Measuring Awareness of Computational Thinking in Kuwaiti Educational Institutions

Safia A. Malallah, Kansas State University, safia@ksu.edu
Khaled N. Alselmi, Public Authority for Applied Education and Training, kn.alselmi@paaet.edu.kw
Joshua L. Weese, Kansas State University, weeser@ksu.edu

Abstract:
Computational thinking (CT) has a vital impact on education. Students and educators need to be aware that CT is more than just using technology or computer science; it is a mindset that increases students' ability to recognize solutional implications. Incorporating CT into the educational system is a shared responsibility between decision-makers and educators. All participants have a duty on how to bring CT into classrooms. This study sought to identify CT awareness in different educational roles to suggest a plan to promote CT in Kuwait education institutes. The promoted plan employs the CT Systemic Change Model, developed by ISTE. We utilize the model with the outcome of our CT awareness surveys to recommend a plan that fits the regulations and roles in Kuwait education. The survey derived from the technological pedagogical content knowledge framework; It investigated CT awareness of content knowledge (knowledge of CT concepts), pedagogical knowledge (knowledge of CT purposes, values, and aims), and technological knowledge (knowledge of the technologies and resources that support CT learning). The survey was distributed to students and educators in educational institutes in Kuwait. The results showed high acceptance and awareness, especially among the department heads. The lowest awareness scores were attributed to the administration's roles; therefore, a recommended training that emphasizes the importance of CT in education for the leadership positions then forming a team including the department heads to incorporate the plan into the classroom. Overall, the results of this study can guide promoting CT activities in the Kuwait education system.

Introduction

Computational thinking (CT) is a mindset tool that uses computing ideas to improve reasoning through the processes of problem-solving. The continuous technological evolution needs more efficient ways to solve problems. In the same token, CT essence embraces reasoning skills to study a problem objectively (logic thinking) by concentrating on the essential features of a problem and ignoring low-level details (abstraction), recognizing similar characteristics (pattern recognition) to break down complex problem into sub-problems (decomposition), using steps of instruction (algorithms) to solve the problem, and finally determining if a solution is efficient for the problem (evaluation). Educators must empower their students to become computational thinkers and encourage them to take ownership of their learning. Introducing CT concepts to students can help them become producers, not just technology consumers; they can use these abilities to impact the world. Policymakers have taken action to empower CT education worldwide [1], yet, not all countries have acknowledged the need for this knowledge like Kuwait. According to the Human Development Index (HDI) in 2020, Kuwait ranked 63 out of 189 countries, with the lowest HDI score among neighbor's countries. This paper aims to measure awareness of CT in educational institutions to propose a plan that can promote CT in the Kuwait education system. ISTE developed a CT Model to guide the way to implement CT in K–12 education [2]. To efficiently allocate the resources, educational researchers suggest first estimate stakeholder awareness of the concept [3]. Because CT is a relatively new concept, many people are unaware of its nature [4]. Determining awareness is a prerequisite for adopting and improving CT [5]. This study investigated CT awareness in

Kuwait, with the primary objective of studying CT awareness of content knowledge (CK), or knowledge of CT concepts; pedagogical knowledge (PK), or knowledge of CT purposes, values, and aims; and technological knowledge (TK), or knowledge of the technologies and resources that support CT learning. Using the Technological Pedagogical Content Knowledge (TPACK) framework [6], the authors developed a questionnaire to measure CT awareness of survey participants using the six Computing at School (CAS) concepts of CT: logical thinking (LOG), algorithms (ALG), decomposition (DEC), patterns recognition (REC), abstraction (ABS), and evaluation (EVA) [7]. The survey was distributed to students and educators in 18 educational institutions in Kuwait. Results showed a high level of awareness of CK, TK, and PK, with 65% of participants demonstrating a high level of familiarity with ALG, LOG, and EVA and less familiarity with DEC, ABS, and REC. Overall, 80% of survey participants were technology consumers. Study results revealed the need for more guides to increase the use of CT, especially for educators with administration rolls who presented the lowest scores of CT awareness. Previous training and the job nature were shown to impact the awareness level for all ages, which guides the formation of a plan using the CT leadership toolkit model.

