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# Thinking critically about critical thinking dispositions in technology education

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**Abstract**
While much research has been done on Critical Thinking (CT) skills, the *disposition toward CT* has not been adequately investigated. The paucity of literature regarding technology teachers' disposition toward CT is particularly problematic as these teachers have to assist learners with the designing and making of solutions (artefacts) to problems that are often ill structured. Solving these problems is complicated and involves critical thinking. Helping learners to find solutions to these problems, therefore, requires teachers to be willing to think critically and encourage critical thinking in the classroom. Profiling these teachers' dispositions could reveal their inclination to employ critical thinking, and give an indication of the likelihood that they may foster CT skills and the disposition toward CT in the classroom. In addition, such profiling could provide a descriptive baseline for further investigation into the relationship that seems to exist between CT dispositions and professions. This study, therefore, aimed to investigate technology teachers' disposition to think critically in terms of their habits of mind. Quantitative research, using an online survey, was employed in this study. A Likert Scale instrument comprising 42 statements, derived from Facione's (Informal Log 20(1): 61–84, 2000) seven habits of mind, was administered to South African technology teachers. The participants had to rate their level of agreement with each statement on a six-point scale. The research findings revealed that this sample had a positive disposition toward CT. The habits of mind that ranked the strongest were CT Self-confidence and Inquisitiveness, while Mature Judgment ranked the weakest (although still in a positive direction). Further research is needed to establish which dispositions should be emphasised in order to address the dispositional needs in technology education.

**Keywords** Critical thinking · Disposition · Habits of mind · Technology education

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## Introduction

The development of critical thinking skills is key to unlocking a lifetime of learning (Trilling and Fadel 2009). Critical thinking has, in fact, become an increasingly important feature in the educational policies of many countries (Binkley et al. 2012). In South Africa, the Department of Basic Education (2011) has also articulated the need for learners to think critically. The development of Critical Thinking (CT) has therefore been explicitly included as one of the educational aims in the National Curriculum Statement Grades R-12.

Technology, a compulsory subject for all Grade 7–9 learners in South African schools, provides many opportunities to foster CT skills through, for example, problem solving. Problem-solving is, in fact, regarded as an essential feature of technology education and is part of almost all technology learning activities in schools around the world (Schooner et al. 2017). However, teachers must be willing to use these opportunities to cultivate CT in the classroom. Halpern (2014) asserts that critical thinking does not develop automatically from standard instruction, but has to be overtly and consciously nurtured in the classroom.

Facione (2000) recommends that teachers not only focus on strengthening cognitive skills, but should also include strategies for building intellectual character in their teaching practice. There is a growing consensus that programmes that aim to fully develop learners' critical thinking ability should include the fostering of their disposition toward CT (Facione et al. 1995; Dwyer et al. 2015). Facione (2000) points out that people's CT skills and their CT dispositions are two separate things, and that people who have a positive disposition toward CT will be more likely to use CT skills in everyday life. Also, since CT skills and disposition toward CT are reciprocally reinforced, they should be fostered together (Facione et al. 1995).

While much research has been done on CT skills, the nature of CT dispositions has not been adequately investigated (Dwyer et al. 2017; Mcbride et al. 2002). The paucity of literature regarding technology teachers' disposition toward CT is particularly problematic as these teachers, inter alia, have to assist learners with the designing and making of solutions (artefacts) to problems that are often ill structured. While well-structured problems—typical textbook exercises—can be solved using a finite number of procedures, laws and principles, ill-structured problems have many conceivable solutions and solution paths (Jonassen 1997). Solving these problems is complicated and involves the use of critical thinking. Teachers, who must assist learners in finding solutions to problems, should thus be inclined to engage CT and consistently foster CT skills and a positive disposition toward CT in learners.

Facione (2000) believes that one persuasive method that teachers can use to nurture learners' disposition toward CT is by modelling it in their own actions. This means that teachers ought to have a positive disposition toward CT themselves. In light of the scarcity of literature regarding technology teachers' disposition toward CT, it was deemed important to investigate this matter. For this reason, and to address this gap in the literature, the study sought to answer the following question: How can technology teachers' disposition toward critical thinking be described?

