

Strategies for fostering critical thinking dispositions in the technology classroom

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Abstract

Critical Thinking (CT) consists of two components, namely, skills and dispositions. Although there is a fair amount of literature focusing on CT and the development of CT skills, the literature on CT dispositions and, in particular, strategies to promote the dispositional component of CT is lacking. This means that there is insufficient literature available to guide teachers in their practice regarding the ways in which they could foster CT dispositions. This is particularly problematic for technology teachers as they may not be fully informed on how to use the opportunities offered by the design process, as prescribed by the South African Department of Basic Education. This study thus aimed to investigate and describe how technology teachers use the opportunities presented by the design process to foster CT dispositions. This study engaged in a qualitative research approach and a case study design. Ten purposefully sampled teachers were interviewed, five of whom were observed for one design-based lesson. Facione's (2011) Seven Dispositions toward CT were used to guide the inquiry. The analysis of the data indicated that the participants used four main strategies that acted as a platform for, or led to the use of another four supporting strategies. The four main strategies are: assessments, questioning, examples, and the classroom environment. The four supporting strategies are: discussions, modelling, feedback, and resources. The results and conclusions of this study are not considered as the final answer to the lack of literature, but they provide a starting point for further investigation and development.

Keywords: Critical thinking; critical thinking dispositions; dispositions; technology; technology education; technology teachers.

Introduction

CT is an essential 21st century skill that is necessary to achieve success in social and professional contexts (Duran & Şendağ 2012; Facione 2000; ITEEA 2020). For this reason, CT should be taught, practised, and developed in educational environments (Aizikovitsh-udi & Cheng 2015; Kezer & Turker 2012).

One of the general aims listed in the South African National Curriculum Statement (NCS) specifically calls for the use of CT to enhance learners' ability to identify and solve problems (Department of Basic Education 2011). Problem solving is an activity and process in which CT is required for the successful generation of viable solutions; it is also considered a major component of the design process (Burghardt & Hacker 2004; Halpern 2014; Ohemeng-Appiah 2014). In South Africa, the design process forms the backbone of technology education as it provides a structure for the teaching and learning of knowledge and skills in the subject (DBE 2011; Schooner, Nordlöf, Klasander & Hallström 2017). The South African Curriculum and Assessment Policy Statement (CAPS) for technology offers many opportunities to foster CT during the design process.

Facione (2011) explains that CT consists of two components, namely: CT skills and CT dispositions. CT skills are related to a person's cognitive capabilities, whereas CT dispositions are concerned with an individual's willingness to think critically (Ennis 1996; Facione 2011). While research regarding CT generally focuses on CT skills (Dwyer, Hogan, Harney & Kavanagh 2017), research on CT dispositions is lacking (Yang & Chou 2008). Yang and Chou (2008) note that despite researchers' call for investigations into CT dispositions, they have continued to provide literature that mostly focuses on its definition, classification and assessment. Consequently, the literature provides limited insights into possible strategies for the fostering of CT dispositions.

Nieto and Saiz (2011) state that CT requires some amount of instruction or teaching as this higher-order thinking skill is unlikely to result from natural maturation. Given the scarcity of literature regarding strategies to nurture CT dispositions, teachers face the challenge of finding ways to develop a positive disposition towards CT in learners so that they are willing to think critically and use CT skills outside an instructional environment. To address this issue, this study sought to answer the following question: What strategies do technology teachers use to foster a positive disposition towards CT in their classrooms? The answer to this question may enhance our understanding of how technology teachers nurture learners' CT dispositions, which could ideally be formalised into teaching guidelines to improve teacher training and professional development.

The design process in the South African context

The school subject technology offers a stimulating environment in which learners can develop their CT skills and dispositions (Fahim & Ghamari 2011; Ohemeng-Appiah 2014). Many scholars consider the design process as the core component of technology, and problem solving its inherent activity (Burghardt & Hacker 2004; Jones, Buntting & De Vries 2013; Mawson 2003). Fahim and Ghamari (2011) opine that the processes of problem solving and decision making pose the greatest opportunity to think critically. Lawson and Dorst (2009) further explain that the classic problem-solving process correlates with the general activities found in the design process. These activities consist of overlapping phases with the aim of creating and finding a suitable solution to the design problem (Dorst 2006; Jonassen 2010; Mawson 2003). Design problems are generally considered as ill-structured (Lawson & Dorst, 2009). Ill-structured problems are vague and have multiple and divergent solutions (Halpern 2014; Jonassen 2010). Figure 1 illustrates the design process as prescribed by the Department of Basic Education (DBE) in the CAPS for technology.

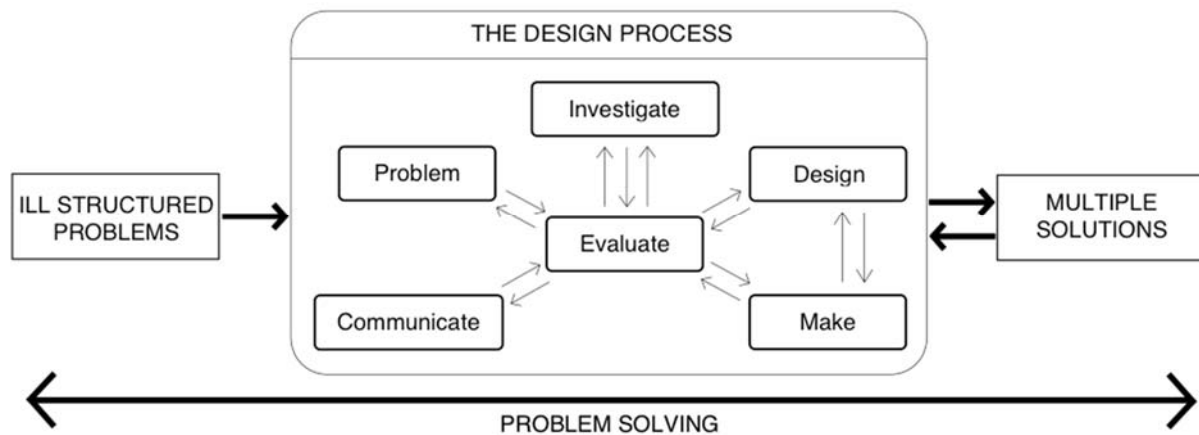


Fig. 1 The design process in technology (Adapted from DBE 2011)

As illustrated in Figure 1, the CAPS document for technology identifies the phases of the design process as *Investigate*, *Evaluate*, *Design*, *Make* and *Communicate* (DBE, 2011). In technology, the design process is used to solve ill-structured problems during Practical Assessment Tasks (PATs) (DBE 2011). In a PAT, learners are presented with a scenario and problem for which they have to design and create a viable solution. While completing the PAT, they are expected to engage in a variety of activities and present their findings and solutions to the given problem.