Background and Related Work

Technology and Education in Kuwait

Kuwait, which is located in the Middle East region between Iraq and Saudi Arabia, has an estimated population of 4.5 million comprised of many ethnicities from South Asian countries and Iran [8]. The primary religion is Islam, and although Arabic is the official language for communication and education, English is widely used and regarded as the compulsory second language taught to students in schools. Kuwait's educational system begins with a 2-year kindergarten stage, followed by a 5-year primary stage, a 4-year middle education stage, and finally a 3-year secondary stage [9]. Students typically then pursue either a two-year diploma or a four-year bachelor’s degree. The Ministry of Education (MOE) implements a national curriculum across all public education systems [10] and provides annual in-house training for teachers [11, 12]. MOE is the sole decision makers for all issues related to national education, with the highest authority of decision-making being the Ministry's Undersecretary Council, chaired by the minister. The Civil Service Commission (CSC) is responsible for appointing employees and teachers to the MOE [13].

Computational Thinking

The history of CT was introduced by Seymour Papert in 1969 when he presented the Logo computer language [14]. In 2006, Jeannette Wing developed CT concepts in an article that described CT as a universal skill that must be mastered not only by computer scientists but also by all individuals to enhance analytical abilities and promote problem-solving skills using multiple levels of abstraction [15].

Institutes define the CT according to unique goals and standards, meaning no unified CT definitions exist among researchers. For example, the International Society for Technology in Education (ISTE) defines CT as a systematic approach for solving problems in computer sciences and other subject areas and careers [16]. According to the K–12 Computer Science Framework, CT is closely related to computer sciences, specifically the capabilities of computers for solving various problems using algorithms. The framework includes core practices for promoting the computing culture, collaborating using computing, defining computational problems, developing abstractions, creating and testing artifacts, and communicating about computing [17]. Computing at School (CAS) defines CT thinking as a cognitive process that involves thinking logically to solve problems using specific sequences in algorithms, decomposition, generalizations, patterns, and evaluation. They present them in a conceptual framework describing pedagogic plans for teachers and offer models for assessment [7]. This current study adopted the CAS definition shown in Table 1.

Table 1. CT concepts and CAS definition [7]

Abbr.	Description
DEC Decomposition	Decomposition usually refers to the ability to break down a problem into sub-problems to reduce its complexity.
ABS Abstraction	Abstraction concentrates on significant information instead of consuming time analyzing worthless details.
REC Pattern recognition	Pattern recognition uses patterns to refer to data sequence for prediction purposes.
ALG Algorithmic thinking	Algorithmic thinking uses ordered rules and logical instructions to solve problems.
LOG Logical thinking	Logical thinking uses a tested premise to reach a conclusion using certain logical steps.
EVA Evaluation	Evaluation judges proposed solutions to enhance creative problem solving and measure student empowerment to formulate problems within the computational context.

Technological Pedagogical Content Knowledge

TPACK is a theoretical integration framework that measures the knowledge required for successful ed-tech integration “while addressing the complex, multifaceted, and situated nature of teacher knowledge” [6]. Koehler and Mishra introduced the TPACK framework in 2006, which includes CK, PK, and TK. CK refers to issues related to content taught by teachers to students, PK is associated with pedagogical activities, practices, and processes used in the educational situation, and TK is related to technologies and technological integration to enhance teaching [18]. Dimensional intersections include pedagogical content knowledge (PCK), or the didactic knowledge related to a content area; technological content knowledge (TCK), which refers to the knowledge of how to employ technology to represent specific concepts; and technological pedagogical knowledge (TPK), or strategies that use technology and TPACK [6]. This research applied the three primary dimensions (CK, PK, and TK) to measure CT awareness among educational institutions.

CT Model for Systemic Change

The Model for Systemic Change was designed to help incorporate CT into K–12 education [2] as part of the CT leadership toolkit plan developed by the ISTE and the Computer Science Teachers Association (CSTA) with generous support from the National Science Foundation (NSF). The Model helps educators understand, value, and implement CT using four main steps: lead, build, connect, and practice. It *leads* efforts to increase CT awareness among leaders and practitioners, *builds* traction by relating CT to local goals, educational initiatives, or reform efforts, *connects* teachers to help them explore grade-appropriate implementation, and creates opportunities to *practice* CT learning activities.

Related Work

Malallah investigated complications associated with adopting a U.S.-based STEM outreach program into the Kuwaiti educational system. The program focused on teaching CT via Arduino and Scratch to students in grades 6–9. Malallah used pre-post self-efficacy surveys to determine increased CT awareness. Survey results revealed that, although students were confused about some CT concepts, their overall CT knowledge improved after the STEM outreach program [19].

In a different study, Bower measured CT understanding of educators before and after CT workshops that identify the strategic issues that happen while using CT to solve problems. The authors applied the TPACK framework to survey teachers, resulting in observed CT skills of problem representation, abstraction, decomposition, simulation, verification, and prediction. The results highlighted teacher awareness, concept understanding, and confidence of CT. The current study also used TPACK, but different CT concepts were applied, and the survey style employed a questionnaire to measure CT instead of pre- and post-workshop surveys [20].