Profiling technology teachers' disposition toward CT may enhance our understanding of these teachers' tendency to engage (and possibly model) CT skills while they support learners with problem solving in the classroom. It could also inform teacher training and curriculum design in that strengths in the teachers' habits of mind can be exploited,

while weaknesses in their habits of mind could be strengthened during training programmes. In addition, it can provide a descriptive baseline for further research.

## Critical thinking

Paul (1995) distinguishes between the cognitive psychologists' and the philosophers' perspectives on CT. He identified 24 contrasting differences between these two disciplines, noting that those whose thinking about thinking is shaped by scholars in one field differ from those shaped by the other—it differs in style, direction, and methods for improving thinking (Paul 1995). Due to the extensiveness of the list, the complete list of 24 contrasting differences will not be discussed here. However, in order to clarify the differences between the two disciplines with regard to CT, certain opposing tendencies will be pointed out in this section.

Halpern (2014), an expert in psychological sciences and CT, notes that although many scholars have attempted to define the term *critical thinking*, their definitions are usually very similar, with substantial overlap of concepts in the definitions. She proposes the following description of CT in an attempt to capture the main concepts:

> Critical thinking is the use of those cognitive skills or strategies that increase the probability of a desirable outcome. It is used to describe thinking that is purposeful, reasoned, and goal directed—the kind of thinking involved in solving problems, formulating inferences, calculating likelihoods, and making decisions, when the thinker is using skills that are thoughtful and effective for the particular context and type of thinking task (Halpern 2014: 8).

From a philosophical viewpoint, such a description of CT seems incomplete. Paul (2012: 184) points out that cognitive psychologists often regard cognitive processes and their "pathology" separate from the affective, social, or political life of the thinker. According to Paul (1995), the problem is not simply to get learners to think, but to get them to think critically and rationally. Rationality is achieved when we ground our beliefs and actions in good reason and evidence; when we recognise and assess our own irrationality; when we do not act on bad reasons or due to irrational motives, fears, desires; when we have fostered a passion for clarity, accuracy, and fairmindedness (Paul 2012). For Paul (2012), an integration of these global skills, passions, and dispositions into a way of acting and thinking is characteristic of a rational critical thinker. In line with this view, Ennis (2018: 181) offers a concise and widely used definition of critical thinking: CT is "reasonable reflective thinking focused on deciding what to believe or do".

The Committee on Pre-College Philosophy of the American Philosophical Association (APA) asked Peter Facione, who became the principal investigator of the project, to make a systematic inquiry into the current state of CT and CT assessment (Facione 1990). A cross-disciplinary international panel of 46 experts (from here onwards the panel will be referred to as the *team of experts*) was convened to work toward a consensus on the role of critical thinking (CT) in educational assessment and instruction. They participated in a two-year Delphi method research project. The multi-round project yielded a conceptualisation of CT in 1990, titled "Critical Thinking: A Statement of Expert Consensus for Purposes of Educational Assessment and Instruction". The team of experts reached consensus on six CT core skills and their associated subskills that strong critical thinkers habitually seem to exhibit. The skills are (the related sub-skills are shown in brackets): Interpretation

(Categorization; Decoding Significance; and Clarifying Meaning), Analysis (Examining Ideas; Identifying Arguments; and Analysing Arguments), Evaluation (Assessing Claims and Assessing Arguments), Inference (Querying Evidence; Conjecturing Alternatives; and Drawing Conclusions), Explanation (Stating Results; Justifying Procedures; and Presenting Arguments), and Self-Regulation (Self-examination and Self-examination) (Facione 1990).

