تقرر قبول هذه الدعوة للمشاركة في هذه الدراسة، يمكنك طرح أي سؤال لديك، و ايضاً يمكنك طرح أي سؤال في أي وقت قبل أو أثناء أو بعد المشاركة من خلال الاتصال بي عبدالعزيز الفائز:

البريد الإلكتروني: Abdulaziz.Alfayez@rockets.utoledo.edu

هاتف امريكا : ٠٠١٦٢٠٧٥٧٦١١٦

هاتف السعودية : ٩٦٦٥٤٦٣٤٤٩٠٠+

إذا كانت لديك أسئلة تتجاوز تلك التي أجاب عنها البحث أو حقوقك كموضوع بحثي أو إصابات متعلقة بالبحث، فلا تتردد في الاتصال ب (IRB Chair) على الرقم ٠٠١٤١٩٥٣٠٢٨٤٤

THE UNIVERSITY OF TOLEDO
SOCIAL, BEHAVIORAL & EDUCATIONAL INSTITUTIONAL REVIEW BOARD
The research project described in this consent has been reviewed and approved as EXEMPT
By the University of Toledo SBE IRB
SBE IRB #: 202137 Project Start Date: 06/28/17

من خلال النقر على الصفحة التالية وبدء الإستبانة، فإنك تُقر بأنك قرأت المعلومات الواردة أعلاه وقبِلتها ، الذي يعني انك موافق على المشاركة في هذا البحث، أنت أيضا تؤكد أنك عمرك ١٨ سنة أو أكثر.

Appendix F

QUESTIONNAIRE OF COMPUTATIONAL THINKING (QCT) – ARABIC VERSION

THE UNIVERSITY OF TOLEDO 1872

استبيان التفكير الحاسوبي (QCT)

القسم الأول : المعلومات الديموغرافية

هذا القسم يسأل عن خصائص معلمي الحاسب الآلي ، يرجى النقر على المربع الذي يصف خصائصك.

س١ :يرجى تحديد الفئة العمرية*

- ٢٢ - ٢٥
- ٢٦ - ٣٠
- ٣١ – ٣٥
- ٣٦ – ٤٠
- ٤١ – ٤٥
- ٤٦ او أكثر

س٢ :يرجى تحديد المستوى التعليمي*

- بكالوريوس
- ماجستير
- دكتوراه
- غير ذالك:____________________

س٣ :يرجى تحديد سنوات الخبرة*

- أقل من ٥ سنوات
- ٦ – ١٠
- ١١ – ١٥
- ١٦ – ٢٠
- ٢١ – ٢٥
- أكثر من ٢٦

س٤ :هل تم تعيينك كمعلم حاسب آلي بناءً علي درجتك في إختبار الكفايات؟*

- نعم
- لا

س٥ :يرجى تحديد عدد الدورات التدريبية التي سبق أن حضرتها فيما يتعلق بتدريس مادة الحاسب الآلي؟*

- صفر
- ١ – ٥
- ٦ – ١٠
- أكثر من ١١

س٦ :هل سبق لك حضور دورة تدريبية عن "مواضيع مقرر الحاسب الآلي ١" ؟*
- نعم
- لا

س٧ :هل سبق لك حضور دورة تدريبية عن "مواضيع مقرر الحاسب الآلي ٢"؟*
- نعم
- لا

س٨ :هل سبق لك أن سمعت عن "التفكير الحاسوبي"؟*
- نعم
- لا

القسم الثاني : مهارات التفكير الحاسوبي ومفاهيمه

يحتوي هذا القسم على ٢٢ سؤال من نوع الإختيارات المتعددة التي تسألك عن معرفتك بمهارات التفكير الحاسوبي وقدرتك على تدريس هذه المهارات لطلابك، يرجى اختيار الإجابة الصحيحة.

س٩ :مهارات التفكير الحاسوبي تعتبر مهارات اساسية لـــ ...*
- A. كل شخص
- B. المعلمين و الطلاب
- C. علماء الحاسب بما في ذلك المبرمجين
- D. المهندسين
- E. علماء النفس

س١٠ :التفكير الحاسوبي يمكن تعريفه بأنه ... *
- A. حوسبة المشاكل بشكل ذهني
- B. إعادة صياغة المشكلة التي تبدو صعبة إلى مشكلة يسهل حلها
- D. كتابة البرامج أو بناء الرموز
- E. استخدام التقنيات لحل المشاكل
- E. التفكير المنطقي والإبداعي

