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TEACHERS' PERCEPTIONS AND INTENTIONS ABOUT INTEGRATING COMPUTATIONAL THINKING INTO SCIENCE INSTRUCTION

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Abstract

This study explored teachers' perceptions of integrating computational thinking in South African science classrooms using the Technology Acceptance Model (TAM). This research adopted a combination of informal discussions and closed and open-ended questions to elicit responses from fifty science teachers in an education circuit in Johannesburg, South Africa, via a google form. Responses from the open-ended questions and informal discussions were analysed using content analysis, and data from the structured questions were analysed using correlation analysis. It was found that teachers demonstrated a positive perception towards the integration of CT in their science classrooms but lacked appropriate technological knowledge and technological pedagogical to teach the concepts of CT in science lessons, affecting their CT teaching efficacy beliefs. The findings of the study revealed a strong positive correlation between teachers' interest in CT and behavioural intention ($r = 0.539$), perceived ease of use of CT with behavioural intention ($r = 0.543$), perceived usefulness of CT with behavioural intention ($r = 0.599$), and a moderate positive correlation between teachers' attitude and behavioural intention ($r = 0.312$). However, there was no statistically significant relationship between teachers' self-efficacy and behavioural intention. Based on these findings, it is recommended that teachers engage in practical training programs that will provide them with the pedagogical experience needed to develop their self-confidence in using CT concepts and practices to teach science. Besides that, teacher education programs need to introduce students to the knowledge of CT and provide learning experiences that can promote the development of teachers' interest, knowledge and efficacy in using CT to teach science content.

Keywords: *Computational thinking, perceptions, science instruction, teachers, intentions.*

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1. Introduction

Computational thinking is recognised as an essential skill in the twenty-first century across all disciplines, particularly in STEM education, as it trains students to have the cognitive flexibility to deal with complex problems in the Fourth Industrial Revolution (Riley & Hunt, 2014). Computational thinking is "the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent" (Wing, 2011, p. 1). In addition to being based on ideas that are fundamental to computer science, computational thinking is also crucial to current research and problem-solving in Science, Technology, Engineering and Mathematics fields (Henderson, Cortina, & Wing, 2007). As a result, the Next Generation Science Standard of the United States specified that students should engage in computational thinking as one of the core scientific practices needed to construct scientific knowledge (NGSS Lead States, 2013). CT is naturally embedded in STEM in the reflection of creativity, procedural thinking, critical thinking, problem-solving and cooperation skills. Barr and Stephenson (2011) suggested nine major computational thinking concepts and abilities that can be used across core content areas in K-12 classrooms to enhance the integration of computational thinking in education. These include data collection, analysis, representation, problem decomposition, abstraction, algorithms and procedures, automation, parallelisation, and simulation. Framing computational thinking with ideas such as decomposition, pattern recognition, algorithm design, abstraction and pattern generalisation provides teachers with a low threshold for taking computing to their classrooms and enables them to see similarities between computational ideas and science lessons (Yadav et al., 2018). In addition, CT involves practices that are also required in science, such as "data practices, modelling and simulation practices, computational problem-solving practices, and systems thinking practices" (Weintrop et al., 2016, p.136). Hence, CT can be used in science classrooms in various ways, including single or multiple learning approaches (Ogegbo & Ramnarain, 2022). In light of the CT concepts and practices mentioned above, computational thinking should be integrated into the educational system as a significant learning objective to ensure that students are prepared with competency for their futures (Grover & Pea, 2013).