Method

Sample and Setting

This study conducted convenience sampling to select education institutions and willing participants. A total of 18 educational institutions were involved in the study, including three universities, one training institute, and 14 public K–12 schools. Overall, 55% of participants (n = 305) were females and 45% were males. Of the total sample, 118 participants were students, 136 were teachers, 19 were department heads, 12 were vice-principals, 5 were principals, and 9 worked in non-educational fields. Participating students earned bonus points from their instructors. The percentages of age groups were: 32.9% aged less than 20 years, 31.9% ages 20–30, 27.5% ages 30–40, and 8.83% above 40 years old. Sample qualifications showed that 14.9% of participants had a postgraduate degree, 56.4% had a university degree, and the remaining participants were high schoolers. The survey was distributed online via social media and MS-Teams platforms, and study protocol was approved by university research compliance.

Design

This study applied survey research methodology to gain insight into educator awareness of CT in Kuwait. The research was carried out over a three-week period in two stages. In the first stage, the pilot stage, the survey was emailed to experts (educators and linguistics) for review, and then it was modified according to their suggestions. The survey was initially applied to a pilot sample of 30 participants from the study community to ensure the questions' validity and reliability. In the second stage, the distribution stage, users were required to sign an online consent form to start the survey. The expected time range to finish the survey was between 30 and 50 minutes, although the survey platform allowed the participants to save their current progress to finish later. After completing the questionnaire, the form was automatically saved onto the server while marking was completed.

Instruments

This study designed and utilized a CT awareness questionnaire derived from the TPACK framework. The questionnaire consisted of three parts. The first part, which was comprised of one section for students (current grades, major) and one section for teachers/employees (job, years of experience, department), collected demographic variables such as age, gender, and qualifications. The second part of the questionnaire was related to technological backgrounds of participants (daily technology usage, previous technology training, CT terms familiarity), and the third part included the six main axes (ALG, DEC, ABS, REC, EVA, and LOG), with each CT categorized as CK, PK, or TK, as shown in Table 2. The questionnaire was answered according to a five-point Likert scale (strongly disagree, disagree, neutral, agree, and strongly agree).

Table 2. CT awareness questionnaire derived from the TPACK framework and CT Concepts

	Content Knowledge (CK)	Pedagogical Knowledge (PK)	Technology Knowledge (TK)
Algorithms	• Individuals should use sequences as a way of solving problems. • Learners should follow rules in order to find solutions to challenging situations. • One must use a systematic approach in dealing with different tasks. • Mathematical processes should be employed in solving problems using finite steps. • Data driven approach is essential for problem solving.	• Teachers should develop students' algorithmic capabilities. • Effective teaching strategies should be provided to enhance algorithms. • Teachers should understand how to integrate algorithms into the curriculum. • Algorithms can be used for doing multiplication or division in classrooms. • Cooperative learning can be used to encourage students to adhere to rules in solving problems.	• Background knowledge of computer sciences can help understand algorithms. • Teachers should understand the mechanism of programming applications. • Teachers should have the ability to digitize a mathematical problem expressed verbally. • Computer based algorithm can be used in order to complete a task on time. • Machine learning can enhance the effectiveness of the learning processes.
Decomposition	• Solving problems will be easier when they are divided into parts. • Identifying the component parts of problems will help understand their different dimensions. • Large systems are usually consisted of smaller parts. • It will be harder to solve a problem that is not decomposed. • Students' cognitive resources can be managed effectively if the problem is broken into manageable parts.	• Knowledge schemas can be used to divide the task into sub-tasks. • Programming activities can be used to enhance decomposition tasks. • Teachers should provide students with strategies to enhance analysis and synthesis abilities. • Teachers present the complex problem and facilitate conversations to help students break it down. • Unplugged coding activities can be used to enhance decomposition abilities.	• Teachers can use Scratch programming activities to enhance students' synthesis and analysis sills. • Coding patterns can be used to divide a problem into manageable parts. • Digital learning environments can be used to enhance problem decomposition. • Structured programming can be used for problem factoring. • Teachers can break down the material on the computer program into parts to keep students' attention.
Abstraction	• One should focus on significant information while solving problems. • All unnecessary information should be deleted to focus attention on the main problem. • It is useful to design a model of proposed solutions after extracting the fundamental characteristics of the problem. • Abstraction helps students create a general framework of the problem and how it can be solved. • Simplifying a problem is regarded a critical step for solving it.	• Teachers should encourage students to simplify situations to facilitate studying its characteristics. • Teachers should explain multiple layers of abstraction and relations among them. • Abstraction can be involved in teaching different subjects such as Humanities and Social Sciences. • Mind mapping can be used in order to enable students to capture relevant information. • Teachers can use teamwork in order to encourage students to summarize the most important details within a lesson.	• Computer hardware can be used to manage the problem complexity. • Computing helps automate different abstractions by providing methods for scalability. • Electronic mind maps can be used to encourage students to focus on details. • Online extractive summarization can help determine the most relevant details in the topic to be studied. • Graph-based methods can help extract significant ideas during learning.
Pattern Recognition	• It is important to search for similarities among problems and within them. • The use of grouping and organizing processes can help reach efficient outcomes. • Students should recognize connections and differences among the different parts of a system. • Identifying patterns help make predictions during learning. • Students must identify the rules that govern adding a new pattern to existing ones.	• Class projects can be used in order to enhance pattern recognition skills. • Pattern recognition can be presented using slides. • Teachers should encourage students to find patterns to increase their awareness of the surrounding environment. • Teachers should encourage students to employ current patterns for solving future problems. • Teachers should encourage students to identify patterns across different disciplines.	• Teachers should help students identify how to use computers for pattern recognition. • Pattern manipulation using a digital slider can help students explore patterns visually. • Computers can be used to sort patterns through their shared characteristics. • Modules with codes can be used to organize related functions. • Artificial intelligence tools can be used for pattern recognition.