Some philosophers stress that thinking is much more than just technique or skill, critical thinking is a specific mental set that calls for distinct, habitual ways of behaving (Beyer 1990). The team of experts regards CT as a pervasive and self-rectifying human phenomenon and describe the ideal critical thinker as one who is

> habitually inquisitive, well-informed, trustful of reason, open-minded, flexible, fair-minded in evaluation, honest in facing personal biases, prudent in making judgments, willing to reconsider, clear about issues, orderly in complex matters, diligent in seeking relevant information, reasonable in the selection of criteria, focused in inquiry, and persistent in seeking results which are as precise as the subject and the circumstances of inquiry permit (APA 1990: 3).

Critical thinking involves both skills/ability and dispositions (Siegel 1999; Facione 2015) and thus both skills/ability and dispositions should be incorporated in instruction and assessment (Ennis 1996).

## Disposition toward critical thinking

A disposition is an inclination to do something under certain circumstances (Ennis 1996). Thinking dispositions are genuine tendencies or inclinations that people have to think in particular ways in particular contexts (Siegel 1999). Perkins et al. (1993) propose a Theory of Good Thinking based on the concept of dispositions. They suggest that a disposition has three components, namely, *inclinations*, which refers to aspects such as motivation, habit, and policy; *sensitivity* to occasion; and *abilities*. They contend that this concept, called triadic dispositions, is jointly adequate and individually necessary to be able to provide an overall characterisation of good thinking (Perkins et al. 1993). However, Ennis (1996) has challenged this notion by asserting that while inclination is a necessary component of a disposition, sensitivity and ability—although important—do not seem to be essential components of every disposition.

Facione (2000) describes the disposition toward CT as a *consistent internal motivation* to engage problems and use CT skills during decision making, when choosing what to believe and what to do. Dewey (1910: 74) asserts that the essence of CT is "suspended judgment; and the essence of this suspense is inquiry to determine the nature of the problem before proceeding to attempts at it solution". Although CT can be defined as a form of cognition (judgment), to cultivate a positive disposition toward CT in students requires an appreciation of the characteristic profile you are trying to foster (Facione 2000). The experts refer to this characteristic profile as a *critical spirit* (APA 1990). The term *critical spirit* is used in a positive manner, referring to the kind of person who would be apt to use their CT skills (see the ideal critical thinker in the previous section) (Facione 2015). To learn CT and to nurture the critical spirit is, according to Facione (2015), not just a means to this end, it is part of the goal itself.

The team of experts identified 19 dispositions that are characteristic of strong critical thinkers: 12 relate to approaches to life and living, and seven are associated with attitudes toward specific issues, questions, or problems (APA 1990). These 19 dispositions were reduced to

seven through statistical factor analyses in the initial development of the California Critical Thinking Disposition Inventory (CCTDI). The seven dispositions that emerged are: Inquisitiveness, Open-mindedness, Systematicity, Truth-seeking, Analyticity, CT Self-confidence and Maturity of Judgement (Facione 2000: 74). Facione et al. (1995: 1) refer to these virtues as "habits of mind", and note that the habits of mind can be used to provide an indication of a person's overall disposition to think critically.

As an alternative, Ennis (1996: 170–171) proposes three basic broad dispositions, namely, to "get it right" to the extent possible; to be clear and honest about the position you represent; and to care about peoples' dignity and worth. Each broad disposition has several sub-dispositions that describes the overall disposition of an ideal critical thinker. Ennis (1996) points out that although the disposition to care about people's dignity and worth is not required of CT, it is necessary in order to be humane.

For this study, it was decided to use Facione (2000) seven habits of mind as a framework to guide the study. The seven habits of mind were empirically derived through rigorous testing using the initial 19 dispositions identified by the team of experts as a basis. Also, Facione (2000) habits of mind framework is widely used and recognised by CT scholars.

## South African technology curriculum

The South African Department of Basic Education (DBE) defines Technology in the school curriculum as:

> The use of knowledge, skills, values and resources to meet people's needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration (Department of Basic Education 2011: 8).

In accordance with this definition, one of the Specific Aims listed in the curriculum stipulates that learners be given the opportunity to develop and apply design skills to solve technological problems (Department of Basic Education 2011).