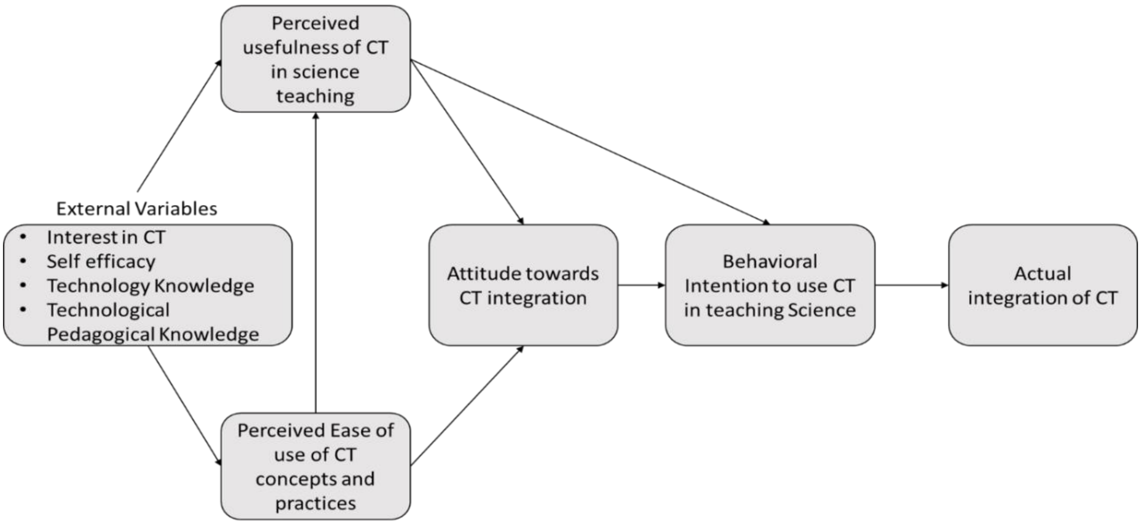
Toward this end, the Department of Basic Education in South Africa incorporated coding and robotics into the curriculum. Furthermore, research has shown that coding and robotics expose students to computational thinking, enhancing their understanding of science (Chevalier et al., 2020). Although researchers and educators stress the importance of computational thinking in education globally (Grover & Pea, 2013), its practice seems to be limited and problematic within the South African context. Given the wide range of skills linked to computational thinking, educators attempting to implement these practices may become confused by the lack of a clearly defined subset of skills. Moreso, research has indicated that the successful integration of computational thinking and its related practices in education depends on teachers' attitudes and perceptions. Based on the above, this study explores teachers' perceptions about integrating computational thinking in South African science classrooms. More specifically, the following research question guided this study:

> What are the perceptions and intentions of teachers regarding integrating computational thinking into science teaching and learning in South Africa?

2. Conceptual framework

The conceptual framework of this study is based on the Technology Acceptance Model (TAM), which proposes that the perceived usefulness (PU) and perceived ease of use (PEOU) of technological tools are the essential determinants of technology use (Davis, 1989). People's predisposition to use a new concept is determined by their belief that the idea will improve their work performance. This implies that what teachers know, believe, and think about a new idea influences their acceptance of and eventual use of such innovation. The Technology Acceptance Model (see Figure 1) has grown in popularity, owing to its adaptability to different contexts and samples and its ability to explain variation in technology intention or use. As a result, several contextual variables like facilitating conditions of technology, subjective norms, interest, knowledge, and self-efficacy have been used to extend the model (Abdullah & Ward, 2016). The essential factors in the TAM are perceived ease of use, which refers to the degree to which a person believes that using technology would be free of difficulty (PEU), and perceived usefulness, which means that using technology would improve their job or task performance (PU). TAM outlines the unstructured connections between perceived usability, perceived usefulness, attitude toward using, and actual usage behaviour of system design elements. TAM has also been demonstrated as a theoretical model that aids in explaining and forecasting user behaviour when interacting with innovative technology (Scherer et al., 2019).

Figure 1. Technology Acceptance Model (Davis, 1989).



Thus, the primary constructs of TAM, which emphasises perceptions (PEOU and PU), and behavioural intentions to use CT were used in this study to determine how teachers perceive and accept the integration of CT in science instructions, as this tends to be closely related to their competence beliefs. (Scherer, Siddiq, & Tondeur, 2019). This implies that teachers may accept a model based on its ease of use and ability to improve their teaching performance.

