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Students' Disposition towards Computational Thinking: A Systematic Literature Review

(Disposisi Pelajar Terhadap Pemikiran Komputational: Sorotan Literatur Bersistematik)

SARALAH SOVEY & MOHD EFFENDI @ EWAN MOHD MATORE*

ABSTRACT

Computational Thinking (CT) transforms life into something greater than you could have ever imagined yourself living since Industry 4.0 optimizes the computerization of Industry 3.0. Most of the attention on embedding CT during the past decade has focused on the integration of CT skills, which involves investigating students' programming or computing skills and designing tools to teach and assess CT with only little concern about their disposition, perception, feeling, or attitude towards the application of CT in problem solving across various disciplines or specifically in daily life. Attitude and disposition reflect students' inclination towards learning CT and reflect their ability to think intelligently about issues confronting them. Hence, this study systematically reviewed how disposition and attitude towards CT have been assessed in the literature of computational thinking. The PRISMA stages of planning, conducting, and reporting the review are phases being applied. This article resulted in three main themes: cognitive, affective, and behavioural components of disposition in CT using SCOPUS and Web of Science (WoS) databases. These three themes produced a total of 17 meaningful sub-themes. This review identifies current research gaps and future directions to conceptualize and assess CT disposition, and the findings are expected to be beneficial for researchers, curriculum designers, and students. In the future, researchers are recommended to develop and validate instruments to measure students' attitudes and dispositions towards CT rather than simply adapting traditional assessments, as CT is a new thinking tool that varies in conceptualization and operationalization as well.

Keywords: Systematic Review; Disposition; Computational Thinking; Students

ABSTRAK

Pemikiran Komputasional (PK) mengubah kehidupan menjadi sesuatu yang lebih hebat daripada yang pernah dibayangkan dalam kehidupan, memandangkan Industri 4.0 mengoptimumkan pengkomputeran Industri 3.0. Sebahagian besar perhatian dalam menyematkan PK sepanjang dekad lalu telah menumpukan kepada penggabungan kemahiran PK yang melibatkan penyiasatan kemahiran pengaturcaraan atau pengkomputeran pelajar seperti mereka bentuk alat untuk mengajar dan menilai PK. Perhatian diberikan terhadap disposisi, persepsi, perasaan, atau sikap mereka terhadap penerapan PK dalam penyelesaian masalah merentasi pelbagai disiplin khususnya dalam kehidupan seharian. Sikap dan disposisi mencerminkan kecenderungan pelajar terhadap pembelajaran PK dan mencerminkan kemampuan mereka berfikir secara bijak tentang isu-isu yang dihadapi. Justeru, kajian ini mengkaji secara sistematik tentang disposisi dan sikap terhadap PK yang telah dinilai dalam literatur PK. Kajian lanjut pada artikel-artikel ini menghasilkan tiga tema utama iaitu komponen kognitif, afektif, dan tingkah laku dalam disposisi PK. Tiga tema tersebut menghasilkan sejumlah 17 sub-tema yang bermakna. Kajian turut mengenal pasti jurang penyelidikan semasa dan arah masa hadapan untuk mengkonseptualisasikan dan menilai disposisi PK. Penemuan ini memberi manfaat kepada penyelidik, pereka kurikulum, dan pelajar. Pada masa hadapan, penyelidik disarankan untuk membangunkan dan mengesahkan instrumen pengukuran sikap dan disposisi pelajar terhadap PK berbanding hanya menyesuaikan penilaian tradisional sahaja. Ini kerana PK ialah alat pemikiran baru yang berbeza dalam aspek konseptualisasi dan operasionalisasi.

Kata Kunci: Literatur bersistematik; Disposisi; Pemikiran Komputasional; Pelajar

INTRODUCTION

Computational thinking is a universal attitude and skill set that should be part of the repertoire of every child, thus an important competency which manipulates nearly all disciplines. Computational Thinking (CT) demystify problem solving, designing systems, and not to be missed understanding human behaviour by drawing on the concepts fundamental to computer science (Wing, 2006). However, despite the high interest in developing CT among schoolchildren and the large investment in CT initiatives, there are a number of issues and challenges for the integration of CT in the school curriculum. The education sector faces rising pressure on computational thinking (CT). CT turning life into more than you'd ever dreamed living since Industry 4.0 optimizes Industry 3.0 computerization. Such recent developments impact virtually all communities and future jobs, including the opportunities of students, who need to prepare themselves for emerging digital technology challenges. Students need to learn at least basic skills to do well in the future because it is one of the criteria and contributing factors before entering the industry. CT skills have since permeated all levels of elementary and secondary schools. This incorporation is achieved through the development of new curricula within computer science education programs as well as in other areas such as math and science (Weintrop et al., 2016; Juskeviciene & Dagiene, 2018; College Board, 2017).

CT is important ingredient for computer application growth, but it can also be used to promote problem solving in all fields, including humanities, math and science. Students who learn CT in the curriculum may begin to see a connection between academic subjects, as well as life within and outside the classroom. The idea of CT as an ability, a skillset, an attitude which every child should possess has emerged since 2006 and has been gaining attention and importance ever since. However, adaptation of CT concepts in everyday life are not going to be easy and require thorough study. Most of the attention on embedding CT during the past decade has focused on integration of CT skill in students with only little concern about their perception, feeling or attitude towards the application of CT in problem solving across various discipline or specifically in daily life.

PROBLEM STATEMENT

As we addressed previously, CT is a newer curriculum field that has very quickly to be adapted into classrooms. As novices in CT, the researchers were unable to anticipate all the issues that arise before implementation (Belanger et al., 2018). Although there has been a broad discussion demystifying pedagogical aspects of CT, the study on assessing CT skills and attitude continues to take place. The attitude which is developed by using CT should be improved to analyse systematic approaches and complex problems (Qiu, 2009). Looking at the studies on past 5 years (2016 to 2020), it became evident that minimal studies were devoted to address the issue of CT disposition / attitude between students. CT, likewise, is not only characterized by skills, but also by attitudes (Wing, 2006). Moreover, the review of the articles also did not provide enough information on the literature search and analyses performed. The review focuses on a certain aspect of attitude especially CT on programming studies or computer science studies. Measuring attitude related to CT is required because there does not yet exist any widely adopted standardized assessments (Weese, 2016; Haseski et al., 2018). It is therefore not surprising that CT evaluation remains a major weakness in this field. There is no widely- accepted assessment of CT which makes it difficult to accurately and validly assess the effectiveness of interventions (Grover & Pea, 2013; Kim et al., 2013; Settle et al., 2012; Shute et al., 2017).