Instrument Reliability and Validity

The pilot stage was validated by a calculated Cronbach's alpha test to determine the reliability of the questionnaire statements, and the Pearson correlation coefficient was used to measure the validity of the statements. The internal consistency validity tested using the Pearson correlation coefficient included the correlation of each item with its dimension in the axes of the survey, with a range of .0716–0.982 for the questionnaire statements. All correlation coefficients were statistically significant at the (0.01) level, which revealed the high level of internal consistency of questionnaire validity. General structural validity was calculated using the correlation of each axis with the total. Correlation coefficients ranged between 0.961** and

0.986**, and the statistically significant high correlation coefficients at the (0.01) level revealed the high level of general structural validity. Alpha Cronbach's reliability coefficient was calculated for the axes that ranged between 0.988 and 0.990, and the overall reliability coefficient was 0.999, which demonstrated high reliability as well as stability and suitability for an application.

Results

This study analyzed student and educator responses to the following research questions:

- **RQ1** What is the level of CT awareness of educators in Kuwait?
  - **RQ1.1** What is the level of CT Content Knowledge awareness?
  - **RQ1.2** What is the level of CT Pedagogical Knowledge awareness?
  - **RQ1.3** What is the level of CT Technical Knowledge awareness?
- **RQ2** How different is the CT awareness between educators?

Responses were analyzed using repeated measures ANOVA and descriptive statistics, Of the total 305 participants, 11 did not complete the questionnaire and were excluded. Results were categorized into 27 datasets, as shown in Table 3.a: Three from averaging the mean of the Knowledge scores Six from averaging the means of the CT concepts. And eighteen combination between the Knowledge scores and CT concepts, as presented in Table 3.b.

Table 3.a The Knowledge Concepts and CT Concepts Datasets

Acronyms	Description	Acronyms	Description
(1) CK	Content Knowledge scores	**(6) ABS**	Abstraction scores
(2) TK	Technical Knowledge scores	**(7) REC**	Pattern recognition scores
(3) PK	Pedagogical Knowledge scores	**(8) EVA**	Evaluation scores
(4) ALG	Algorithmic thinking scores	**(9) LOG**	Logical thinking scores
(5) DEC	Decomposition scores		

Table 3.b The Dataset's Between the Knowledge Concepts and CT Concepts

Acronyms	Description	Acronyms	Description
(10) ALG-CK	The scores of *Algorithmic thinking* and *Content Knowledge* questions.	**(19) REC-CK**	The scores of *Pattern recognition Content Knowledge* questions.
(11) ALG-TK	The scores of *Algorithmic thinking* and *Technical Knowledge* questions.	**(20) REC-TK**	The scores of *Pattern recognition* and *Technical Knowledge* questions.
(12) ALG-PK	The scores of *Algorithmic thinking* and *Pedagogical Knowledge* questions.	**(21) REC-PK**	The scores of *Pattern recognition* and *Pedagogical Knowledge* questions.
(13) DEC-CK	The scores of *Decomposition* and *Content Knowledge* questions.	**(22) EVA-CK**	The scores of *Evaluation* and *Content Knowledge* questions.
(14) DEC-TK	The scores of *Decomposition* and *Technical Knowledge* questions.	**(23) EVA-TK**	The scores of *Evaluation* and *Technical Knowledge* questions.
(15) DEC-PK	The scores of *Decomposition* and *Pedagogical Knowledge* questions.	**(24) EVA-PK**	The scores of *Evaluation* and *Pedagogical Knowledge* questions.
(16) ABS-CK	The scores of *Abstraction* and *Content Knowledge* questions.	**(25) LOG-CK**	The scores of *Logical thinking* and *Content Knowledge* questions.
(17) ABS-TK	The scores of *Abstraction* and *Technical Knowledge* questions.	**(26) LOG-TK**	The scores of *Logical thinking* and *Technical Knowledge* questions.
(18) ABS-PK	The scores of *Abstraction* and *Pedagogical Knowledge* questions.	**(27) LOG-PK**	The scores of *Logical thinking* and *Pedagogical Knowledge* questions.