Critical thinking

Duron, Limbach and Waugh (2006) describe CT simply as the ability to analyse and evaluate information. Bailin et al. (1999) explain that this analysis and evaluation is directed towards the purpose of making up one's mind to fulfil the standards of adequacy and accuracy in terms of a specific area of interest. CT, according to Facione (2000, p. 65), is a "self-adjusting process of judging what to believe or what to do in a given context." The process involves the utilisation of cognitive skills to form, evaluate, reflect on, and improve judgments to increase the probability of a desirable outcome (Ennis 1996; Facione 2000; Halpern 1999). CT is the practical activity of making decisions through reasonable, reflective thinking (Ennis 1996) where reflective thinking is the act of suspending judgment while investigations are underway (Dewey 2010).

A cross-disciplinary international panel of 46 CT experts, henceforth referred to as the Delphi team, participated in a two-year Delphi Method research project to study the state of CT and CT assessments. The Delphi team concluded that CT can be described as "purposeful self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as an explanation of evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based" (American Philosophical Association 1990, p. 3). CT, as understood by the Delphi team, consists of two components that have to be learned, developed, and practiced. These are: CT skills and CT dispositions, which offer a framework for conceptualising the qualities of CT (Abrami et al. 2009). According to Facione (2011), these two components are mutually reinforcing. The one does not assure the other, but both are necessary for an individual to be considered a strong critical thinker. Paul and Elder (2012) highlight the importance of making thinking, and more specifically CT, explicit in order to ensure that flawed reasoning does not go undetected. The framework developed by Facione causes the abilities and qualities of a critical thinker to be clear by providing six CT skills and seven CT dispositions. Figure 2 illustrates Facione's conceptualisation of CT.

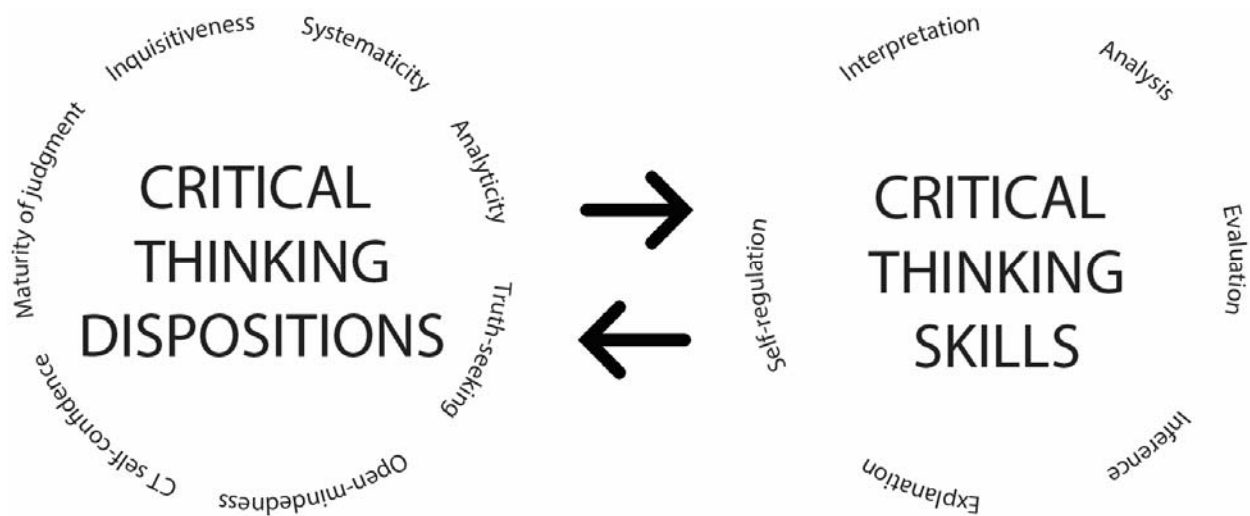


Fig. 2 CT as conceptualised by Facione (2011)

The skills and dispositions illustrated in Figure 2 are not a by-product of general instructional activities; one has to actively teach CT (Halpern 2014; Murawski 2014).

CT skills

CT skills are cognitive strategies and abilities that aid in the process of making decisions and informed judgements (Ennis 1996; Facione 2011; Halpern 2014). These skills include the ability to: interpret, analyse, evaluate, infer, explain, and self-regulate (American Philosophical Association 1990). These skills manifest in performance and can be developed through direct instruction when engaging in and completing tasks (Aizikovitsh-udi & Cheng 2015; Facione 2000).

Many researchers believe that in order to be considered a strong critical thinker, one should not only possess CT skills, but it is also necessary to have a positive disposition towards CT to ensure that these skills are applied (Ennis 1996; Halpern 1999; Nieto & Saiz 2011; Yang & Chou 2008). This idea is reinforced by Facione et al. (1996, p. 67), who opine that "we must habitually, not just skillfully, engage in critical thinking."

CT dispositions

Strong critical thinkers are internally motivated and willing to use CT skills appropriately and in a variety of contexts - they are positively disposed towards CT (Halpern 1999; Yang & Chou 2008). Dispositions are understood as "habitual ways of acting" (Facione 2000, p. 63) or the "tendency to do something, given certain conditions" (Ennis 1996, p. 166). Ennis, Halpern and Facione have provided conceptualisations of CT dispositions.