There is always an urge to distinguish ways to envision the measurement of CT across all disciplines. Consequently, the issue of assessment in current studies was found lacking compared to the studies investigating approaches to teach CT. Thus, a review presenting the holistic picture of CT on the disposition/ attitude dimension, clearly defining and differentiating between types of disposition/ attitudes appeared to be lacking. In conclusion, there seemed to be a need for a new systematic review on student disposition/ attitude towards CT in education. The prime reason is that adroitness in thinking does not develop on its own. Rather, it requires deliberate, continuing instruction, guidance and practice in order to develop to its fullest potential (Mayer, 1983; Swartz & Perkins, 1989). Review of related literature on thinking as well as the evolution of thinking (Osman, 1999) unveils three main thinking enterprises that become the major thrust of thinking activities, namely, as skills, knowledge, and dispositions. It is therefore conceivable that adroitness in executing cognitive as well as metacognitive skills *per se* is not adequate.

Besides possessing a repertoire of knowledge, someone has to instill a positive attitude towards thinking (or thinking dispositions) who will act as a motivator to inspire students to continuously think effectively and creatively. Attitude, as conceptualised by Krech, Crutchfield and Ballackey (1962) embrace three distinct components: the *affective*, the *behavioural (conative),* and the *cognitive*. Mildenhall (1998) in his literature analysis of several problem-solving studies discovered that beside domain specific knowledge, other affective dimensions such as interest, motivation, confidence, perseverance and willingness to take risks have been considered in problem solving research. To reiterate, critical thinking theorists also argue that thinking requires something more fundamental than knowledge or skills, namely a set of dispositions (Beyer, 1987, 1988; Costa & Lowery, 1989; Ennis, 1985; Norris & Ennis, 1989). These dispositions are classified by Beyer (1987, 1988) as those that relate to thinking in general and as those that relate to specific cognitive operations.

The aim of this review is providing an overview of how student disposition/attitude towards CT was described in previous research. Thus, the first research question to be answered is: What is the terminology used in previous research to describe student disposition/attitude towards CT? The second goal covered what the disposition / attitude of the student towards CT is about. Whereas the first objective of this analysis applied to systemic aspects of the student's disposition / attitude, this objective zoomed in on the substance of disposition / attitude, distinguishing between superficial and deep disposition / attitude level. The goal was thus to gain insight into the depth of the predominant disposition / attitude of the students and how important this is.

METHODOLOGY

The Systematic Literature Review (SLR) used in this study is a systematic, deliberate and explicit method to identify, select, critically evaluate, collect and analyze data from relevant past research (Gillath & Karantzas 2019; Moher et al., 2009). This approach has been selected, because it aims to synthesize in detail all applicable scholarly literature. The systematic review was conducted in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; see Figure 1). The method, which includes resources (SCOPUS & Web of Science) to run the systematic review, eligibility and exclusion criteria, steps of the review process (identification, screening, eligibility) and data abstraction and analysis. Keywords used was as stated as Table 1. Electronic databases were used to conduct literature searches with a variety of keywords to identify articles (see Figure 1).

By scanning the reference lists of publications retrieved from the repositories, more papers were found to ensure the related studies were not missing. We narrowed the search to papers published from January 2016 through 2020. That analysis had been evaluated against a set of requirements for inclusion and exclusion. Excluded studies were tabulated against reasons for exclusion (see Figure 1). A full-text review was conducted for eligible studies, with the finalized set of published studies subjected to qualitative synthesis. In this section the method used to retrieve articles related to students' disposition/attitude towards CT is discussed.

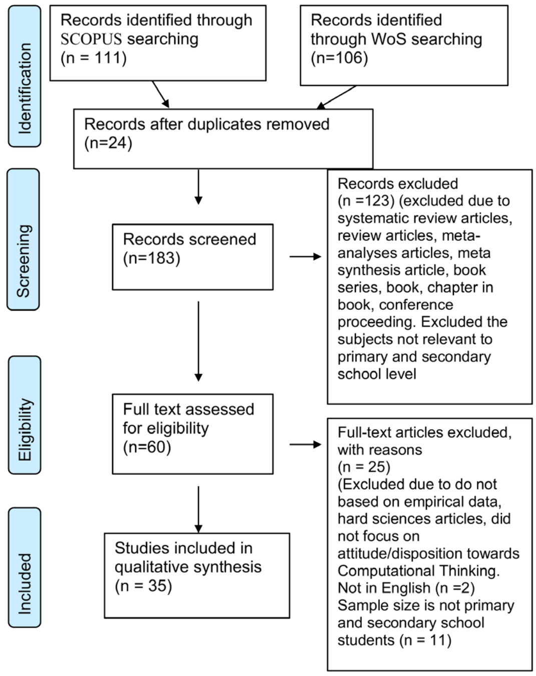

Figure 1. A flow diagram detailing the application of PRISMA to the qualitative synthesis of published attitudes in computational thinking studies conducted between January 2016 and January 2020.

PRISMA (PREFERRED REPORTING ITEMS FOR SYSTEMATIC REVIEWS AND META-ANALYSES)

The review was guided by the PRISMA Statement (Preferred Reporting Items for Systematic reviews and Meta-Analyses). PRISMA guide the researcher to define clear research questions that permits a systematic research, identifies inclusion and exclusion criteria and attempts to examine large database of scientific literature in a defined time (Sierra-Correa &Kintz 2015). Nevertheless, the PRISMA Statement allows for rigorous search of terms related to student disposition/ attitude towards CT reviews.

RESOURCES

Nowadays, electronic databases are a typical source in the literature search. Electronic databases constitute the predominant source of published literature collections (Petticrew & Roberts, 2006). Since no database offers the complete set of published materials, a systematic search for literature should be performed from multiple databases (Xiao & Watson, 2017). Based on this, the author relied on two main journal databases; SCOPUS and Web of Science (WoS). WoS and SCOPUS databases were chosen as the primary source in the search process, as the databases were popular educational technology databases and the CT publications contained in these databases were academic papers (Haseski et al., 2018). Moreover, these databases offer comprehensive archive covering numerous fields including statistical studies, interdisciplinary social sciences, social concerns, life sciences, physical sciences and development topics.