س١١ :مفهوم التحلُّ "Decomposition" يمكن تعريفه بأنه ... *
- A. إضافة تفاصيل لجعل المشكلة أكثر تعقيدا
- B. تجاهل التفاصيل الغير ضرورية لتسهيل حل المشكلة
- C. جمع التفاصيل والخصائص الضرورية لتسهيل حل المشكلة
- D. تجاهل الخصائص الغير ضرورية لتسهيل حل المشكلة
- E. تقسيم المشكلة إلى أجزاء أصغر، يمكن التحكم فيها

س١٢: الأفراد تُفكك المشكلة المعقدة من أجل ... *

- A. تسهيل حل المشكلة
- B. تغيير المشكلة
- C. جعل المشكلة قابله لتحكم
- D. تقليل مدة حل المشكلة
- E. العمل في مجموعات لحل المشكلة

س١٣ :أي من الأمثلة التالية يعتبر مثال على مفهوم التحلُلُ؟*

- A. معرفة كيف يعمل جهاز الحاسب الآلي من خلال النظر بالتفصيل إلى أجزاء الحاسب الداخلية و كيف يعمل كل جزء
- B. النظر إلى أنواع مختلفة من أجهزة الحاسب الآلي من أجل إيجاد أوجه التشابه بينها
- C. مشاهدة فني يصُلح جهاز حاسب آلي فيه عطل في اللوحة الإم "Motherboard"
- D. جمع معلومات كافية عن الحاسب الآلي لفهم كيفية عمله
- E. مشاهدة فيديو تعليمي حول كيفية تفكيك أجزاء جهاز هاتف ذكي مثل iPhone 7

س١٤ :بناءً على التفكير الحاسوبي، مفهوم التجريد "Abstraction" يمكن تعريفه بأنه ...*

- A. عملية تمثيل السمات الأساسية
- B. عملية إخفاء المعلومات المطلوبة وذات الصلة
- C. عملية تصفية التفاصيل الغير الضرورية
- D. عملية تصفية الخصائص الغير الضرورية
- E. عملية تصفية الخصائص والتفاصيل الغير الضرورية

س١٥ :أي من الخصائص التالية تعتبر خاصية عامة للحاسبات المحمولة؟*

- A. معظم أجهزة الحاسب الآلي المحمولة تحتوي علي منفذين USB
- B. هذا الحاسب الآلي المحمولة يحتوي على منفذ USB واحد فقط
- C. جهازي يحتوي على بلوتوث
- D. هذا الحاسب الآلي المحمولة لونه أسود
- E. هذا الحاسب الآلي المحمول يحتوي على شاشة كبيرة

س١٦: لتصميم عرض تفاعلي فعال بناءً على التفكير الحاسوبي، أي من الخصائص التالية تعتبر خاصية ضرورية يجب معرفتها عند تصميم عرض تقديمي فعال؟*

- A. متي سيتم تقديم العرض
- B. أين سيتم تقديم العرض
- C. ملابس الجمهور
- D. من هم الجمهور المستهدف من العرض
- E. تصميم الغرفة التي سيقدم فيها العرض

س١٧ :بناءً على التفكير الحاسوبي، مفهوم تصميم الخوارزميات "Algorithm Design" يمكن تعريفه بأنه...*

- A. سلسلة من الخطوات المرتبة التي تُتخذ من أجل حل مشكلة أو تحقيق نهاية ما
- B. لغة برمجة
- C. الأنماط والاتجاهات المستخدمة في حل مشكلة
- D. طريقة لحل المشكلة باستخدام الرسوم البيانية
- E. طريقة لعرض الحل الصحيح لمشكلة معينة

س١٨ :يمكن تمثيل خوارزمية عن طريق ...*

- A. رسوم بيانية
- B. صور
- C. مخططات انسيابية
- D. التعليمات البرمجية المستعارة
- E. مخططات بيانية أو التعليمات البرمجية المستعارة

س١٩ :بناءً على التفكير الحاسوبي، مفهوم التشغيل الآلي "Automation" يمكن تعريفه بأنه ...*

- A. استخدام الحاسب الآلي في حل المشكلات
- B. وجود أجهزة حاسب آلي أو أدوات أخرى لتنفيذ المهام المتكررة أو مملة
- C. أستخدام التطبيقات المُعتمدة على شبكة الإنترنت في حل المشكلات
- D. استخدام الأجهزة الذكية لحل المشكلات
- E. استخدام تطبيقات الأجهزة الذكية لحل المشكلات

س٢٠ :بناءً على التفكير الحاسوبي، مفهوم جمع البيانات "Data Collection" يمكن تعريفه بأنه ...*