The datasets were compared by gender (male, female), education roles (student, teacher, department head, vice-principal, principal, and non-educational careers), concept familiarity (no, yes, not sure), technology usage (always, usually, rarely, never), previous technology training (MS office, programing, graphic design, database, search and browsing, others), ages (less than 20, less than 30, less than 40, more than 40), and qualifications (high school, college degree, post-graduate degree).

Tables 4 and 5 show significant results shaded based on associated p-values. The effect size following eta-squared η2 =($\boldsymbol{SSeffect/SStotal}$) is noted as a small, moderate, and large reference; bold font indicates a large effect (.14), underlined results indicate a medium effect (.06), and no marks indicate a small effect (.01). The abbreviation M stands for the mean and SD for the standard deviation.

Table 4. Mean of CT Concepts for Gender and Roles

		ALG			**DEC**			**ABS**			**REC**			**EVA**			**LOG**		
		CK	PK	TK	CK	PK	TK	CK	PK	TK	CK	PK	TK	CK	PK	TK	CK	PK	TK
Female	M	4	4.1	3.8	3.8	3.9	3.8	3.8	4.2	3.7	3.8	3.9	3.8	3.8	3.9	3.8	3.9	4.2	3.7
	SD	0.7	0.8	0.8	0.8	0.8	0.9	0.8	0.9	0.9	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0
Male	M	4	4.2	4.1	4.2	4.1	4.3	4.1	4.1	4.2	4.1	3.8	4.2	4.2	4.3	4.3	4.2	3.7	4.2
	SD	0.6	0.6	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.6	0.7	0.7	0.7	0.6	0.7
Student	M	4.1	4.4	4.4	4.2	4.2	4.4	4.2	4.4	4.2	4.2	4.3	4.2	4.3	4.3	4.4	4.3	4.2	4.2
	SD	0.5	0.6	0.6	0.6	0.5	0.6	0.5	0.5	0.6	0.7	0.7	0.7	0.6	0.7	0.7	0.6	0.7	0.7
Teacher	M	4.4	4.4	4.3	4.2	4.3	4.2	4.1	4.4	4.1	4.1	4.2	4.2	4.4	4.2	4.3	4.2	4.3	4.1
	SD	0.6	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Dep-Head	M	4.8	4.7	4.7	4.6	4.8	4.7	4.6	4.5	4.6	4.7	4.6	4.6	4.4	4.3	4.6	4.5	4.6	4.5
	SD	0.3	0.3	0.6	0.6	0.4	0.4	0.2	0.1	0.2	0.0	0.2	0.3	0.1	0.2	0.2	0.1	0.2	0.1
Vice-principal	M	3.5	4	3.7	3.2	3.5	3.5	3.2	3.5	3.5	3.3	3.5	3.5	3.4	3.6	3.5	3.5	3.4	3.3
	SD	0.9	1.1	0.9	0.9	1.0	1.1	1.0	1.2	1.1	1.2	1.1	1.1	1.1	1.2	1.1	1.2	1.1	1.1
Principal	M	3.3	3.4	3.6	2.6	3.4	3.6	3.3	3.2	3.3	2.6	3.3	3.4	3	3.1	3.3	3.5	3.7	3.7
	SD	0.9	1.2	0.9	0.9	1.0	0.8	1.0	1.2	1.0	1.0	1.2	1.0	0.9	1.1	0.9	1.3	1.1	1.0
Other	M	4	4.3	4.5	3.9	4.2	3.7	3.5	3.8	3.7	3.9	4.1	4.3	4.5	4.1	4.5	4.6	3.9	4.6
	SD	0.7	0.2	0.2	0.3	0.9	0.8	1.1	0.4	1.4	0.2	0.5	0.5	0.8	0.2	0.5	0.9	0.5	0.5
Total	M	4.2	4.2	4.2	3.7	4	4	3.8	3.9	3.89	3.8	4	4	4	4.1	4.1	4.19	4	**3.99**
	SD	0.6	0.7	0.7	0.7	0.8	0.8	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.7	0.8	0.8	0.7	0.8
Overall	M		**4.13**			**3.9**			**3.87**			**3.93**			**4.06**			**4.0**	
	SD		.626			.766			.733			.800			.77			.76	