3. Method

This research adopted a "convergent mixed methods" design (Creswell, & Plano Clark, 2018:41). This design involves a "one-phase project in which the researcher collects and analyses two separate databases—quantitative and qualitative—and then merges the two databases to compare or combine the results" (Creswell, & Plano Clark, 2018:41). It is regarded as a convergent design because it aims to obtain different but complementary data on the same topic, to best understand the research problem. Informal discussions and a semi-structured questionnaire (closed and open-ended questions) are used to collect data from 50 science teachers from a school district in Gauteng, South Africa. Participants were required to complete the online survey during an informal discussion following a professional development activity. The closed-ended questions contain statements to which teachers respond on a four-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). The items are grouped according to computational thinking ideas using the primary construct of TAM. In order to show the correlations between constructs, Pearson coefficients (2-tailed) were calculated. Results from the quantitative data were analysed using correlation analysis, while findings from the open-ended questionnaire and informal discussions were analysed using content analysis. Results from the quantitative and qualitative data are then integrated into a coherent whole to provide a complete understanding of the phenomenon under investigation. Fifty per cent (50%) of the teachers who completed the questionnaire are between the ages of 21 to 25 years, 38% are between the ages of 26 to 30 years, and 12% are from 31 years and above. Eighteen of the teachers were males, and thirty-two were females. It should be noted, however, that the sample size used in this study is insufficient to generalise the findings to the entire population of South African science teachers.

4. Findings

Mean (average) calculations were performed to identify general response trends for each scale and item. For each scale, standard deviations were calculated to determine the degree of consistency among respondents. The strength and direction of the relationship between the constructs and items were described using correlation analysis. The results of the closed-ended question analysis were combined with the results of the open-ended questions and informal discussions to form a coherent whole. Table 1 displays the statistical results from the survey (closed-ended) questions. Cronbach's alpha for each construct (scale) was greater than 0.70, indicating strong internal consistency within each scale (Pallant, 2007). The low standard deviation for each construct suggests that the participant's responses were consistent.

Table 1. Descriptive statistics and reliability for CT scale.

Constructs	No of Items	Scale Mean	SD	Cronbach alpha
Perceived Usefulness	4	3.44	.496	.763
Perceived Ease of Use	7	2.97	.274	.701
Interest	5	3.33	.354	.717
Attitude	9	4.03	.411	.706
Self-efficacy	6	2.87	.570	.865
Behavioural Intention	5	3.22	.449	.755

The findings show that teachers have a positive attitude toward incorporating CT into their science classrooms. From the perspective of the perceived usefulness of CT, teachers believe that using CT can enable students to solve problems ("Using technology and CT will help improve learners' problem-solving abilities", M= 3.42, SD = .575). They also believe that acquiring programming skills and knowledge can improve science instruction ("I expect that learning programming skills/concepts will enhance my science teaching abilities", M = 3.54, SD = .646). Teachers also talked about the affordances of CT in the open-ended question and informal discussions, as evidenced by the following excerpts, which refer to the benefits of CT for learners.

> *Computational thinking in science education provides learners with a more authentic image of science as it is practised today; it also increases access to powerful modes of thought and marketable skills for various careers.*
> *Using computational thinking in the classroom can give students ownership of their work while providing them with the skills they need to be digital citizens.*
> *Science teachers can use CT to plan lessons that promote deep learning. The teacher can use CT to create complex problems that require students to think deeply when solving them.*

> *This is a valuable skill to have when confronted with complex and messy situations or scientific problems; you can then piece together the puzzles and patterns to understand the connectivity between elements in such situations.*

The survey result shows that teachers had a strong positive response to the perceived ease of use of CT. Teachers believe that incorporating computational thinking into their classroom practices will not overburden them. This was evident in their response to statements ("integrating modelling and simulations in the science curriculum will not increase the teacher's workload" M = 3.32, SD = .551; "integrating problem-solving practices with the use of technology in the science curriculum will not increase teachers workload" M= 3.44, SD =.501; "integrating data practices in the science curriculum will not increase the teacher's workload" M= 3.64, 4.85, and "integrating system thinking practices in the curriculum will not increase teacher's workload" M = 3.16, SD = .738). However, it was discovered that the majority of teachers (about 68%) believe that integrating CT into the curriculum will affect how they prepare for their lessons ("Integrating CT in the curriculum will not affect the time spent on the preparation and process of science teaching" M= 2.34, SD = 1.042). This was expressed quite aptly by a teacher during the informal discussion:

> *The Department of Education prioritises curriculum completion, and incorporating computational thinking takes significant time. This could result in fewer hours spent on lesson planning and delivery.*
> *This might be time-consuming, and teachers would then have less time to finish the syllabus.*