- A. عملية تجميع البيانات المناسبة
- B. عملية تجميع البيانات عامة
- C. عملية تجميع البيانات النوعية
- D. عملية تجميع البيانات الكمية
- E. عملية تجميع كل من البيانات الكمية والنوعية

س٢١ :بناءً على التفكير الحاسوبي، مفهوم تحليل البيانات "Data Analysis" يمكن تعريفه بأنه ...*

- A. تقسيم المشكلة إلى أجزاء أصغر، يمكن التحكم فيها
- B. محاولة فهم البيانات، وإيجاد أنماط (أوجه التشابه)، وإستخلاص النتائج
- C. بناء نماذج من الأنماط أو أوجه التشابه
- D. تطبيق الإختبارات الإحصائية
- E. عملية صنع القرار

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س٢٢ :بناءً على التفكير الحاسوبي، تحليل البيانات بشكل مناسب يؤدي إلى ...*

- A. الوصول إلى حل صحيح وفعال للمشكلة
- B. الوصول إلى حل صحيح للمشكلة
- C. الوصول إلى حل فعال للمشكلة
- D. تطبيق إختبارات إحصائية متعددة
- E. عرض الحل على شكل جدول

س٢٣ :أي من العبارات التالية يحتوي على نمط "Pattern" ...*

- A. جهازي لونه اسود
- B. جهاز الحاسب الآلي الخاص بصديقي يحتوي على منفذين USB
- C. جهازي المحمول يحتوي على بلوتوث
- D. يحتوي هذا الحاسب الآلي على مكبر صوت مدمج
- E. جميع أجهزة الحاسب الآلي تحتوي على ذاكرة

س٢٤ :بناءً على التفكير الحاسوبي، مفهوم تمثيل البيانات "Data Representation" يمكن تعريفه بأنه ...*

- A. طريقة لوصف وترميز المعلومات
- B. وصف وتنظيم المعلومات في رسوم بيانية، عبارات، أو صور مناسبة
- C. تطوير نموذج لمحاكاة العمليات التي تحصل في العالم الحقيقي
- D. طريقة لجمع البيانات المناسبة لحل مشكلة معينة
- E. طريقة لتحديد المعلومات ذات الصلة لحل مشكلة معينة

س٢٥ :بناءً على التفكير الحاسوبي، مفهوم المحاكاة "Simulation" يمكن تعريفه بأنه ...*

- A. تقليد العمليات التي تحصل في العالم الحقيقي
- B. طريقة لعرض حل ممكن لمشكلة معينة
- C. عملية تسمح للأفراد بإجاد حلول للمشاكل
- D. عملية تمثيل السمات الأساسية
- E. إيجاد أنماط لفهم البيانات وإستخلاص النتائج

س٢٦ :المحاكاة تساعد الافراد على ...*

- A. شرح أفكار محددة والحصول على فهم متعمق للمشكلة
- B. إيجاد حل للمشكلة
- C. تفكيك وتحليل مشكلة بشكل صحيح
- D. الوصول إلى الحل الصحيح للمشكلة
- E. إختيار الاختبار الإحصائي المناسب

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س٢٧ :بناءً على التفكير الحاسوبي، مفهوم الموازاة "Parallelization" يمكن تعريفه بأنه ...*

- A. حل مشكلتين في وقت واحد
- B. طريقة لحل مشكلة جديدة في وقت سريع بناءً علي الخبرات السابقة لمشكلة مشابهة
- C. ترتيب المعلومات المشفرة على شكل متوازي
- D. معالجة مجموعة من المهام الصغيرة المنبثقة من مهمة أكبر في وقت واحد للوصول إلى هدف مشترك بكفاءة عالية
- E. عرض حل المشكلة بطريقة متوازية

س٢٨ :بناءً على التفكير الحاسوبي، أي من الأمثلة التالية يعتبر مثال على مفهوم الموازاة عند إنتاج الفيديو التعليمي؟*

- A. أستخدام القوالب المصممة مسبقا لإنتاج فيديو تعليمي جديد
- B. تقسيم مراحل إنتاج الفيديو التعليمي إلى مهام أصغر ويتم تنفيذ كل مهمة من قبل مجموعة في وقت واحد
- C. تقسيم مراحل إنتاج الفيديو التعليمي إلى مهام أصغر ويتم تنفيذ كل مهمة من قبل مجموعة في أوقات مختلفة
- D. تقسيم مراحل إنتاج فيديو تعليمي إلى مهام أصغر ويتم تنفيذ كل مهمة من قبل مجموعة بشكل متتالي
- E. الفرد ينتج الفيديو التعليمي بطريقة منهجية مثل :كتابة النص، وجمع الصور ذات الصلة، وتصميم الفيديو ... الخ