To realise this Specific Aim, the DBE (2011) prescribes that the Design Process (Investigate, Design, Make, Evaluate, and Communicate) be used when engaging Practical Assessment Tasks (projects). One Practical Assessment Task must be done in each term and each Practical Assessment Task should focus primarily on one of four content areas, namely processing, structures, mechanical systems and control, and electrical systems and control. At the beginning of the Practical Assessment Task, learners are given a problem, need or opportunity as a starting point. They then have to use the Design Process—or in some Practical Assessment Tasks only certain phases of the design process—to develop solutions to the problems, rectify design issues and satisfy needs (Department of Basic Education 2011). The potential for teachers to develop CT—by fostering both CT skills and a positive disposition toward CT—is thus evident in the South African Technology curriculum. The question of whether they are inclined to utilise these opportunities, will be addressed in the remainder of the article.

## Research design and methodology

Quantitative research was used to provide insight into the participating technology teachers' disposition toward critical thinking. A survey design was deemed suitable to access these teachers' habits of mind on a wide front.

## Sampling

It was decided to focus on secondary schools, as the level of problem solving required from learners in these schools is higher compared to those in primary schools. This implies that technology teachers in secondary schools are more likely required to engage CT skills when they assist learners in class with finding solutions to problems. Since technology is offered only up to Grade 9 level in South African schools, Grades 8 and 9 technology teachers were targeted; they were invited via an email to participate in the study. The invitation was sent twice to 14 government technology facilitators, 730 government school principals and 97 private school principals. They were asked to forward the invitation to the technology teachers. The invitation contained a hypertext (hyperlinked to Google Docs if clicked) that directed the teachers to an online survey (i.e. Web-based survey), which they had to complete.

Due to a low response rate, the invitation was extended to other messaging platforms, i.e. WhatsApp, and postings on teacher Facebook pages. Finally, 44 South African technology teachers participated in the study. Possible reasons for the low response rate will be discussed in the limitations of the study section.

The biographical profile of the sample shows that 24 males and 13 females participated in this study. Seven participants did not disclose their gender. In terms of the number of years of teaching experience: 21 indicated that they have been teaching less than 10 years; 9 participants have been teaching between 11 and 20 years; and 8 indicated more than 20 years of teaching experience. Six participants did not answer this question. The participants' indicated the following qualifications as their highest qualifications in education: Postgraduate Certificate in Education (n = 4); Higher Diploma in Education (n = 10); Bachelor of Education degree (n = 7); Bachelor of Education with Honours degree (n = 7); and Masters in Education degree (n = 3). 13 participants did not answer this question.

## Ethical considerations

Before commencing with the research, ethical clearance was requested from and granted by the Ethical Committee of the institution to which the researchers are affiliated. Standard ethical protocols—such as respect for anonymity, privacy and confidentiality of the participants—were adhered to. The invitation email (see previous section) outlined the purpose of the study and explained the ethical principles that will apply. The teachers who wanted to participate (i.e. voluntary participation) could click on a hypertext that was included in the email. This hyperlink opened a landing page in Google Docs which provided a more thorough description of the project. The landing page also explained that if the teachers press the Start button, located at the bottom of the description, it means that they consent to participate in the research. It was also pointed out that they are free to withdraw from the survey at any point without any negative consequences.

## Instrument

The online survey, which was developed and administered through Google forms, consisted of a Likert-type scale instrument. The instrument comprised 42 statements with which the participants had to rate their level of agreement on a six-point scale. The scale options were Strongly Agree; Agree; Slightly Agree; Slightly Disagree; Disagree; and Strongly Disagree. The Likert scale did not include any neutral items.