SYSTEMATIC REVIEW PROCESS

A. IDENTIFICATION

Four stages were involved in the systematic review process (Karantzas et al., 2019). The review process was performed on January 2020. The first phase identified keywords used for the search process. The keywords for the search were derived from the research question(s). Then, author dissect the research question into concept domains (Kitchenham & Charters, 2007). The author also takes the concepts in the search statement and extend them by synonyms, abbreviations, alternative spellings, and related terms to CT attitude/ disposition/interest, were used (Rowley & Slack, 2004; Kitchenham & Charters, 2007). At this stage, after careful screening, ten duplicated articles were removed.

Table 1. Keywords and Searching Information Strategy

Databases	Keywords used
Scopus	TITLE-ABS-KEY ((disposition OR tendency OR attitude OR "habit* of mind" OR feeling* OR intention* OR value* OR "internal motivation" OR inclination) AND ("computational thinking" OR "computing education" OR "digital age skill" OR "computer science education" OR "coding education" OR "programming education" OR "analytical thinking" OR "computational literacy") AND (student* OR children OR learner OR "primary student*" OR "secondary student*"))
Web of Science	TS=((disposition OR tendency OR attitude OR "habit* of mind" OR feeling* OR intention* OR value* OR "internal motivation" OR inclination) AND ("computational thinking" OR "computing education" OR "digital age skill" OR "computer science education" OR "coding education" OR "programming education" OR "analytical thinking" OR "computational literacy") AND (student* OR children OR learner OR "primary student*" OR "secondary student*"))

B. SCREENING

Several eligibility and exclusion criterion are determined. The first selection in the wide variety was done on the basis of the titles. Literature sources with titles that were not applicable to the topic under review, that did not refer to any of the words defining the student's disposition / attitude or that referred to elements that did not meet the selection criteria were excluded. First regarding literature type, only article journals with empirical data are selected which means review article, book series, book, chapter in book and conference proceeding are all excluded.

Second, in order to avoid any confusion and difficulty in translating, the searching efforts excluded the non-English publication and focused only on articles published in English. Thirdly, with regard to timeline, a period of 5 years are selected (between 2016 and 2020), an adequate period of time to see the evolution of research and related publications. Fourth, with regard to subject matter, all the irrelevant topic related with primary and secondary grade (Grade 1 till Grade 11) such as medicine, bio chemical, immunology and others were excluded as these topics are relevant only after Grade 11 (Karantzaz et al., 2019; Xiao & Watson, 2017; Kitchenham &Charters, 2007; Okoli & Schabram, 2010).

Table 2. The inclusion and exclusion criteria

Criterion	Eligibility	Exclusion
Literature type	Journal (research articles)	Journals (systematic review), book series, book, chapter in book, conference proceeding
Language	English	Non-English
Time line	Between 2016-2020	<2016
Samples	Primary and secondary school students only	Preschool children, teachers, College/ University Students, Special need students
Subjects	Core subjects for primary and secondary level	Other subjects

C. DATA ABSTRACTION

The remaining sources were further assessed by their abstract and, if necessary (if the abstract did not provide proficient information), further reading. Once again, these were judged on the basis of their title, abstract, and further reading if appropriate. The remaining papers have been reviewed and analysed. The data were collected first by reading through the abstracts, then the full articles (in-depth) to define themes and sub-themes that were important.Qualitative analysis was performed using content analysis to identify themes related to students' disposition/attitude. The author then organized sub-themes around the themes established by typology (Thomas & Harden, 2008; Rowley & Slack, 2004).

D. ANALYSIS

After screening and data abstraction processes, only 35 articles that fulfil the research requirement was selected (Table 3).

Table 3. Overview of the included studies

AUTHOR	COUNTRY	STUDIES
Kynigos & Grizioti (2020)	Greece	This paper discusses how programming could be seen as jointly cultivating meaning making of computational concepts with the adoption of practices and strategies in a relevant meaningful context for learners through a broader integrated pedagogical approach. The author identifies a digital game which consist programming and other computational concepts.
Deng et al. (2020)	China	This study aimed to test the effects of different programming tools with the same teaching content on learners' computational thinking and computer learning attitude in real classroom teaching. The author identifies that students learning in a mixed text-based and block-based Pencil Code programming environment not only improved computational thinking, but also increased self-confidence and enjoyed learning programming.
Carlborg et al. (2019)	Sweden	This paper investigates the factors that are important for teaching Computational thinking with micro: bit in Swedish schools. In accordance with the new curriculum, the study identifies a model to support teachers in developing and appropriating material for teaching programming and computational thinking at individual progress.
Witherspoon (2019)	USA	In this study, the authors examine middle school students' pre- and post-tests of computational thinking, attitudinal surveys and surveys of theirteacher's instructional goals to determine if student attitudes and learning gains in computational thinking are associatedto the educational objectives endorsed by their teachers while implementing a shared curriculum for robotics programming.
Hadad et al. (2019)	USA	The project in this paper studied how instructors could use formative assessment to uncover students' prior knowledge and improve their use of CT. The aim of this study is to produce a qualitative analysis of one lesson within the unit implementation of an informal maker space environment that sought to be responsive to culture. The study analyses moments of notice, or instances where formative assessment could guide students' understanding of CT. The study discusses the use of materials in conjunction with promoting CT concepts and dispositions, focusing on drawing for understanding, debugging practice and the fluidity of roles in the learning space.
Negrini & Giang (2019)	Italy	This study examines how pupils perceive educational robotics as a tool to improve their creativity, collaboration, computer science and computational thinking skills and to foster their interest in STEM disciplines. Results have shown that boys and girls have different perceptions about which skills they could enhance. In addition, the results showed that educational robotics activities might increase interest in coding, computer science, and engineering, but this was observed predominantly in boys.
Mesiti et al. (2019)	USA	This research study focused on three specific exhibit design approaches that conveyed problem decomposition content in The Science Behind Pixar (Pixar), a 13,000 square foot traveling exhibition about the computer science, Mathematics, and science behind Pixar's innovative films. Phase One investigated how to support novice learners in interacting with exhibits and understanding problem-solving strategies that address complex, creative computer programming challenges. Phase Two investigated the affordances of these exhibits in middle and high school youth to build capacity, feelings of efficacy, and interest in problem-decomposition content.
Papavlasopoulou et al. (2019)	Norway	This paper presents a two-year design-based research (DBR) approach, based on constructionism-based coding experiences for children after the four DBR stages. The study identifies nine design principles that may assist us in achieving greater engagement during the coding activity. Moreover, positive attitudes and high motivation were found.
Ciancarini et al. (2019)	Italy Ireland	In this paper, Exploratory Structural Equation Modeling technique was used to introduce and analyze *Cooperative Thinking* (CooT), a model of team-based computational problem solving. The author identifies that cooperative thinking is new competence which aim is to support cooperative problem solving of technical contents suitable to deal with complex software engineering problems. This article suggests tackling the CooT construct as an educational goal, training software development students to improve their individual and team performance.
Roque & Rusk (2019)	USA	This study aims to seek young people's perspectives on what they viewed as important in their long-term participation in a coding community. Besides, key experiences that motivated, influenced their development and inspired their emerging leadership also been discussed.