CT dispositions are understood by Ennis (1996, pp. 170–171) in terms of three basic actions, namely: "(1) 'To 'get it right' to the extent possible, (2) To represent a position honestly and clearly, and (3) To care about the dignity and worth of every person." The first action is related to an awareness that decisions and beliefs should be justified and true. The second action denotes that a person is able to represent his or her own and others' positions truthfully and plainly. The third and last action is not explicitly required by the definition of CT, but Ennis (1996, p. 171) states that without this "correlative disposition", caring for others, CT may become less valuable and more dangerous to society. Ennis' framework for describing a person's disposition towards CT is valuable in the sense that it is easy to understand because it is expressed in terms of actions. It could be argued that these actions are more a result of being positively disposed to CT rather than the internal qualities of a person who is disposed to it.

Halpern (1999) describes the dispositions of CT as relating to a person's attitude towards CT. According to Halpern, the dispositions of a critical thinker will be demonstrated in a person's: (1) Willingness to plan, (2) Cognitive flexibility, (3) Persistence, (4) Inclination to be self-critical, (5) Mindfulness, and (6) Consensus-seeking attitude (Halpern, 2014). Halpern's understanding of CT dispositions relating to an attitude towards CT is sensible. Attitude is understood as "a settled way of thinking or feeling," which is typically reflected in behaviour or action (Lexico Online Dictionary, 2020a). It is important to note that even though an 'attitude' is considered to be an established position in the mind, this position can take the form of being open to different and opposing views, as expressed by Halpern's second disposition: to be cognitively flexible. Furthermore, to be 'disposed to' indicates that a person is internally motivated to behave in a certain manner. This behaviour can be seen as manifesting in certain actions. Halpern's conceptualisation can therefore also be understood in terms of actions or activities that a person is inclined or willing to complete. Relating the dispositions to attitudes comes closer to describing the internal qualities of a person who is disposed to CT rather than the actions that follow.

Facione (2000) explains CT dispositions as the characterological attributes of a person, which are consistent yet malleable. Attributes are the characteristics, inherent qualities or traits of a person or object (Lexico Online Dictionary, 2020b). Dispositions could be considered as traits of a person. These dispositions would thus result in certain attitudes and actions associated with a strong critical thinker. The Delphi team initially identified 19 dispositions (APA 1990). From the original 19 dispositions, seven dispositions were identified through a process of factor analysis (Facione 2011). Table 1 provides a brief description for each disposition.

Table 1: Conceptualisation of CT dispositions

CT dispositions	Conceptualisation
Inquisitiveness	An inquisitive, critical thinker is intellectually curious and has an eagerness to learn and be well-informed, even if at that moment the application of the knowledge in question is not known.
Analyticity	A person who is positively disposed to analyticity values the application of reasoning, the use of evidence, and the ability to anticipate the consequences of choices.
Systematicity	Being systematic indicates that a person is concerned with the orderly, focused and diligent manner in which relevant information is sought out, and arguments are presented.
Truth seeking	A truth seeker is eager to ask questions and considers alternative opinions to gain the best knowledge, even if it does not support their own beliefs.
Open-mindedness	An open-minded, critical thinker understands, tolerates and respects divergent views and is sensitive towards their own biases.
CT self-confidence	A person who engages in CT self-confidence trusts in their own reasoning process and the soundness of their own judgments when responding to problems.
Maturity of judgment	Maturity of judgment signifies that an individual is judicious about the making, suspending and revising of their decisions.

Descriptions sourced from Aizikovitsh-Udi and Amit (2011); APA (1990); Facione et al. (1994); Ordem (2017); and Yang and Chou (2008)

Conceptual framework

The conceptual framework used in this study is based on Facione's (2011) seven dispositions towards CT, augmented with the DBE's (2011) description of the importance of the design process in the subject technology. Facione's conceptualisation of the CT dispositions was chosen because it is widely accepted, used and acknowledged by scholars in the field of CT. The DBE's (2011) conceptualisation of the design process in technology was included due to the context of inquiry in this study being that it took place in South Africa.

Figures 1 and 2 were used to develop the conceptual framework. Firstly, this study only focused on the dispositional component of CT to address the gap in the literature. The value of problem solving in practicing CT and as part of the design process further informed the framework. Figure 3 illustrates the conceptual framework that guided this study.

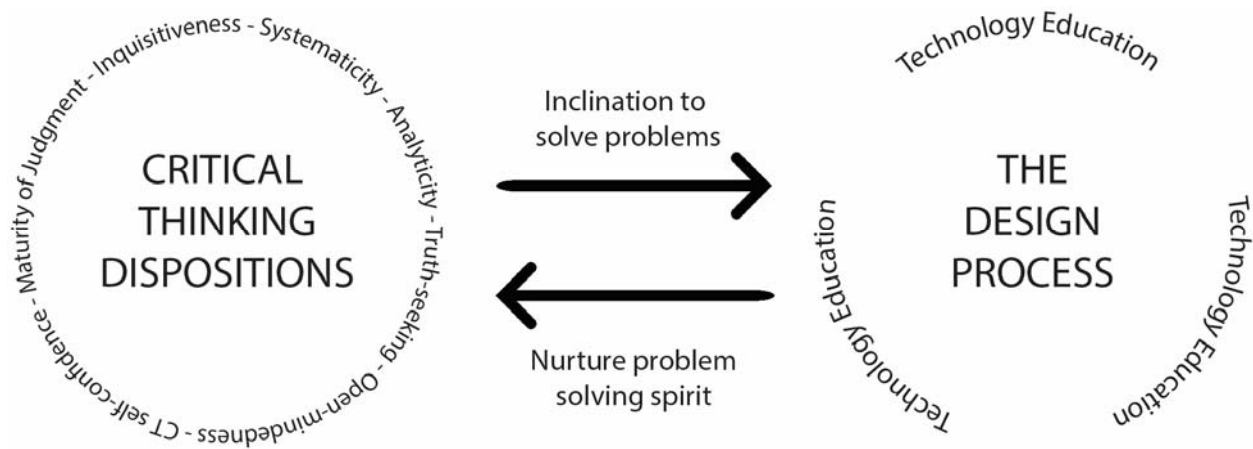


Fig. 3 The conceptual framework

The conceptual framework depicted in Figure 3 consists of two main elements, namely, CT dispositions and the design process in technology. These elements are linked through the activity of problem solving. The design process in technology presents many opportunities to foster a problem-solving spirit and develop CT dispositions. Teachers must be willing to engage with these opportunities because the willingness to solve or deal with a problem cannot be assumed (Dostál 2015).