س٢٩ :بناءً على التفكير الحاسوبي، مفهوم التعميم "Generalization" يمكن تعريفه بأنه ...*

- A. طريقة لحل مشكلة جديدة في وقت سريع بناءً علي الخبرات السابقة لمشكلة مشابهة
- B. تنظيم الموارد اللازمة لأداء المهام في وقت واحد لتحقيق هدف مشترك
- C. محاولة فهم البيانات، وإيجاد أنماط (أوجه التشابه)، واستخلاص النتائج
- D. تعميم حقيقة (نتيجة)أو اكثر
- E. بيان أو فكرة عامة تنطبق على الجميع

س٣٠ :بناءً على التفكير الحاسوبي، عملية التعميم تسمح للأفراد بـــ ...*

- A. إنشاء النماذج والقواعد والمبادئ، أو نظريات الأنماط الملاحظة
- B. نقل المعرفة بحل سابق لمعالجة مشكلة حالية لها أنماط مماثلة
- C. إيجاد الأنماط وفهم البيانات
- D. إنتاج بيان عالمي
- E. استكشاف المشاكل واختبار الحلول الممكنة

القسم الثالث :الاستراتيجيات التربوية

يحتوي هذا القسم على سؤالين يسألانك عن الاستراتيجيات التربوية التي تستخدمها لتطوير مهارات التفكير الحاسوبي لدى طلابك، يرجى الإجابة على الأسئلة التالية عن طريق كتابة فقرة أو أكثر.

س٣١ :ما هي الاستراتيجيات التربوية التي تستخدمها لتطوير مهارات التفكير الحاسوبي لدى طلابك؟*

....

....

س٣٢ :ما هي الاستراتيجيات التربوية التي تستخدمها بشكل متكرر لتدريس مهارات التفكير الحاسوبي؟*

....

....

القسم الرابع :تقنيات الفصل الدراسي

يحتوي هذا القسم على سؤالين يسألانك عن التقنيات التعليمية (Educational Technologies) المتوفرة في الفصل و التي تُستخدم لتطويرمهارات التفكير الحاسوبي لدى طلابك، يرجى الإجابة على الأسئلة التالية عن طريق كتابة فقرة أو أكثر.

س٣٣ :ما هي التقنيات التعليمية (Educational Technologies) المتوفرة في فصلك؟ *

....

....

س٣٤ :ما هي التقنيات التعليمية (Educational Technologies) التي تستخدمها بشكل متكرر لتدريس مهارات التفكير الحاسوبي؟*

....

....

القسم الخامس: مستوى الثقة

يحتوي هذا القسم على سؤال واحد من من نوع الإختيارات المتعددة و ايضاً سؤالين من نوع الأسئلة المفتوحة التي تسألك عن مستوى ثقتك في تدريس مهارات التفكير الحاسوبي، يرجى الإجابة على الأسئلة التالية بالنقرعلى المربع الذي يصف مستوى ثقتك وكتابة فقرة أو أكثر.

س٣٥: هل أنت واثق من قدرتك على تدريس مهارات التفكير الحاسوبي؟

- نعم
- لا

س٣٦ :إذا كنت غير واثقاً من قدرتك على تدريس طلابك مهارات التفكير الحاسوبي، فما الذي يمنعك من الشعور بالثقة؟

....

....

س٣٧ :إذا كنت واثقاً من قدرتك على تدريس طلابك مهارات التفكير الحاسوبي، فما الأسباب التي منحتك هذه الثقة؟

....

....

شكرا لك على المشاركة ،،،

Appendix G

SURVEY/INTERVIEW VALIDATION RUBRIC FOR EXPERT PANEL - VREP©
By Marilyn K. Simon with input from Jacquelyn White

Survey/Interview Validation Rubric for Expert Panel - VREP©
By Marilyn K. Simon with input from Jacquelyn White

Reviewers Name: ______________________________

Expertise in Related area (please note courses taught, professional experience, publications, or degrees in related areas): ______________________________

Criteria	Operational Definitions	Score **1=Not Acceptable** (major modifications needed) **2=Below Expectations** (some modifications needed) **3=Meets Expectations** (no modifications needed but could be improved with minor changes) **4=Exceeds Expectations** (no modifications needed)				**Questions NOT meeting standard (Please list the questions (that needs to be revised if any, (e.g. 1a, 2c etc.) as written in the survey.** ***Please use the comments and suggestions section to recommend revisions.***
		1	2	3	4	
Clarity	• The questions are direct and specific. • Only one question is asked at a time. • The participants can understand what is being asked. • There are no *double-barreled* questions (two questions in one).					
Wordiness	• Questions are concise. • There are no unnecessary words					
Negative Wording	• Questions are asked using the affirmative (e.g., Instead of asking, "Which methods are not used?", the researcher asks, "Which methods *are* used?")					
Overlapping Responses	• No response covers more than one choice. • All possibilities are considered. • There are no ambiguous questions.					
Balance	• The questions are unbiased and do not lead the participants to a response. The questions are asked using a neutral tone.					