The statements were derived from the seven habits of mind as identified by Facione (2000) and a number of the statements used in the instrument were sourced from Facione et al. (1995). Six statements were formulated for each of the habits of mind (see Table 1). Based on Ary et al.'s (2010) reccomendations on Likert scales constructing, half of the statements were formulated to express a clearly favourable disposition to CT, while the other half were framed to be clearly unfavourable. The positions of the statements were randomised in the instrument. Table 1 shows a list of the statements that were used in the instrument: the statements are grouped according to the habit of mind that they represent and are separated into favourably and unfavourably framed statements.

SPSS was used to calculate the value of the Cronbach's Alpha to determine the reliability of the instrument. A Cronbach's Alpha of 0.728 indicates that the survey has an acceptable internal consistency. Field (2009) views an alpha value above 0.7 as an acceptable, reliable value. SPSS identified six specific statements that can be removed to increase the Cronbach's Alpha to 0.8, which according to Field (2009) indicates good internal consistency. The six statements are I6, S5, T4, T5, S-c6, and M3. It is recommended that, in future use, these six statements be edited and reviewed in order to improve the reliability of this instrument. However, given the nature of this study, it was decided to persevere with the identified statements and utilise the data it collected. The validity was enhanced by deriving the survey statements directly from the conceptual framework: the seven habits of mind in the conceptual framework were empirically derived through rigorous testing using the initial 19 dispositions identified by the team of experts as a basis. In addition, each habit of mind (construct) was measured with six statements: half were in favour of a habit of mind, while the other half of the statements were unfavourable statements.

## Data collection

The technology teachers who were willing (i.e. voluntary participation) to participate in the study were asked to click on a clearly marked link in the invitation email that was sent to them. The link directed them to the online survey in which they were required to rate their level of agreement on a six-point scale to each of the 42 statements. At the end of the survey, the participants had to select the 'Submit' option in order to electronically submit their responses. Once the completed survey was submitted, the responses were automatically saved in a database. The data were then exported to Excell and SPSS, which were used to do the calculations and to draw the graphs.

## Data analysis

The frequency of responses to each scale for each statement was counted and converted to a percentage in order to determine the distribution of responses on each scale for each statement. Cumulative percentages were calculated to determine the percentage of "Agree"-related statements versus the percentage of "Disagree"-related statements. The method used by Jonsson and Lindén (2009) for the calculation of balances was used to determine the aggregate balances for the statements. Balances are the difference between the positive and negative answering options (Jonsson and Lindén 2009). The formula that was used to calculate the balances was based on the principle of weighted averages, as suggested by Jonsson and Lindén (2009):

**Table 1** List of statements used in the instrument [certain statements were sourced from Facione et al. (1995)]

| Habit | Framing | Item no. | Statements |
|---|---|---|---|
| Inquisitiveness | Favourable statements | I1 | I read articles, blogs, website entries and content on social media weekly to find out about new technologies and to learn something new |
| | | I2 | When someone tells me about a new technological development, I usually read up on it |
| | | I3 | Learn everything you can, you never know when it could come in use |
| | Unfavourable statements | I4 | I do not understand the importance of attending technology training courses after graduation |
| | | I5 | When I buy a new product, I prefer not to read the manual to figure out how it works |
| | | I6 | Too much knowledge is not good for learners |
| Open-mindedness | Favourable statements | O1 | I believe that I can learn a lot from people that disagree with my point of view |
| | | O2 | When marking learners' Practical Assessment Tasks (PATs), I'm concerned that my subconscious biases may influence their marks |
| | | O3 | It is important for me to understand what and how inexperienced learners think about things |
| | Unfavourable statements | O4 | I believe that open-mindedness has its limits, especially in terms of the correct solution to a problem |
| | | O5 | I do not think that learners are developed enough to make good decisions; I must tell them what to do |
| | | O6 | Once I have made my decision, I never change my mind |
| Systematicity | Favourable statements | S1 | I spend a lot of time explaining the problem before allowing learners to attempt an answer |
| | | S2 | When typing a message, I am conscientious about what I want to say before sending the message |
| | | S3 | My files and desk are most often organised |
| | Unfavourable statements | S4 | I am impulsive when solving a problem; I don't waste time on planning |
| | | S5 | I'm used to making quick decisions, even in critical situations |
| | | S6 | I feel confused most of the time |
| Truth-seeking | Favourable statements | T1 | Teachers should always consider evidence and reason before selecting a solution |
| | | T2 | I am honest and objective enough to search for marks for learners' designs that I don't particularly like |
| | | T3 | I am courageous enough to reconsider my most cherished beliefs |
| | Unfavourable statements | T4 | Everyone always reasons from their own self-interest, including me |
| | | T5 | Learners should not spend time focusing on drawing multiple solutions if they already know how to solve the problem |
| | | T6 | Learners should not argue with me because I am always right |