The positive perception of teachers towards the integration of CT into science lessons is underlined by their interest in CT with a strong correlation with PEOU (r = .416, $p < 0.05$) and PU (r = -.702, $p < 0.05$). Teachers' interest in CT was revealed in their responses to item statements like "I am willing to learn new ideas/instrument/methods/technologies required for integrating CT into science instructions" (M = 3.70, SD = .463). Despite teachers' interest in embedding CT in science instructions, they perceived themselves as less competent in using relevant technology and advanced programs/devices to create activities that support CT integration. This was evident in the following statements ("I can create real and virtual artefacts using a variety of software on a range of digital devices" M= 2.34, SD =1.136; "I can plan and create associated programs that can be used to teach science" M= 1.88, SD =1.081; "I take time to create science activities that involve the selection and modification of advance technology applications in solving problems" M = 2.12, SD = 1.023). The responses of teachers to open-ended questions also revealed their inability to incorporate CT concepts using appropriate technology:

> *It is rather unfortunate that I don't have the technological strategy or approach that can be used to assist and scaffold some of the virtual activities using these CT concepts.*
> *Because this is an unfamiliar field for some of us teachers, we may be hesitant to use these new tools and materials.*

Furthermore, results show that teachers have a positive attitude toward using CT, as evidenced by their strong positive response to the statement, "I like the idea of using CT concepts and practices in the teaching and learning of science." M = 3.14, SD = .808. Moreover, the findings show that teachers' perceptions of the use of CT were consistent with their attitude toward CT, which strongly correlated with perceived ease of use (r = .471, p = 0.000) and perceived usefulness (r = .446, p = 0.001). On the construct 'Behavioural Intention', teachers responded to item statements indicating their intention to incorporate computational thinking into science instructions. Their responses to the statements such as "I plan to use existing lesson plans that take advantage of CT tools and approaches in my classroom" M = 3.06, SD = .740; and "Computational thinking will be incorporated in my science classroom by allowing students to solve problem" with M =3.24, SD= .591 demonstrated their willingness and readiness to use CT. This is also emphasised in responses to another statement "I plan to be involved in the process of learning and teaching science by integrating CT concepts in my classroom, M = 3.18, SD = .596). The correlation analysis showed that teachers' behavioural intention towards the integration of CT into science instruction significantly correlated with interest in CT (r = 0.539, p = 0.000), perceived ease of use of CT (r = 0.599, p = 0.000), perceived usefulness of CT (r = 0.543, p = 0.000) and attitude towards integrating CT (r = 0.312, p = 0.001). However, there was no statistically significant relationship between behavioural intention towards integrating CT and teachers' self-efficacy in CT.

5. Discussion and conclusion

The findings of this study reveal that teachers have positive perceptions of computational thinking in terms of perceived ease of use and perceived usefulness of CT, which significantly impacts their behavioural intention in incorporating CT into their science lessons. Moreso, the sampled teachers were found to have a positive attitude toward incorporating CT into their science classrooms. The attitudes recorded were generally positive and strongly correlated with their behavioural intentions, with only a small percentage of participants expressing reservations or resistance. This implies that teachers appear to be familiar with the CT concept and recognize its importance in education while also stating their intention to incorporate it into their teaching and attend relevant training. These findings support the view that the perceived ease of use and perceived usefulness of technology can influence the adoption of a specific behaviour (Fessakis & Prantsoudi, 2019). However, findings show that teachers' intentions to integrate CT were more influenced by their interest in CT than their self-efficacy. As a result of their low CT self-efficacy, teachers demonstrated positive intentions to attend CT-related training. Research indicates that high CT self-efficacy could help with problem-solving, algorithmic thinking, designing systems, and understanding human behaviour (Fessakis & Prantsoudi, 2019). This finding can be beneficial in effectively organising and delivering practical training programs. Such programs should boost teachers' confidence in using CT concepts and practices to teach science. Providing teachers with the competencies and materials required for integrating computational thinking concepts helps improve their self-efficacy and attitude towards using CT (Yadav et al., 2018). These findings also call for teacher education programs to introduce preservice teachers to the knowledge of CT and provide them with learning experiences that can foster teachers' interest, understanding and efficacy in using CT to teach science content.

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