Research design and methodology

This study used a qualitative research approach guided by an interpretivist paradigm. The case study design with multiple participants was considered an appropriate method to answer the research questions posed. The case under investigation was technology teachers' fostering of CT dispositions in their classroom. The use of a qualitative approach presented the opportunity to provide a rich description of the participants' strategies and how these strategies were actualised in the classroom. The interpretivist paradigm provided a foundation for the investigation and exploration of the subjective experiences of the participating individuals (Ponterotto, 2005). Using both interviews and observations, the researchers were able to gain an in-depth understanding of the strategies the participants used and made it possible to thoroughly describe how these strategies were actualised in the technology classroom.

Sampling

A combination of purposive and convenience sampling was used to select the participants for the interviews and observations. For the interviews, each participant was purposefully chosen based on a set of predetermined criteria. The criteria included Grade 8 and 9 teachers who taught

technology in Pretoria and Johannesburg (both cities are located in Gauteng, a province in South Africa). Teachers in Pretoria and Johannesburg were sought out due to the time constraints of this study and the researchers' place of residence, making it more convenient to gather the data. Furthermore, Grade 8 and 9 teachers were specifically selected because these are the highest grades in which the subject technology is taught. This potentially presents greater opportunities to foster CT dispositions because of the increased difficulty in the levels of problem solving. The principle of saturation determined the sample size for the interviews. An initial 10 interviews were conducted with participants during which data saturation occurred. This left the sample size at 10 participants, one participant from Johannesburg and nine from Pretoria. Five participants from the same group of participants who were interviewed were observed for one design related lesson, which included one participant from Johannesburg and four from Pretoria. The selection for the observations was based on the participants' willingness to be observed and whether they taught in the areas in Gauteng for which ethical clearance was received from the DBE.

Instruments and data collection

Data were collected through semi-structured interviews and classroom observations. The aim of the interviews was to investigate how technology teachers describe the strategies they use to foster a positive disposition towards CT. Each participant was interviewed at a place, date and time that suited him or her best. All interviews were audio recorded and transcribed. Creswell (2014) states that qualitative interviews generally make use of open-ended questions to elicit the participants' views. Therefore, all of the questions were open-ended and aimed to encourage the participants to provide detailed answers and not limit their responses. Questions about each disposition were grouped together, and each grouping started with 'how do you foster the particular dispositions in your classroom'. Thereafter a strategic set of open-ended questions were asked based on and informed by Facione's (2011) seven dispositions towards CT and the conceptualisation of each disposition, as shown in Table 1. If needed, the researcher asked additional questions based on the answers provided by the participants. A definition and explanation of the particular disposition were provided in writing to ensure that the participants understood their meaning before being asked these questions. The definition included the conceptualization in Table 1, and the opposite or negative attribute for each disposition.

Observation can be used in conjunction with other data collection strategies as it presents an opportunity for researchers to verify data and observe subtleties that may lie outside of the participant's consciousness (Ary et al., 2010; Creswell, 2012; Given, 2008). The data collected

from the observations were used to indicate how and if the strategies identified during the interviews were used, and how they were actualised in the technology classroom. An observation schedule derived from Facione's (2011) seven dispositions towards CT and the interview analysis guided the collection process and the analysis of the data. The classroom observations were conducted during one design-based lesson that suited the participant and school best. Elements that were noted during the observations include the seven CT dispositions and the eight strategies identified during the interview analysis with no new strategies being observed. Notes were taken during the observations, which provided descriptions of, and reflections on what the researcher heard, saw and understood during and after the observation and the lessons were video recorded.

Data analysis

The collected data were coded and analysed using emergent coding and thematic analysis to identify the major themes and thoroughly answer the research question. This study made use of emergent coding because codes were added and changed as they emerged during the analysis process (Maree, 2016). However, initial codes for each CT disposition were used to identify instances where each disposition was noted.

The interview data went through four phases of coding. During phase one, the data were coded based on the seven CT dispositions, as outlined in the conceptual framework. After this preliminary examination and coding of the data, notes and initial codes concerning the strategies that the participants used to foster CT dispositions were made and identified. In the second phase, the data were coded in terms of the identified initial codes. At this point strategies were broadly coded since the researchers' understanding was still developing. After this phase, codes were discussed with an expert in the field of CT, and some codes were changed, adapted or merged as part of defining them clearly. The third phase of coding consisted of all codes being checked against the developed description and adapted, amended or re-coded as needed. During this phase, notes were taken on initial themes to organise and understand the data better. Themes were reviewed by looking for and grouping together utterances that were considered relevant. During this review, a fourth phase of working through the data took place where all of the codes were once again checked and changed where necessary.

The observation data went through five phases of coding. For the first phase of coding, the codes identified from the interviews were used. During the analysis of the interviews, these codes were carefully developed and defined in terms of the participants' answers. This made it possible to identify the actions associated with the codes during the observed lessons. As part of this phase,

notes were taken to clearly define instances and actions when CT dispositions were fostered. During the second phase, indications of the fostering of specific CT dispositions were coded. As part of this phase, the code descriptions for the fostering of CT dispositions were further developed and defined, and the initial codes regarding strategies were checked and re-coded where necessary. During the third phase of coding, the CT dispositions codes were recoded where necessary and all these instances were critically considered to determine the specific action or strategy used by the participant. This assisted in checking and re-coding strategies where necessary, and noting any new actions or strategies; no new strategies were identified. The fourth phase of working through the data involved the consideration of possible themes that emerged. During the previous phase, it was evident that the participants tended to use specific combinations of strategies to foster CT dispositions. All codes were once again checked and re-coded where necessary. In the fifth phase of working through the data, utterances and instances where the identified themes were evident were noted and grouped. During this phase, some codes were added or removed where necessary.