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AUTHOR	COUNTRY	STUDIES
Maeng (2019)	South Korea	This paper, presents a way to teach CT by using coding notes and analyse its educational effects on CT. The study identifies that student's logical reasoning ability can be improved and their academic achievement is also relatively great by using SW coding notes.
Kert et al. (2019)	Turkey	In this study, the effectiveness of a high school computer science course is investigated. The study not only measured the perceptions of teachers, but also investigated the developments of students in their perceptions of academic achievement and computational thinking, as well as correlations between the sub-factors of computational thinking.
Sharma et al. (2019)	Norway	The goal of the study is to investigate how collaboration and engagement moderate children's attitudes about coding activities.
Song (2019)	Republic Korea	Exploring the dependent variables as computational thinking skill and interest in software education, and verify the effectiveness of the unplugged block coding system.
Tsortanidou et al. (2019)	Spain	This paper aims to present a novel pedagogical model that aims at bridging creativity with computational thinking (CT) and new media literacy skills at low-technology, information-rich learning environments.
Zhao &Shute (2019)	USA	In this study, cognitive and attitudinal influences of playing a video game named Penguin Go, designed to target the development of middle school students' computational thinking (CT) skills. The study found that the game did not influence students 'attitudes towards computer science, but that the constraints of the game had a negative impact on students' attitudes towards computer science.
Cheng, G (2018)	Hong Kong	This paper explores factors influencing the acceptance of visual programming environment among boys and girls in primary schools.
Pei et.al (2018)	USA	The researchers discussed Lattice Land, a computational learning environment and accompanying curriculum designed to promote the development of mind mathematical habits and computational thinking practices in mathematics classrooms at high school. The author describes how Lattice Land design offers learners the opportunity to use computational thinking practices and develop mathematical mental habits, including tinkering, experimentation, pattern recognition, and formalizing hypothesis in conventional mathematical notation.
Kong et al. (2018)	Hong Kong	The author conceptualized programming empowerment as composed of four components: meaningfulness, impact, creative self-efficacy, and programming self-efficacy.
Papavlasopoulou et al. (2018)	Norway	The eye-tracking activity was used in this study to measure indicators of learning and activity for children. The objective of the study is to understand the activity of children while learning how to code and determine any potential association between the attitudes of children and their gaze.
Pérez (2018)	USA	The author suggests a framework to conceptualize computational thinking (CT) disposition consists of tolerance for ambiguity, persistence, and collaboration and yet facilitate integration of CT in mathematics learning.
Ragonis & Shilo (2018)	Israel	The effect that learning Logic Programming (LP), while applying logic inference, has on students' understanding of argumentation texts been discussed. Additionally, students' attitudes towards the connection between the two disciplines also investigated.
Tsai et al. (2018)	Taiwan	The aim of this study was to develop an instrument, Computer Programming Self-Efficacy Scale (CPSES), for all students above middle school to understand the perceptions of young students about their own computer programming learning.
Yagcı (2018)	Turkey	The purpose of this study was to develop a scale that can be used to measure high school students' computational thinking skills (CTS). Exploratory and confirmatory factor analysis showed that 42 items expressed with a construct consisting of four problem-solving factors, co-operative learning & critical thinking, creative thinking and algorithmic thinking.
Basnet et al. (2017)	USA Canada	The researchers discussed the use of an online automated practice and assessment system called Kattis for homework assignments and final project. The study suggested that continuance intentions to use Kattis is driven by the level of satisfaction of students with the system, the degree of students' confirmation of expectations, and the perceived usefulness of the system.

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AUTHOR	COUNTRY	STUDIES
Durak & Saritepeci (2017)	Turkey	The purpose of this study is to determine how much different variables explain computational thinking skills of students. Computational thinking ability was found to be highly predicted by variables, respectively;" thinking styles, academic success in mathematics class, and attitude to mathematics class.
Korkmaz et al. (2017)	Turkey	A scale was developed in this study for the purpose of determining the students' levels of computational thinking skills (CTS).
Martín-Ramos et al. (2017)	Portugal	This author discussed about first exposure to Arduino software through peer-coaching and identifies the impact on students' attitudes towards programming.
Farris & Sengupta (2016)	USA	This article discusses about a democratic approach to children's computing education in a science class focusing on the *aesthetics* of children's experience. The authors promoted the power of Deweyan's aesthetic experience to make computational thinking accessible and attractive to all children.
Brady et al. (2016)	USA	This paper sets out the practical and theoretical motivations for the Computational Thinking for Girls (CT4 G) project, and specifically highlights the use of physical and social computing as a means of engaging students in CS.
Pilkington & Sanders (2016)	South Africa	This paper determine what the value learners and educators realised in using web design and Hyper Text Markup Language (HTML). It was found that there was some disagreement as to the level of support offered to educators who had to learn HTML and that most learners enjoyed learning web design and were responding to the demands of learning HTML.
Leonard et al. (2016)	USA	This paper outlines the findings of a pilot study which used robotics and game design to develop computational thinking strategies for middle school students. This study contributes to the STEM literature on the use of robotics and game design to influence the technology and CT self-efficacy.
Mouza et al. (2016)	USA	The author examines how equitable pedagogical practices can be applied to the design of computer programs and how participation in such programs affects the learning of computer science concepts, computer practices and attitudes towards computing by middle school students.
Saez Lopez et al. (2016)	Spain	The purpose of this study is to evaluate the use of a Visual Programming Language using Scratch in classroom practice, analysing the outcomes and attitudes of 107 elementary school students in five different schools in Spain from grade 5 to 6.
Shim et al. (2016)	South Korea	The aim of the research is to propose a practical educational programming environment for young students which integrates the effective programming tools, material, and learning methods previously researched

DISCUSSION

FREQUENCY AND TREND ANALYSIS

Figure 2 shows the frequency of previous studies related to the attitude/disposition to computational thinking that have been published over the last 5 years (2016 – 2020). A total of 35 studies from all 17 countries were identified. The study was comprised of 7 study from Asian countries, 10 studies from European countries, 5 from Middle East, 12 studies American countries and one study from South Africa. Although the total findings of this study are small (averaging 8 publications per year), they are still sufficient because this study focuses only on articles that examine students' attitude in practicing computational skill. Accordingly, these findings at the same time also indicated that studies of computational thinking attitude/disposition in the context of education are still lacking and deserve more attention.