*RQ1 What is the level of **CT** awareness of educators in Kuwait?*

A repeated measure ANOVA between the CK, PK, and TK scores indicated a significant difference for scores ($F(1.88,551.7) = 27.4$, $p = .00$, partial-eta-squared = .086). All main interactions were statistically significant at the .05 significance level except for the PK score. The effect size was small on PK and moderated on CK and TK. The comparison yielded a similar means to CK (M = 4.03, SD = .67) and TK (M = 4.03, SD = .73), followed by PK (M = 4.02, SD = .73).

Table 4. shows group interactions between the three knowledge and the six CT concepts. A significant difference of ($F(17,4964) = 10.19$, $p = .00$, partial-eta-squared = .034). The highest CK scores occurred near LOG (M = 4.2, SD = .8), with a similar mean between ALG (M = 4.0, SD = .6) and EVA (M = 4.0, SD = .8), followed by REC (M = 3.8, SD = .8) and ABS (M = 3.8, SD = .7) and finally DEC (M = 3.7, SD = .7). The highest PK scores occurred near ALG (M = 4.2, SD = .8) and then EVA (M = 4.1, SD = .7), with a similar mean between DEC, REC, and LOG (M = 4.0, SD = .8) and finally ABS (M = 39, SD = .7). The highest TK scores were ALG (M = 4.2, SD = .7) and then EVA (M = 4.1, SD = .7), with a similar mean between DEC and REC (M = 4.0, SD = .79), followed by LOG (M = 3.9, SD = .8) and ABS (M = 3.8, SD = .8). Concept ALG always showed the highest score, followed by EVA, while ABS demonstrated the lowest knowledge scores.

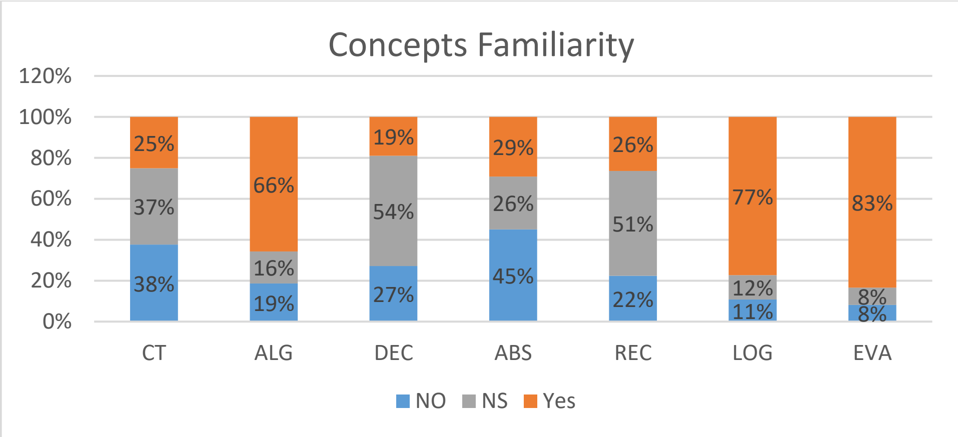

Figure 1. CT Concept Familiarity

*RQ1.1 What is the level of CT **Content Knowledge** awareness?*

Pairwise comparisons between the CK scores and the CT groups showed the following statistical results: ALG-DEC (p = .02), ALG-REC (p = .003), ALG-EVA (p = .005), ALG-LOG (p = .00), ABC-DEC (p = .003), ABC-REC (p = .03), and ABC-LOG (p = .00). Figure 1 illustrates CT terminology familiarity to highlight the sequence of CT scores. Figure 1 and Table 4 show that the ALG concept had the highest scores in familiarity (Yes) and mean (M = 4), reinforcing the observation that high familiarity coincides with high means, which could be a result of CT learning at school since high school math lessons introduce the concepts algorithm "خوارزميات"[22]. Also, the words originate from an Arabic scientist, thus, the information can be repeated in several subjects[23]. The term Evaluate "تحليل" is used in almost all science courses[24, 25]. Logic thinking as terminology is popular among society. Many logic thinking trainings exists in Kuwait; for example, logical thinking taught and used at the debate club of the Kuwait University Engineering Department[26]. However, at least 70% of the answers indicated that the concepts DEC, ABS, and REC were new or unfamiliar to the participants. Overall, the participants demonstrated a high level of familiarity with ALG, LOG, and EVA concepts and high unfamiliarity with DEC, ABS, and REC concepts, with a moderate effect size, meaning introduction to these concepts should be increased in the educational system.