In line with the interpretivist perspective, each interview and observation were coded, analysed and interpreted before moving to the next participant to ensure that each participant was analysed regarding his/her specific context. After coding the interviews and observations, all interviews and observations were compared to further analyse the data. Due to similarities and frequent occurrences of some strategies, it was decided not to discuss individual participants.

Rigour and ethical considerations

A variety of methods were applied to enhance the trustworthiness of this study through improving the credibility, transferability, dependability, and confirmability thereof.

Credibility was enhanced through structural corroboration by way of triangulation of the data gathered from the interviews and observations (Ary et al., 2010). Research bias was controlled throughout the study by applying reflexivity. Notes were consistently taken during and after all the coding phases to ensure that the descriptions of the codes and coding was consistent. Low-inference descriptors were used in the form of direct quotes to convey each participant's context and experiences accurately.

The transferability of this study was increased by stating the limitations of the study to provide a greater understanding of the context of the research (Ary et al., 2010). Reactivity was limited by providing detailed descriptions of the methods utilised. Furthermore, purposive sampling also

increased the transferability of this study as it provides an opportunity to closely replicate the study (Anney, 2014).

To ensure the dependability of this study, all choices were documented during the research process, and the raw data and interview and observation notes were kept to provide a thorough audit trail. Structural corroboration through triangulation, as mentioned earlier, contributed to this study's dependability. Furthermore, the code-recode strategy was employed during data analysis to ensure a deeper understanding of the data patterns, increasing the ability to present the participants' perceptions and behaviours accurately.

Confirmability was addressed through the use of triangulation by collecting data from the interviews and observations since the findings in the interviews could be checked through the observations. All collected data and notes were kept to provide a thorough audit trail.

Regarding ethical considerations, only information related to the research questions and the intention of this study were considered and accepted during data collection. All of the participants were adults who did not represent a vulnerable population and their participation was voluntary. There were also no explicit benefits or consequences as a result of participating in this study. Lastly, permission and informed consent were acquired from the DBE, the ethics committee of the affiliated university, and the schools, principals and teachers involved.

Results and findings

Interviews

During the interviews, the participants described how they fostered each CT disposition in their classroom. Eight strategies were identified during the analysis of the data, namely: assessments; discussions; the classroom environment; examples; feedback; modelling; questioning; and resources.

Assessments (As) involve occurrences where learners had to complete a task, assignment or where the PAT was mentioned. The participants made reference to three components: the instructions or guidelines, and the rubric provided in the assessment brief. *Discussions (Di)* include cases where the teachers would talk about a topic, concept or idea with the learners. These discussions would take place in class, in groups, or with individual learners. The *classroom environment (En)* refers to the atmosphere that the participants created, the structure of their lesson, and any class rules they mentioned. *Examples (Ex)* imply any physical, electronic or

mental concept or idea the participants used to foster CT dispositions. Physical examples refer to any object or model with which the learners could interact in class. Electronic examples include images or videos shown to the learners. Mental examples refer to ideas or concepts mentioned to aid in the fostering of CT dispositions. *Feedback (Fe)* involves any formal or informal occurrence where the participants reacted to or provided constructive criticism regarding a learner's performance or ideas. *Modelling (Mo)* includes occasions where the participants demonstrated a disposition. *Questioning (Qu)* considers direct and leading questions asked by the participants; it also includes rewarding questions asked by learners and responding to learners' questions promptly. Lastly, *resources (Re)* imply any extra physical or electronic aids used in the process of fostering CT dispositions.

Table 2 summarises the findings from the interviews. The identified strategies are presented in eight columns and the seven dispositions shown in the rows. The intersecting cells reveal the context in which each strategy was used. A grey cell indicates that the specific strategy was not mentioned to foster its corresponding disposition.

Table 2: Interview results summary

	As	Di	En	Ex	Fe	Mo	Qu	Re
Inquisitiveness	Problem choice	Class	Atmosphere	Physical Electronic Mental		Demonstration	Direct Leading	Physical Electronic
Analyticity	Problem choice Guidelines Rubric	Class Group		Physical Electronic	Informal	Demonstration	Direct Leading	Physical Electronic
Systematicity	Problem choice Guidelines Rubric	Group Individual	Atmosphere Lesson structure Rules	Physical Electronic	Informal	Demonstration	Direct Leading	Physical Electronic
Truth seeking	Rubric	Class Group Individual	Atmosphere	Physical Electronic Mental		Demonstration	Direct, Leading Reward Qu Answer promptly	Physical Electronic
Open-mindedness	Rubric	Class Group	Atmosphere	Mental		Demonstration	Direct Leading	
CT self-confidence	Problem choice Guidelines	Class	Atmosphere		Informal Formal		Direct Leading	
Maturity of judgment	Guidelines Rubric		Atmosphere	Electronic	Informal Formal	Demonstration	Direct Leading	Electronic

Table 2 indicates that assessments and questioning were used to foster all of the CT dispositions. The participants frequently mentioned the use of discussions, the classroom environment, and examples to foster a variety of dispositions. However, only some described the act of modelling, even if it was regarding most of the dispositions. Resources were also frequently mentioned, even if it was only in relation to fostering five of the seven dispositions, while providing feedback was only referred to in the fostering of four of the seven dispositions.

Assessments, specifically design tasks, were the most frequently mentioned strategy described during the interviews. This made observing a lesson concerning a design activity an appropriate context for witnessing the fostering of CT dispositions. The participants mostly referred to the assessment rubric and also regularly mentioned the choice of problem and the formulation and provision of guidelines. The participants explained that they critically considered the problem or scenario presented in assessments to encourage learners to engage in CT. They further spoke about providing guidelines to guide learners through the design process in a critical manner.

...and then also how questions are set up (Participant 4).

...when you design you have to make sure you give them guidelines (Participant 2).