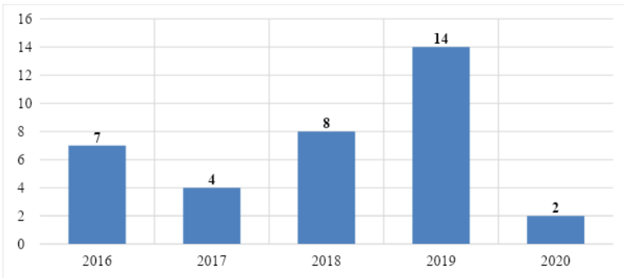

Figure 2. Number of papers published yearly from 2016 to 2020.

Note: The total for publications in 2020 is not complete, with the search period concluding on 7 Feb 2020.

SCOPE OF STUDY

Based on the thematic analysis, the scope of the study of these articles can be summarized into conceptual study and theories, module or instrument development study, module review study and assessment study.

METHODOLOGY DESIGN

Figure 3 shows the frequency of previous studies related to the type of research method that have been applied in the study of attitude/disposition to computational thinking published over the last 5 years (2016 – 2020). Viewed from the research methodology dimension, the results of the thematic mapping of the articles distinguished that, 15 of the articles analysed using quantitative methods, seven more using qualitative methods while 13 of them were mixed methods.

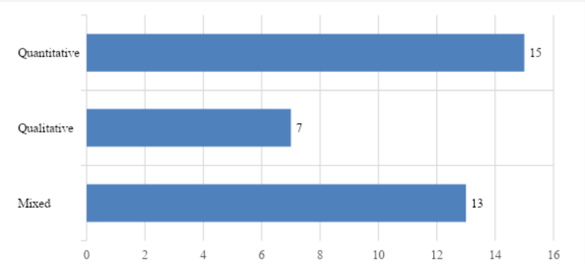

Figure 3. Frequency of the type of research method article publishing on students' attitude/disposition towards computational thinking

The analysis of the method and type of studies used are given in Table 4 below. Most studies have used quantitative measurements which is survey to measure learners' CT attitude/disposition, although some have applied qualitative design such as interview to analyse students' attitude. A number of models and theories have been developed and utilized to understand the relationship between the attitude towards new technologies and the experiences using the technology (e.g., UTAUT or its initial form Technology Acceptance Model-TAM). TAM is a model connecting the ease of use, intention to use, user behaviour and the usage outcomes (enjoyment, engagement, learning to name a few). Numerous studies have used this model as a basis for their analyses or extending the basic model given by Davis (1989). In addition, conducting surveys before and after a learning often becomes a significant study concern. Qualitative methods such as interviews provide a more in-depth understanding of students' attitude/disposition towards CT.

Table 4. Analysis of the methods and types of studies on students' attitude/disposition towards computational thinking

	Author	Journal	Methodology	Instrument	Database
1	Gerosa et al. (2022)	Frontiers in Psychology	Experimental study (Quantitative)	Pre-post survey	SCOPUS
2	Deng et al. (2020)	Computer Applications in Engineering Education	Experimental study (Quantitative)	Pre-post survey	WoS
3	Kynigos & Grizioti (2020)	British Journal of Educational Technology	Mixed method (Design Based research)	Screen Audio recordings Artefact-based interviews	WoS
4	Carlborg et al. (2019)	International Journal of Child-Computer Interaction	Qualitative	Module	SCOPUS
5	Ciancarini et al. (2019)	The Journal of Systems and Software	Exploratory Structural Equation Modeling (Quantitative)	Model	WoS
6	Hadad et al (2019)	Journal of Science Education and Technology	Qualitative analysis	Student engineering notebooks Field observations Video &audio recordings	WoS
7	Kert et al. (2019)	Informatics in Education	Mixed Method (Sequential Explanatory Method)	Pre-post test	WoS
8	Maeng (2019)	International Journal of Recent Technology and Engineering	Experimental Study (Quantitative)	Survey	SCOPUS
9	Mesiti et al. (2019)	Museum Education	Mixed method	Interview Pre-post questionnaire	WoS
10	Negrini & Giang (2019)	Journal of e-Learning and Knowledge Society	Experimental study (Quantitative)	Pre-post survey	SCOPUS