*RQ1.2 What is the level of CT **Technical Knowledge** awareness?*

Pairwise comparisons between the TK scores and the CT groups showed no statistically significant effect between the groups. Previous training and technology were analyzed to understand the high TK scores.

Figure 2 shows that approximately 80% of the study participants use technology in their daily life, with a majority of those respondents identifying as educators or college students. It could infer that the awareness high score due to the participants agreement to include technology in the classroom. The 20% of participants who responded that they rarely used technology were comprised of a mix of high school students and school principals, who are typically involved in decision making and administration [27].

Figure 3 illustrates participants' previous technological experience. Results showed that 87% of respondents had participated in MS office training and 40% had taken diverse training courses, which could explain the high TK scores. Notably, less than 20% of study participants had database, programming, or data searching skills, which are directly related to CT skills, potentially implying that individual's consumer of technology not producer.

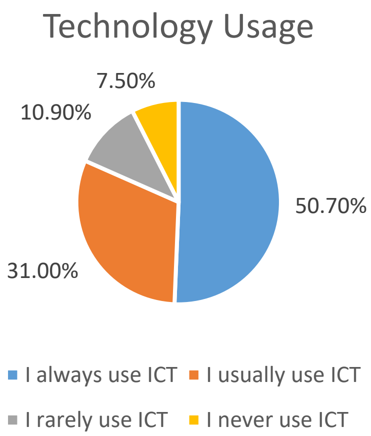

Figure 2. Technology Usage

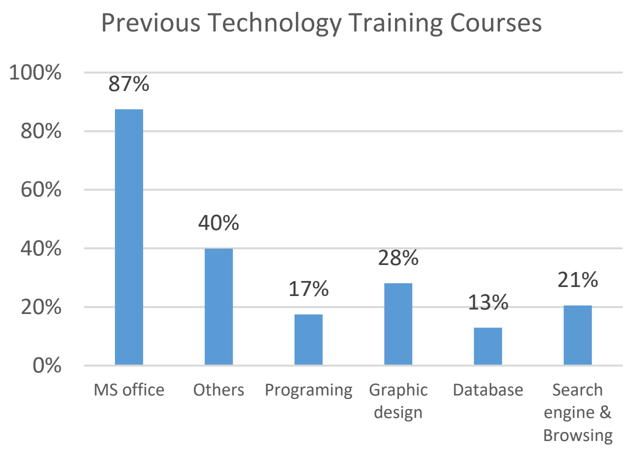

Figure 3. Previous Technology Training Courses

*RQ1.3 What is the level of CT **Pedagogical Knowledge** awareness?*

Pairwise comparisons between the PK scores and the CT groups showed the following statistical results: ALG-DEC (p = .00), ALG-REC (p = .003), ALG-EVA (p = .005), ALG-LOG (p = .00), DEC-ABS (p = .003), ABS-REC (p = .03), and ABS-LOG (p = 0.00). The highest score was for ALG (M = 4.2, SD = .7), followed by EVA (M = 4.1, SD = .7). A similar trend was observed for DEC, LOG, and REC with (M = 4.0, SD = .79), followed by ABS (M = 3.9, SD = .7).

Table 5. Mean of Age and Qualification for the CK, PK and TK Scores

		CK		PK		TK		**P**	#
		M	SD	M	SD	M	SD		
Age	Less than 20	4.1	.45	3.93	.47	4.2	.4	**.00**	97
	Less than 30	4.3	.6	4.1	.64	4.2	.6		94
	Less than 40	3.93	.8	4.2	.85	3.9	.8		81
	40 and older	3.8	.63	3.82	.68	3.85	.6		22
Qualification	High school or below	3.8	.7	3.8	.77	3.9	.8	.09	84
	University degree or diploma	4.1	.61	4.2	.63	4	.6		166
	Post-graduate degree	4.1	.63	4.1	.69	4.2	.7		44
Total	M	4.03		4.02		4.03			294
	SD	.67		.7		.73			

Table 5 shows the knowledge scores for the age and qualification groups. The qualification group did not demonstrate a significant difference in PK scores (F(2,293) = 9.07, p = .09, partial-eta-squared = .03). The highest score was seen in the college (M = 4.2, SD = .6), followed by the post-graduate degree category (M = 3.9, SD = 0.6) and then high school or below (M = 3.8, SD = .7). The age group showed statistically significant results (F(3,293) = 7.56, p = .00, partial-eta-squared = .074), with significant interaction between the groups (20-&40-)(p=.01), (20-&40+)(p=.002), and (30-&40+)(p=.00). The highest gain was observed for the younger ages; the PK scores gradually decreased with increase aging.