Concerning discussions, Yang and Chou (2008, p. 668) mention that it is important to "provide opportunities for peer interaction around thinking" to teach and encourage CT dispositions. When engaging in discussions, the participants mostly mentioned class discussion and also made reference to group discussions and individual discussion.

...you have to make sure that you always start talking it through, "But ok, I understand this, but how do you see it? I see it like this," and then begin to ask questions and talk it out, and I would prefer in front of the class so that the class can see for themselves 'but this is why sir is saying this and why he explains it like this' (Participant 5).

I reason with them but I try to pull it out of them rather than just giving it to them (Participant 1).

Creating a classroom environment conducive to the fostering of CT dispositions was mostly focused on creating a comfortable, open and organised atmosphere where most of the dispositions could be nurtured. Lesson structure and rules were only mentioned regarding the fostering of systematicity. By structuring the lesson in an orderly and focused manner, and having specific classroom rules, the participants would attempt to motivate learners to engage in systematicity specifically.

...having discussions, having talks with friends being loud in class and all of that because it actually creates an atmosphere of not corporal matter (Participant 6).

In my classroom, to stay focused, we stick to themes (Participant 4).

All types of examples – physical (e.g. physical models), electronic (e.g. images) and mental (e.g. concepts) were regularly referred to, with electronic examples mentioned the most and mental examples the least. Physical and electronic resources were used when presenting physical and electronic examples. From the literature review conducted in this study, no explicit research was found regarding the use of examples or resources.

I will show them an example of a picture; try and analyse this, is it a good design, is it a bad design and whoever says it is a good design must justify why (Participant 9).

...you can give them examples, as I said a model and this can lead to, ok this is how it works and then they engage in reasoning by themselves (Participant 5).

...and then I like to use videos to explain it to them practically (Participant 3).

On the occasions that the participants spoke about providing feedback, it generally concerned the informal feedback offered during class interactions with some references made to formal feedback being provided at the end of assessments.

...it is amazing to see if you only, oh that was nice, and you see that self-confidence boost (Participant 3).

I call them after school and, "Listen here, this is what, this is your project, these are the flaws, these are the flaws in your paperwork. Go home, go see what you did wrong," but I didn't tell them everything (Participant 6).

As for modelling, Facione (2000) states that it is useful in fostering CT dispositions. Yang and Chou (2008, p. 668) also discuss the principles required in teaching CT dispositions to "provide good models of good thinking behaviour." The use of modelling concerned the demonstration of the CT dispositions by the participants.

If you are interested in it and you can show the children this is interesting, you basically transfer that energy (Participant 1).

...if a child tells me, "But sir, I don't agree," then I would say, "ok cool, now please explain to me how you think about it," and then I will take the time to listen (Participant 7).

During the interviews, questioning was the only other strategy referred to in discussing fostering all of the CT dispositions. Ennis (1996) holds that questioning is essential, especially the ability to ask pointed questions. Schooner et al. (2017) further find that Swedish technology teachers tend to use questioning to explore concepts and ideas critically. The participants mostly mentioned direct and leading questions when describing the strategy of questioning. It was only concerning the fostering of a truth-seeking spirit that some of the participants mentioned the importance of rewarding and answering learners' questions.

...what will happen if something strong pulls the car and there is nothing underneath and then they must think, okay this is what is going to happen because there is nothing that will support it (Participant 3).

When you explain something in class and a child asks you but why then you guide him to the answer but I really want them to think for themselves ...if a child asks a good question, to give credit to that it helps and motivates the guys to ask even more questions and to show more interest in the topic (Participant 7).

Lastly, both physical and electronic resources were stated as aids in the fostering of some CT dispositions, with electronic resources being mentioned slightly more.

It requires some effort to get videos and other additional materials to build their curiosity (Participant 7).

...extra books in my class that they can use and I am not that strict on cell phone use, I encourage them to use it, especially if they have to do research about specific topics (Participant 7).

It is necessary to note that some of the strategies were mentioned in conjunction with or leading to the use of other strategies. There is a strong correlation between the use of examples, specifically physical and electronic examples, and the use of physical and electronic resources. This is sensible because one would require resources to showcase physical and electronic examples. Furthermore, when examples were used, the participants generally mentioned that they would also engage in discussions and ask questions about the example. When the participants used questioning, whether direct or leading, it would generally lead to discussions. The use of assessments and the classroom environment acted as a platform for some of the other strategies to be used. The use of assessments provided a platform for asking questions, especially about the design process. It also provided opportunities for formal and informal feedback. The comfortable and open atmosphere to which the participants referred regarding the classroom environment was usually created to ensure that learners would be willing to ask

questions and engage in discussions. This suggests that the strategies identified during the interview data analysis are not always used in isolation.

Observations

Of the 10 participants who were interviewed, five were selected for one design-related lesson observation. Four of the five participants presented a lesson that focused on a Practical Assessment Task (PAT), in line with the requirements outlined in the CAPS document. One participant presented a lesson that included a design activity.

The data collected from the observations show that the participants used combinations of strategies to foster all CT dispositions. The reporting of the observation data therefore focuses on the combination of strategies used by each participant as opposed to the context in which the strategies were used as presented during the interviews. It was evident that there were four main strategies that the participants used to foster all of the CT dispositions. These strategies were the initial action that acted as a platform for or led to the use of supporting strategies. The main strategies included the use of assessments, specifically a project brief; questioning; examples; and the classroom environment. Table 3 summarises the findings from the observation data. The four main strategies are presented in the columns and the seven dispositions are shown in the rows. The intersecting cells reveal the supporting strategies utilised.