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	Author	Journal	Methodology	Instrument	Database
11	Papavlasopoulou, et al. (2019)	Computers in Human Behavior	Mixed method (Design Based Research)	Observation Pre-post questionnaire	WoS
12	Roque & Rusk (2019)	Information and Learning Sciences	Qualitative	Interviews	WoS
13	Sharma et al. (2019)	International Journal of Child-Computer Interaction	Mixed method	Observation Pre-post questionnaire	SCOPUS
14	Song (2019)	Universal Journal of Educational Research	Quantitative (Experimental)	Questionnaire	WoS
15	Tsortanidou et al. (2019)	Information and Learning Sciences	Document Analysis (Qualitative)	Model	WoS
16	Witherspoon (2019)	Information and Learning Sciences	Experimental study (Quantitative)	Pre-post survey	WoS
17	Zhao &Shute (2019)	Computers & Education	Quantitative (Survey)	Video game Online pre-post test	WoS
18	Cheng,G (2018)	Computers in Human Behavior	Mixed method	Interview Pre-post questionnaire	WoS
19	Kong et al. (2018)	Computers and Education	Quantitative (Survey)	Questionnaire	WoS
20	Papavlasopoulou, et al. (2018)	International Journal of Child-Computer Interaction	Mixed method (Design Based research)	Observation Pre-post questionnaire	SCOPUS
21	Pei et al. (2018)	Mathematical thinking and learning	Case study (Experiments)	Pre-post interview	WoS
22	Pérez (2018)	Research in Mathematics Education	Qualitative	Document analysis	WoS
23	Ragonis & Shilo (2018)	Journal of Information Technology Education-Research	Mixed method (Quasi experimental design)	Pre-post-test Questionnaire	WoS
24	Tsai et al. (2018)	Journal of Educational Computing Research	Quantitative	Questionnaire	WoS
25	Yagci (2018)	Education and Information Technologies	Mixed method	Document analysis	WoS
26	Basnet et al. (2017)	Education and Information Technologies	Quantitative (Survey)	Online Questionnaire	WoS
27	Durak & Saritepeci (2017)	Computers & Education	Quantitative	Online Questionnaire	WoS
28	Korkmaz et al. (2017)	Computers in Human Behaviour	Quantitative (Survey)	Questionnaire	WoS
29	Martín-Ramos et al. (2017)	Computers in Human Behaviour	Quantitative	Pre-post questionnaire	WoS
30	Brady et al. (2016)	IEEE of Transaction on Education	Quantitative	Pre-post questionnaire	WoS
31	Farris & Sengupta (2016)		Case study (Qualitative)	Interview	SCOPUS
32	Leonard et al. (2016)	Journal of Science Education and Technology	Mixed method (Quasi-experimental)	Observation Pre-post questionnaire Recording Artefacts Rubric	WoS

continue ...

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	Author	Journal	Methodology	Instrument	Database
33	Mouza et al. (2016)	Journal of Research on Technology in Education	Mixed method	Observation Pre-post questionnaire Artefacts Assessment	WoS
34	Pilkington & Sanders (2016)	African Journal of Research in Mathematics, Science and Technology Education	Mixed method	Interview Survey	WoS
354	Saez Lopez et al. (2016)	Computers & Education	Mixed method (Design Based research)	Observation Pre-post questionnaire	WoS
36	Shim et al. (2016)	IEEE Transactions on Education	Quantitative	Pre-post questionnaire	WoS

THEMATIC ANALYSIS

Wing (2006) proposed CT as a set of applicable attitude and skill everyone would use. Meanwhile, Barr and Stephenson (2011) uses the term 'disposition' to define the operational definition of the attitude of CT as the values, motivations, feelings, stereotypes, and attitudes applicable to CT. Robles (2012); attitude is including in soft skills; soft skills are personal specific skills, which are the character traits, attitudes, and behaviours. In this study, attitudes refer to soft skills required in CT problem-solving process.

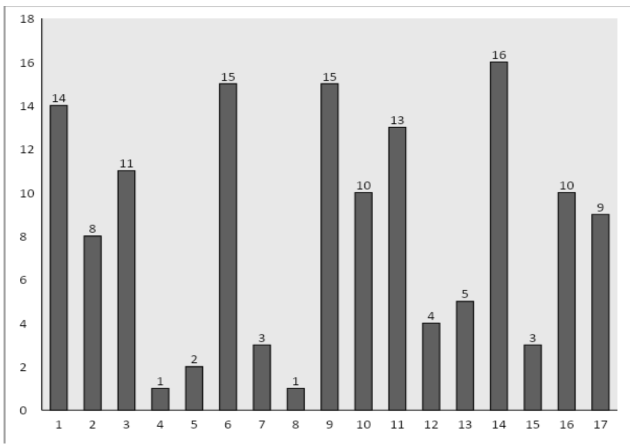

Figure 4 . Category of attitude/disposition that influence student computational thinking

For thematic analysis (Figure 4), the result mapping for the studies into three skills of disposition/attitude which is cognitive, affective and behavioral then extended into sub-themes as stated in Table 5. The author referring to Barr & Stephenson (2011) definition of dispositions as the basis for defining and identifying the expected CT disposition/ attitudes. Figure 4 shows the category distribution of the 17 identified subthemes by three categories namely cognitive, affective and behavioural. Cognitive and behavioural components were the most frequently studied factors, followed by affective component of the total four subthemes.

COGNITIVE COMPONENT

Cognitive component is arguably a mental function, which generates awareness and a belief system in the individual, of new knowledge. Cognitive aspect is vital as students required to think in heuristic way to approach and solve problems. In this review, cognitive component consists of subtheme such as connection, creative, perception, ethics, expectation and usefulness. These subthemes are basically emerged from perspective dimension of Brennen and Resnick (2012) CT framework (i.e. expressing, connecting and questioning). These subthemes investigate learner's understanding of themselves and the technological world. 14 studies focus on creativity which is the dominant in this category (Carlborg et al., 2019; Ciancarini et al., 2019; Kynigos & Grizioti, 2020; Negrini & Giang, 2019). When students realises that CT is vital in digital economy, it creates a belief system within themselves which is a subtheme of cognitive component. Besides this, students' ability to perceived learning, tendency to connect ideas, perception and evaluate computationally also being discussed and investigated through these articles.

Table 5. Analysis of the components in each category studies on students' attitude/disposition towards computational thinking

					COGNITIVE					**AFFECTIVE**					**BEHAVIOURAL**			
	Author	Creativity	Connection	Perception	Ethics	Expectation	Usefulness/impact/ Meaningfulness	Satisfaction	Anxiety	Interest/Attention	Excitement/Enjoyment	Self-efficacy/ Self-confident/ Identity/ Competency	Perseverance/Persistence	Communication	Cooperative /collaboration/team work	Tolerance	Motivation/ Enthusiasm/ Encouragement	Engagement / Participation/ Involvement
1	Deng et al. (2020)			x			x		x	x	x						x	x
2	Kynigos & Grizioti (2020)	x	x				x			x								
3	Carlborg et al. (2019)				x		x			x							x	
4	Ciancarini et al. (2019)	x								x				x	x			
5	Hadad et al. (2019)											x	x	x	x	x		x
6	Kert et al. (2019)						x			x	x	x					x	
7	Maeng(2019)						x											
8	Mesiti et al.(2019)	x	x	x						x		x						
9	Negrini & Giang (2019)	x								x					x			
10	Papavlasopouloet al.(2019)		x			x	x				x	x		x	x		x	x
11	Roque & Rusk (2019)	x						x		x		x		x	x		x	x
12	Sharma et al. (2019)														x			x
13	Song (2019)									x						x		
14	Tsortanidou et al. (2019)	x	x												x			x
15	Witherspoon (2019)									x		x						
16	Zhao & Shute (2019)			x							x							
17	Cheng,G (2018)			x			x					x					x	
18	Kong et al. (2018)	x					x					x					x	
19	Papavlasopoulou, et al.(2018)			x							x				x			x
20	Pei et.al (2018)	x	x										x					
21	Pérez (2018)												x		x	x		
22	Ragonis & Shilo (2018)		x				x											
23	Tsai et al. (2018)			x								x						

continue ...