The study sample consisted of 62% of young educators with at least a bachelor's degree in teaching. Although it was not statistically supported, young educators had higher scores than older educators, presumably because younger generations are more tech-savvy and more open to learning via technology and logic [28]. This study concluded that, overall, students and younger educators are eager to obtain CT skills and logic within pedology, while remain educators may require more CT training.

RQ2 How Different is the CT Awareness Between ***Educators****?*

A repeated measure ANOVA indicated a significant difference in knowledge scores among the various education roles (F(10.8, 3138.4) = 3.480, p = .00, eta = .012). All effects were statistically significant at the .05 significance level except students and others (in non-educational fields). As shown in Table 4, the highest scores were obtained from department heads (M = 4.6, SD = 0.3), followed by students (M = 4.29, SD = .6), teachers (M = 4.2, SD = .8), vice-principals (M = 3.48, SD = 1.1), and principals (M = 3.3, SD = 1). Although educators are trained in the same basic technological knowledge, recent graduates gain the latest technological skills and standards in education. In addition, the MOE offers in-house training for educators to remain abreast of advancements in education [29, 30]. The Development and Training Sector of MOE prepares workshops and training to fit the needs of each educational role, including communication skills, critical thinking, classroom management, technology deployment, and school administration and planning. Consequently, age, training, and occupational role can be the reasoned behind the alternate of the awareness scores.

Results also showed that roles were not significantly affected by the gender of the participant (F(3, 293) = 3.3, p = 0.08, partial-eta-squared = 0.34). The CT scores were slightly higher for males (M = 4.13, SD = .64) compared to females (M = 3.8, SD = .87). A comparison of gender over the role of department head, shows, females had the highest scores (M = 4.6) compared to males (M = 4.5). even though the results weren't statistically significant

Suggested CT Implementation Plan into the Kuwaiti Educational System

The proposed Model of Systemic Change would introduce CT into the Kuwaiti educational system. The first step in model implementation is the lead process, or influencing the decision makers, in which Kuwait's stakeholders must understand the importance of implementing CT into the educational system. The results of this study revealed that leadership positions often have decreased CT awareness; therefore, a third party should provide training and emphasize the importance of CT in education via collaboration between the MOE training center and an international specialized organization. A third party is essential because, according to the Human Development Index (HDI) in 2020, Kuwait ranked 63 out of 189 countries, with the lowest score among Gulf Cooperation Council countries [31]. A leading team can then be developed to plan for CT adoption. The team should include a principal, vice-principal, educational superintendent, and a department head. The department head would have a critical role in the change plan because they are the link between the teachers and the leaders. According to the survey results, department head educators had high scores and abilities, making them a valuable resource for the teachers. All departments should be part of the development plan, and the leadership team should receive additional training to learn about CT standards.

The second step of model implementation is the build step, in which the leadership team builds CT awareness among teachers. The department heads and curriculum development department should map and align Common Core standards as well as CT standards and concepts to the current curriculum. The leadership team should also develop or adapt instruments to measure CT and yearly progress.

The third step of implementation, the connect step, extends existing lessons in CT to build value and understanding. Teachers and department heads should work together to provide age-appropriate activities for their curriculum, emphasizing STEM content and 21st century skills in plugged and unplugged activities. In addition, the teachers should prepare the CT vocabulary appropriate for the development sequence. The practice step, the fourth and final step of model implementation, incorporates the plan into classroom instruction, including regular measures of development.

Limitations

A primary limitation of this study was the lengthy questionnaire, which occasionally overwhelmed the participants, causing them to provide inaccurate or dishonest answers. Additional limitations were the risk of different interpretations of question meanings and biased data due to non-response questions.

Conclusion

CT has been gaining worldwide attention as a 21st century learning skill. Therefore, this study developed a survey to measure CT awareness from the cognitive, educational, and technological aspects. Survey results provided valuable insights, including the high rate of acceptance and CT awareness, the eagerness of young ages educators and students to adopt CT into the classroom with or without technology. Negative insights included less familiarity of DEC, ABS, and REC concepts and society's tendency to be technology consumers due to the nature of the education system. Also, older educators demonstrated a lower score of CT awareness although members of the older generation are the educational stakeholders in Kuwait. From these insights, a suggested plan was presented to begin the process of implementing CT into the Kuwaiti education system.

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