Table 3: Observation results summary

	Assessments	Questioning	Examples	Environment
Inquisitiveness	Discussions Examples	Modelling	Discussions Resources	Questioning
Analyticity	Discussions Modelling	Assessment Discussions Examples Modelling	Discussions Modelling Resources	Feedback Modelling
Systematicity	Discussions Environment Feedback Modelling	Discussions Modelling	Modelling Resources	Assessment Questioning Resources
Truth seeking	Discussions	Discussions Modelling	Discussions Modelling	Questioning Resources

	Assessments	Questioning	Examples	Environment
		Environment	Resources	
Open-mindedness	Discussions	Discussions Modelling	Discussions Resources	Questioning
CT self-confidence	Discussions Feedback	Discussions Examples Feedback Modelling	Feedback	Feedback Modelling
Maturity of judgment	Discussions Modelling	Assessment Discussions Examples Modelling	Discussions Feedback Modelling Resources	Feedback Modelling

Similar to the strategies that were prominently mentioned during the interviews, the participants frequently made use of assessment and questioning to nurture a positive disposition towards CT. Most of the participants regularly used discussions; created a comfortable, open, respectful and orderly classroom environment; used examples; and modelled the dispositions. The use of resources, which was frequently mentioned in the interviews, was not as evident during the observations. Finally, the provision of feedback was mentioned and observed only a limited number of times during the interviews and observations.

From the analysis of the data, it was evident that the formulation of the assessments strongly fostered systematicity through the guidelines in the project brief. The requirements in the brief generally led to discussions around the expectations of the project to foster all of the CT dispositions. During these discussions, the participants would also model analyticity and maturity of judgment, and refer to examples to aid in the process of cultivating inquisitiveness. Feedback was generally provided to encourage CT self-confidence in learners and guide them in systematicity. Lastly, the assessment provided a platform for the lesson structure and in doing so created an ordered and focused classroom environment.

Findings from Participant 8's observation

During Participant 8's interview, he mentioned that he used the requirements and guidelines in assessments to foster CT dispositions. In the PAT, the questions followed a sensible pattern,

starting with the investigation phase, followed by the design brief, then the design ideas and, finally, the technical drawing of the final idea. In this way, he possibly motivated and developed learners' systematicity by requiring them to communicate their PAT in an orderly and focused manner.

While Participant 8 discussed the requirements of the assessment, he also consistently modelled a positive disposition towards analyticity and maturity of judgment. He did this by mentioning his own reasoning process and then stating where and when judgments would have to be made. One could assume that him acting in this manner would influence the learners to act in the same manner while completing the PAT.

Through the use of questioning, analyticity and CT self-confidence were consistently fostered. When the participants asked a question, they would require learners to apply analyticity and then provide them with an opportunity to practice their CT, thus fostering self-confidence therein. The participants tended to model maturity of judgment and systematicity as a response to the answers learners provided. They also modelled many of the other dispositions as part of discussions and examples presented after a question was asked. On occasion, the assessment, feedback, and the classroom environment were also used as supporting strategies to questioning. The answering of questions led some participants to refer back to the assessment to motivate analyticity and maturity of judgment or provide the opportunity for feedback to foster CT self-confidence. Lastly, the act of allocating time for questions at the end of the lesson led to creating a classroom environment where learners were provided with the opportunity to be truth seeking.

Findings from Participant 1's observation

Participant 1 asked some direct questions while discussing the PAT. When asking these questions, he required the learners to apply reasoning (analyticity) to formulate an answer, and then provided them with the opportunity to develop and practise their CT self-confidence by allowing a learner to answer the question. After he discussed the entire PAT, he asked the learners questions about each phase of the process to check their understanding. In his interview, he mentioned that he believed that learners must explain their own understanding, and this was evident at the end of the lesson. After a learner answered the question, he summarised the answer through a class discussion. While summarising the answer regarding the identification of a problem, he modelled his own reasoning process (analyticity).

The use of examples generally led to discussions to foster inquisitiveness, analyticity a truth-seeking spirit, open-mindedness, and maturity of judgment. When an example was provided by a participant or one of the learners, a discussion would usually follow and the participants generally modelled analyticity, a truth-seeking spirit, and maturity of judgment during these interactions. Some of the participants made use of resources, usually PowerPoint presentations, to visually present examples to the learners. Through these presentations, they would model analyticity, systematicity, and maturity of judgment by providing an ordered and focused example. They further made use of the resources to nurture inquisitiveness, a truth-seeking spirit, and open-mindedness by exposing learners to a variety of possibilities. Providing feedback was occasionally used when commenting on learners' ideas and examples to foster CT self-confidence and maturity of judgment.

Findings from Participant 9's observation

Participant 9 projected a video with numerous examples of amusement park rides. It could be said that she sparked learners' curiosity (inquisitiveness) through these examples and also guided them to be truth seeking by bringing different possibilities to their attention. This coincided with her interview where she mentioned that she used videos and other electronic resources to aid in developing CT dispositions. Furthermore, as part of the class discussions around electronic examples presented or mental examples provided by the learners, she modelled open-mindedness by allowing many learners the opportunity to speak. The following was answered regarding a question about webbing:

*Give me a plain example that everyone could understand. *Learner name 1* and then I'll come to *learner name 2*.... you have a different example? (Participant 9).*

The last main strategy, the classroom environment, was not necessarily a strategy used from which supporting strategies would explicitly flow. It was rather a strategy that had been cultivated over time to act as a platform for the fostering of a variety of CT dispositions. Firstly, the atmosphere and opportunities that the participants created in the classroom environment to ask questions encouraged learners' inquisitiveness and open-mindedness. They further created a comfortable and open classroom environment that strongly encouraged a truth-seeking spirit. The learners were willing to ask questions, and some were allowed to use their cell phones as a resource to search for information. By structuring the lesson around the project brief, which strongly fosters systematicity, using questioning to guide learners and utilising resources in the form of slides to structure the lesson meant that the participants created an environment in which

orderly and focused communication were important. While the learners were working, the participants further created an environment that was conducive to CT by providing feedback and modelling analyticity, CT self-confidence, and maturity of judgment.

Findings from Participant 4's observation

Participant 4 created a comfortable environment and atmosphere in which learners were more than willing to ask questions, engage in discussions, and actively interact with the content of the lesson. Whenever a learner had a question, he immediately stopped to answer the question, and all questions were validated and answered with respect. During Participant 4's interview, he mentioned that he found it very important to discuss different ideas from different people. All of the groups, and individual learners, were provided the opportunity to answer specific questions, which could motivate them to understand and respect other's views (open-mindedness). He further boosted their CT self-confidence by providing positive feedback and recognising good ideas and elements by saying "that is a good idea" or "that can work" (Participant 4). He also explained learners' ideas back to them to show that he was listening. It could be said that all of this creates an environment where learners are comfortable and eager to ask questions, fostering a truth-seeking spirit.