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24	Yagci (2018)	x													x		x	
25	Basnetet al.(2017)			x		x	x	x										
26	Durak & Saritepeci (2017)	x													x			
27	Korkmaz et al.(2017)	x												x	x			
28	Martín-Ramos et al.(2017)			x			x			x		x			x		x	
29	Brady et al.(2016)	x	x	x						x	x				x			
30	Farris & Sengupta(2016)	x	x							x					x			
31	Leonard et al. (2016)	x									x	x						
32	Mouza et al.(2016)						x				x	x	x		x		x	
33	Pilkington & Sanders (2016)			x			x	x		x	x							
34	Saez Lopez et al.(2016)						x				x	x						x
35	Shim et al. (2016)			x			x			x								x
	Total	**14**	**8**	**11**	**1**	**2**	**15**	**3**	**1**	**15**	**10**	**13**	**4**	**5**	**16**	**3**	**10**	**9**

AFFECTIVE COMPONENT

Affective component encompasses feeling and emotion. They are four subthemes been identified in this category (i.e. satisfaction, anxiety, interest and excitement). These subthemes emerged from the feeling within student about themselves and their ability regarding CT. The 23 studies in the literature identify and focused on affective dimension of CT among students. Most researchers agree that interest of CT determine the attitude in CT (Cheng, 2018; Deng et al., 2019; Kert et al., 2019; Kong et al., 2018; Kynigos & Grizioti, 2020; Mouza et al., 2016; Zhao & Shute, 2019) and should be incorporated in the study of attitude/disposition. In sum students will contribute confidently in the digital world if they feel empowered (Kong et al., 2018).

BEHAVIORAL COMPONENT

Meanwhile, the 30 studies in the literature identify behavioural components of attitude or disposition. It is believed that competence, perseverance, collaboration, communication, tolerance, enthusiasm and engagement are important subthemes which were assessed to determine learners' capability to attain the designated types of performance in the context of CT. Collaboration which stresses students' relationship with others is the dominance in this category (Brady et al., 2016; Farris & Sengupta, 2016; Hadad et al., 2019; Korkmaz et al., 2017; Negrini & Giang, 2019; Pei et al., 2018; Perez, 2018; Roque & Rusk, 2019; Tsortanidou et al., 2019; Yagcı, 2018). Besides that, students' self-formation through perseverance and engagement directly reflect their interest and enjoyment of learning and practicing CT. In sum, all the subthemes are interconnected with each other and it highlights the relation between CT and attitude/disposition. Table 5 summarizes the components of attitude that have been categorized in each component.

DISCUSSION

Based on the systematic review conducted, it is understood that the behavioural components playing an important role in determining the CT attitude. Figure 5 indicates that behaviour (43%) is the most frequently discussed attitude in assessing CT among students followed by cognitive (36%) and affective (21%). Behaviour component comprises of collaboration and communication which is a personnel preference in broadening their perspective and enrich learning besides working effectively in teams locally and globally is an essential condition to navigate variety of technologies thus perform meaningfully in CT. On top of that, persistency and tolerance in behavioral component also required for students to demonstrate an ability to persevere and handle greater ambiguity as they work to solve open-ended problems

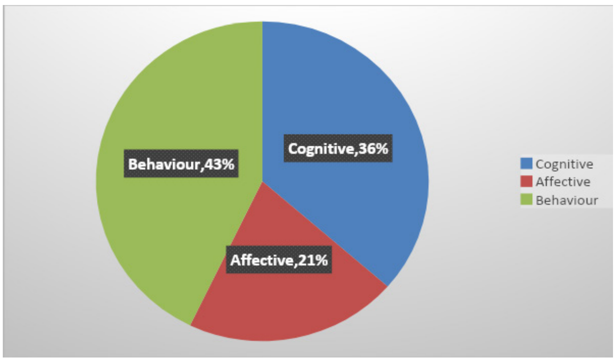

Figure 5. Analysis of components of attitude/disposition

Cognitive components needed as a feasible and essential mindset to engage in CT. Conceptually, Computational thinking intersects with 21st century skills such as creativity, critical thinking and problem solving (Lye & Koh, 2014). Thus, most of the researchers believe that CT is intertwined creative thinking (Romero et al., 2017). Creativity promotes out-of-the-box thinking and innovative approaches to problem solving; and as a means of creative expression, it seeks to promote the development of computational artefacts. Creative reasoning could provide learners with a better understanding of CT practices (Romero et al., 2017).

It has been argued that CT can promote creativity, as one of the key competencies of the 21st century by enabling students not only to be technology users, but also to create sources that can have a significant impact on society (Mishra & Yadav, 2013). It involves developing ways of thinking that enable learners to make creative use of computational tools within the disciplines. The core reason for including creativity in this mix is that computing not only expands conventional forms of human expression, but also encourage new forms of expression to be generated (The College Board, 2012). Therefore, creativity is a fundamental attitude that learners can develop and to embed a certain amount of ambiguity and complexity in CT which allows students to incorporate ideas yet to understand the CT concepts well.

Affective component and behavioural component are equally popular and frequently investigated. Conceptually, affective component is one of the most widely studied issues in the social sciences. Since affective or emotion is a very subjective matter, it is therefore entirely dependent on the variables of the present circumstance and the context. This also means the affective component of attitudes / dispositions is omnipresent, making it one of the most widely used variables in the context of student behaviour.

Various sub-topics in the field of affective, such as enjoyment and interest for example, have also attracted researchers to study more intensely. When we focus on K-12 education, we find a recent wave of research related on how the new visual programming languages, such as Scratch, Phyton and video games like Blockly, are contributing to increase interest, motivation and self-efficacy of primary and secondary students in programming tasks (Kong et al., 2018; Carlborg et al.,2019; Zhao & Shute, 2019). In summary, research has shown some promising results regarding attitudinal impacts of video games on children's CT growth.