**Table 1** (continued)

| Habit | Framing | Item no. | Statements |
|---|---|---|---|
| Analyticity | Favourable statements | A1 | I can usually correctly predict what will go wrong in potentially problematic situations |
| | | A2 | When I am involved in a disagreement scenario, I challenge group members to give reasons for their arguments |
| | | A3 | It is important for me to predict the consequences of my actions |
| | Unfavourable statements | A4 | It is impossible to know if one solution is better than another |
| | | A5 | When asking for permission from my HoD or Principal, it catches me off-guard if they ask me to provide evidence to support my request |
| | | A6 | I do not have to defend my opinions to learners |
| CT Self-confidence | Favourable statements | S-c1 | I habitually reflect on my thinking during the problem-solving process |
| | | S-c2 | I take pride in my ability to understand the ideas behind learners' concept drawings |
| | | S-c3 | I am good at convincing others when making decisions by providing reasons |
| | Unfavourable statements | S-c4 | I don't trust my own reasoning |
| | | S-c5 | 90% of the questions I set deal with what learners remember, not what they think |
| | | S-c6 | I will rather submit to other people's ideas than try to convince them of my idea |
| Mature Judgment | Favourable statements | M1 | Uncertainty doesn't stop me from progressing with a difficult task |
| | | M2 | When learners select their final solution, out of multiple sketches, I want to see the reflection of their judgment |
| | | M3 | Things are more complex than they appear to be |
| | Unfavourable statements | M4 | The best way to solve problems is to ask someone who knows the solution |
| | | M5 | When learners draw solutions to a technological problem, I do not encourage them to reflect on all possible solutions; they should go with their first idea |
| | | M6 | I often regret the purchases that I make |

$$\text{Balance of each statement} = \left(\text{SA} + \left(\frac{2}{3}\text{A}\right) + \left(\frac{1}{3}\text{SLA}\right)\right) - \left(\text{SD} + \left(\frac{2}{3}\text{D}\right) + \left(\frac{1}{3}\text{SLD}\right)\right)$$

Here, SA = Strongly Agree; A = Agree; SLA = Slightly Agree; SD = Strongly Disagree; D = Disagree; and SLD = Slightly Disagree. The frequency percentages were used in the calculation. Using this formula resulted in balances that ranged from −100% if all of the participants selected the Strongly Disagree scale, to +100% if all of the participants selected the Strongly Agree scale. This made it possible to determine the direction, positive or negative, as well as the strength of each *statement*. In this article, the first three statements of each habit of mind were formulated favourably, which meant that the positive balances for these statements would indicate a positive disposition toward this habit of mind, while negative balances would signal a negative disposition. Also, the last three statements of each habit of mind were framed unfavourably, which, due to the negative symbol in the formula, meant that a negative balance for these unfavourable statements would indicate a positive disposition toward this habit of mind, and vice versa. Thus, a participant who was positively inclined to the habits of mind would score positive balances for the favourably formulated statements and negative balances for the unfavourably framed statements.

In order to determine the direction and strength of each *habit of mind*, the average of the balances of the six statements was calculated for each habit of mind.

$$\text{Average balance of each habit of mind} = \frac{(\text{S1} + \text{S2} + \text{S3}) - (\text{S4} + \text{S5} + \text{S6})}{6}$$

Here, S represents the balance percentage, and the associated number indicates the statement number. The purpose of the negative sign in the formula is to reverse the negative balance signs of the unfavourable statements.