It is worth mentioning that modelling and discussions were used to support all of the main strategies numerous times. This indicates that having a discussion or modelling a disposition usually followed or was a result of using one of the main strategies. The four main strategies were also occasionally used as supporting strategies a similar amount of times. This suggests that even the main strategies can be a result of using another strategy. As for the use of resources and providing feedback, the participants used these supporting strategies the least. The use of resources was not observed for the fostering of CT self-confidence and providing feedback was not observed for nurturing inquisitiveness, a truth-seeking spirit and open-mindedness. This does not suggest that these strategies were deemed as less valuable or were not used; it only indicates that they were not witnessed during the five observations.

Discussion

The descriptions provided by the participants during the interviews were organised into eight strategies with the accompanying contexts in which they were used. During the observations, all eight strategies were noted with no new strategies being observed. The analysis of the

observation data yielded insights into how these strategies were actualised in the technology classroom.

Table 4 summarises the findings of this study and provides the answer to the main research question, which was: what strategies do technology teachers use to foster a positive disposition towards CT in their classrooms? The eight strategies that the participants described during the interview were actualised in the classroom as four main strategies: assessments, questioning, examples, environment; and four supporting strategies: discussions, modelling, feedback, and resources. It was evident that the use of assessments, questioning, examples, and the classroom environment acted as a platform for or led to the use of the supporting strategies, and occasionally other main strategies. Discussions and modelling were supporting strategies that were frequently observed to be the result of using one or more of the main strategies. Providing feedback and the use of resources were not noted as frequently, but were still observed in the process of fostering a positive disposition towards CT. The four main strategies are presented at the top of the table, followed by the four supporting strategies. The context in which each strategy was referred to and used is listed underneath each main or supporting strategy.

Table 4: Strategies used to foster CT

Main strategies			
Assessments	Environment	Questioning	Examples
Problem choice	Atmosphere	Direct	Physical
Guidelines	Lesson structure	Leading	Electronic
Rubric	Class rules	Reward	Mental
		Answer	
Platform for using other strategies		Leads to the use of other strategies	
Supporting strategies			
Discussions	Modelling	Feedback	Resources
Class	Demonstration	Informal	Physical
Group		Formal	Electronic
Individual			

The four main strategies as indicated in Table 4 represent the initial action taken by the participants. These actions would act as a platform for or lead to the use of other strategies. When a main strategy was used, another main strategy may have followed or a supporting strategy would be used. Many different combinations of these strategies could be used to foster a positive disposition towards CT.

The main strategies of assessments (Fahim & Ghamari 2011; ITEEA 2020) and questioning (Halpern 2014; ITEEA 2020; Schooner et al. 2017; Zabit 2010), as well as the supporting strategies of discussions (Fahim & Ghamari 2011; Mandernach 2006) and modelling (Facione 2000) were found in the literature regarding the fostering of CT, and its skills and dispositions. The main strategy of the classroom environment and the supporting strategy of providing feedback relate to the principles for teaching CT dispositions as summarised by Yang and Chou (2008). The three main strategies: assessments, environment and questioning; and the three supporting strategies: discussions, modelling and feedback corroborate the strategies mentioned in the literature to nurture CT and CT dispositions. No explicit literature was found regarding the use of examples or resources to foster CT dispositions. Furthermore, no clear research about how the strategies are used and how they are actualised in the classroom were found either. Strategies were usually mentioned separately with no indication of other strategies being used simultaneously.

Limitations of the study

This study was limited by the sample profile and the duration of the study.

The selected teachers all taught at well-resourced schools situated in Pretoria and Johannesburg, South Africa. This sample profile is not exhaustive, and is limited to a very specific group of teachers. This study also only considered how teachers describe the way in which they foster CT dispositions and how these perceived strategies are actualised in the classroom. Learners' opinions, experiences or ideas about their teachers' strategies were not considered. This study is therefore limited to the experiences and intention of the teachers who participated in the study. The researchers suggest that future research include a variety of participants, which include teachers from different contexts, as well as learners. Furthermore, since the findings are only an account of the strategies mentioned and used by the participants, conclusions about the value of each strategy cannot be determined by the data gathered in this study. Investigating the effectiveness and success of these identified strategies used to foster CT dispositions could yield valuable findings and present important contributions to this emerging body of literature.

The data collection phase of this study was completed over a seven-month period. The interviews started during the third term of the school year and, due to regulations stated by the DBE, observations could only commence the following year in Term 1. The five teachers who were observed were only observed for one lesson and a small component of the design process. This limitation leads the researchers to suggest further investigations to include the entire design process and school year to gain an even greater understanding of how CT dispositions are fostered in the technology classroom.

Conclusion

Existing literature on CT mostly focuses on CT skills, while investigation into the dispositional component of CT is wanting. While the literature mentions some strategies for the fostering of CT – skills and dispositions – there are no accounts of its actualisation in the classroom. This study was therefore aimed at contributing to the literature on CT dispositions to enhance our understanding of the strategies currently used in technology classrooms.

The findings of this study indicate that the participants used eight strategies to foster a positive disposition towards CT in their learners. They would use one strategy as an initial action from which other strategies would flow. The use of assessments, questioning, examples, and the classroom environment were identified as the main strategies or initial actions taken by the participants. These strategies acted as a platform for or led to the use of other strategies. The use of discussions, modelling, feedback and resources were identified as supporting strategies. These strategies would be the result of using one of the main strategies. It is necessary to note that one main strategy could also flow from the use of another main strategy. Moreover, the participants used different combinations of strategies to foster all of the CT dispositions.

The findings and conclusions of this study are not considered as the final answer to the lack of literature regarding CT dispositions, but pose as a departure point for further investigation and development.

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