Besides that, collaboration is another strand of attitude which might be linked to empowerment via creative self-efficacy or programming self-efficacy. Collaboration in CT also described as the attitude and capacity to understand the work of others, where students need to be able to decipher and interpret (Korkmaz et al., 2017; Perez, 2018). Moreover, attitude toward collaborative programming described as a person's orientation or feelings toward cooperative programming activities with peers (Tseng et al., 2009). Usually, students work together in pairs or small groups on a computer programming task with one computer can boost students' programming efficiency and trust (Sharma et al., 2019; Yagci, 2018).

Collaboration can be a source of meaningful uncertainty or situational ambiguity in the context of CT experiences and other tasks which can lead to growth and may increase persistence. When students participate in a group, they also offer advice to solve problems and obtain it from others. Research has found that collaboration among students significantly impacts student motivation, student confidence and knowledge building (Leonard et al., 2016). Thus, it makes sense to cultivate a willingness to collaborate with others in the context of CT explorations. In general, students with stronger attitudes to collaboration are more likely to consider mutual goals and shared gains from collaborating with others. Such students might exert more effort when working with others, build better collaborative skills and collaborate more effectively to solve difficult problems creatively (Kong et al., 2018; Sharma et al., 2016).

On top of that, collective intelligence is a skill related to the whole design thinking process enhanced in collaborative activity when each member's contribution is pivotal for finding the best solution through sharing and comparing knowledge and experience (Tsortanidou et al., 2019). Therefore, we should recognize collaboration as a form of valuable learning tool in the process of increasing quality in learning. Future studies can also consider assigning student roles to foster the collaborative problem-solving process and maintain student engagement in order to further develop student collaboration skills (Taylor, 2016).

FUTURE DIRECTION

Although the efforts to promote CT is numerous, but only a few studies investigated on the attitude on CT. Ideally many learners focussing on the output rather than the process of learning. The positive sight is students get motivated, on the other hand there are chances for the students being impatient and try to overlook or skip a few steps to reach the end result (Carlborg et al, 2019). Thus, lack of specifications in the dimension of ethics was noteworthy. Our goal is to prepare the young learner to become optimistic computational thinkers who understand how today's digital tools can help tomorrow's problem. They need to be an intelligent creator of technology and not just a competent consumer. There remains much that is unknown about the role of attitude/disposition in computational thinking environment. Researchers must do in depth exploration study to gain more insight into attitudes/dispositions which will reveal its inter-relatedness with CT dispositions that are crucial in learning CT. Therefore, it could be argued that students' CT dispositions reflect their attitudes.

Husen (1997) highlighted that learning phenomenon is inherently complex, and therefore its research demands a complementary use of the qualitative and quantitative paradigms. A consequence from an operational point of view, is the need of gathering and analysing data from different sources, in order to allow a more precise comprehension of the observed phenomena. Thus, future studies should consider using more qualitative designs. A qualitative perspective offers in-depth analysis and detailed explanations on students' perspectives about computational thinking practices. Discovery of attitudes towards CT will help students to demystify the concepts to be personally meaningful and help them to discover the ubiquitous nature of CT in everyday life. Moreover, Berrang-Ford et al. (2015) noted that more explicit and detailed reporting of analysis methods for qualitative reviews can result in an improved transparency and increased ability to critically assess the rigor of review methods while at the same time reflects new and diverse systematic methods to research synthesis.

Researchers are also recommended to develop and validate instruments to measure students' attitude/disposition towards CT rather than adapting instrument from programming or computer science in general. As we know CT is a new but systematic thinking tool that require a recent conceptualisation and operationalization in terms of assessment. Only a CT orientated assessment tool, able to identify the advances and limitations of the research in that area. These results suggest the importance of designing an interest-driven computational thinking curriculum, with collaboration opportunities to enhance students' self-efficacy, creativity, motivation and so on to enhance students' CT empowerment.

CONCLUSION

This systematic review has highlighted the types of attitudes/dispositions that influence practices of computational thinking among school students on global. Based on the systematic reviews performed, authors have identified three attitudes/dispositions patterns namely cognitive component, affective component and behavioural component. In sum, the findings of this study indicate the relationship of non-cognitive variables which is the disposition/attitude as it can help to expand the nomological CT network and reinforce its continuity as an evolving psychological framework. To conclude, even though CT is integrated as a core collection of problem-solving competencies, there is also a complementary non-cognitive side of CT. Thereafter, educational strategies and initiatives aimed at promoting CT should be considered on both sides. Besides, the scope of CT measurement methods needs to be expanded such that the field's increasing diversity is reflected in the corresponding measuring instruments.

To sum up, teachers and researchers will get a better understanding of the CT attitudes/disposition that learners will possess. Also, teachers with limited experience and knowledge of CT may need detailed descriptions of the studies that have already been conducted to guide their practice. Therefore, the summary will instruct teachers on the content of learning activities for lesson planning. Consequently, this systematic analysis is also essential to support the development and assessment of CT education curricula. This finding can also be used to inform the learners about the attitude to cultivate to enjoy CT in practices of everyday life.

The review suggests some recommendations for future studies. First, more qualitative studies are needed as it offers in-depth analysis and detailed explanations on students' attitudes/dispositions along with their perspectives about computational thinking practices. Research on Computational Thinking integration in education is still scarce. Especially, studying how CT can be developed in students in disciplines other than computer science is required. In addition, the claim that developing CT also increases the ability of students to deal with complexity and open-ended problems needs to be studied in-depth. Next, researchers are encouraged to practice complimentary searching techniques such as citation tracking, reference searching, snowballing and contacting experts. Future researcher also recommended to explore more valuable attitudes through in-depth interviews of the related experts, filtering articles in other foreign languages and using a broader database.

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Saralah Sovey
SMK Sungai Ramal, 1, Jalan Rakyat 2,
Sungai Ramal Luar, 43000 Kajang, Selangor
saralahsovey@gmail.com

Mohd Effendi @ Ewan bin Mohd Matore
Kumpulan Penyelidikan Univeriti Penilaian Pendidikan,
Fakulti Pendidikan,
Universiti Kebangsaan Malaysia
effendi@ukm.edu.my

*Corresponding Author: Mohd Effendi @ Ewan bin Mohd Matore

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