Use of Jargon	• The terms used are understandable by the target population. • There are no clichés or hyperbole in the wording of the questions.					
Appropriateness of Responses Listed	• The choices listed allow participants to respond appropriately. • The responses apply to all situations or offer a way for those to respond with unique situations.					
Use of Technical Language	• The use of technical language is minimal and appropriate. • All acronyms are defined.					
Application to Praxis	• The questions asked relate to the daily practices or expertise of the potential participants.					
Relationship to Problem	• The questions are sufficient to resolve the problem in the study • The questions are sufficient to answer the research questions. • The questions are sufficient to obtain the purpose of the study.					
Computational Thinking (CT)	• The survey adequately measures this construct: **Computational Thinking (CT) Skills and its Concepts**					
Pedagogical Strategies	• The survey adequately measures this construct: **Pedagogical strategies used to develop students' CT skills**					
Technologies	• The survey adequately measures this construct: **Technologies used to develop students' CT skills**					
Confidence level	• The survey adequately measures this construct: **Teachers' confidence level in teaching CT**					

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* The operational definition should include the domains and constructs that are being investigated. You need to assign meaning to a variable by specifying the activities and operations necessary to measure, categorize, or manipulate the variable For example, to measure the construct *successful aging* the following domains could be included: degree of physical disability (low number); prevalence of physical performance (high number), and degree of cognitive impairment (low number). If you were to measure creativity, this construct is generally recognized to consist of flexibility, originality, elaboration, and other concepts. Prior studies can be helpful in establishing the domains of a construct.

Comments and Suggestions

Types of Validity

VREP is designed to measure face validity, construct validity, and content validity. To establish criterion validity would require further research.

Face validity is concerned with how a measure or procedure appears. Does it seem like a reasonable way to gain the information the researchers are attempting to obtain? Does it seem well designed? Does it seem as though it will work reliably? Face validity is independent of established theories for support (Fink, 1995).

Construct validity seeks agreement between a theoretical concept and a specific measuring device or procedure. This requires operational definitions of all constructs being measured.

Content Validity is based on the extent to which a measurement reflects the specific intended domain of content (Carmines & Zeller, 1991, p.20). Experts in the field can determine if an instrument satisfies this requirement. Content validity requires the researcher to define the domains they are attempting to study. Construct and content validity should be demonstrated from a variety of perspectives.

Criterion related validity, also referred to as instrumental validity, is used to demonstrate the accuracy of a measure or procedure by comparing it with another measure or procedure which has been demonstrated to be valid. If after an extensive search of the literature, such an instrument is *not* found, then the instrument that meets the other measures of validity are used to provide criterion related validity for future instruments.

Operationalization is the process of defining a concept or construct that could have a variety of meanings to make the term measurable and distinguishable from similar concepts. Operationalizing enables the concept or construct to be expressed in terms of empirical observations. Operationalizing includes describing what is, and what is not, part of that concept or construct.

References

Carmines, E. G. & Zeller, R.A. (1991). *Reliability and validity assessment*. Newbury Park: Sage Publications.

Fink, A., ed. (1995). *How to measure survey reliability and validity v. 7*. Thousand Oaks, CA: Sage.

Appendix H

PERMISSION TO USE AN EXISTING VALIDATION RUBRIC FOR EXPERT PANEL (VREP©)

PERMISSION TO USE AN EXISTING VALIDATION RUBRIC FOR EXPERT PANEL (VREP)

April 22, 2017

To: Alfayez Abdulaziz

Thank you for your request for permission to use VREP in your research study. I am willing to allow you to reproduce the instrument as outlined in your letter at no charge with the following understanding:

- You will use this survey only for your research study and will not sell or use it with any compensated management/curriculum development activities.
- You will include the copyright statement on all copies of the instrument.
- You will send your research study and one copy of reports, articles, and the like that make use of this survey data promptly to our attention.

If these are acceptable terms and conditions, please indicate so by signing one copy of this letter and returning it to me.

Best wishes with your study.

Sincerely,

Marilyn K. Simon, Ph.D

Signature

I understand these conditions and agree to abide by these terms and conditions.

Signed **Date** April 23,2017
Expected date of completion: May 10th, 2018