Finally, to determine the direction and strength of the participants' *disposition toward CT* (the results shown in Fig. 1), the average of the habits of mind aggregate balances was calculated. This was done by adding the average of balances and then dividing the answer by seven (the number of habits of mind).

## Results

In this section, the presentation of the data will be structured according to the seven habits of mind respectively. A brief description of each habit of mind will be provided first, followed by a table that will summarise the frequency distribution for each statement. The table will also show the balances, which indicate the direction and strength of the participants' responses to each statement. The content of the table will then be discussed.

### Inquisitiveness

Inquisitiveness is an inclination to be intellectually curious and to have a hunger for new knowledge (learning), even if at that moment it is not clear how the knowledge is relevant (Facione et al. 1995). Intellectual curiosity is marked by an enthusiasm to investigate problems; a tendency to wonder; and a posing of probing questions (Perkins et al. 1993). Watson (2015: 279) describes an inquisitive person as being "characteristically motivated to engage sincerely in good questioning." The antithesis of inquisitiveness is to be indifferent (e.g. toward new knowledge and findings) (Facione 2000).

The participants' responses to the six inquisitiveness statements are summarised in Table 2.

Table 2 shows that the balances of the three favourable statements are positive and that the balances of the three unfavourable statements are negative, indicating that the participants leaned towards inquisitiveness through all six statements. Statement I3 ranked the strongest toward inquisitiveness with a balance of 62.7% (in total, 86.4% of the participants agreed with this statement), indicating that most of the participants were eager to acquire new knowledge. Statement I4 ranked second strongest toward inquisitiveness with a balance of −59.1%—in total, 81.8% of the participants disagreed with this unfavourably framed statement—suggesting that the majority of the participants understood the value of attending technology training courses after graduation. Although Statement 1 had the lowest balance (31.8%), most of the participants agreed (65.9%) with this favourably framed statement—adding to the positive tendency of this habit of mind. The average balance for this habit of mind (46%) indicated that the participants had a positive disposition toward inquisitiveness, suggesting that this sample was intellectually curious and had a desire to know new things.

### Open-mindedness

Open-mindedness is the habit of always being tolerant of diverging opinions, ideas and views, and to have a sensitivity to one's own prejudice (Facione et al. 1995). Halpern (2014: 21) refers to an "attitude of flexibility," which manifests itself through a willingness to consider alternatives, attempt new things, and review existing problems. She describes an open-minded person as someone who is prepared to hold back judgment, collect additional information, and attempt to make difficult and complicated issues clear (Halpern 2014). The opposite of open-mindedness is intolerance (e.g. of opposing ideas) (Facione 2000).

Table 3 summarises the participants' responses to these six statements.

The responses of the participants leaned towards open-mindedness through all six statements (Table 3). The balances of the three favourable statements were positive and the balances of the three unfavourable statements were negative. Statement O1 ranked the strongest toward open-mindedness with a balance of 76.2% (in total, 97.7% of the participants agreed with this statement), indicating that most of the participants agreed that they could learn from people who hold a different point of view. The average balance for this habit of mind (37.8%) indicates that the participants had a positive disposition toward open-mindedness.

### Systematicity

Systematicity, according to Facione et al. (1995), involves organisation, orderliness, focus, and diligence in inquiry. This habit of mind seems to be similar to a disposition that Perkins et al. (1993) call intellectual carefulness, which refers to a desire for mental orderliness and organisation, and an eagerness to be meticulous. The antonym of systematicity is haphazardness (e.g. in terms of procedures) (Facione 2000), and being disorganised.

The participants' responses to the six statements are summarised in Table 4.

Table 4 displays a positive pull towards systematicity through five (S1, S2, S3, S4, and S6) of the six statements, indicating that the participants were inclined to be orderly and

**Table 2** Frequency distribution and balances for inquisitiveness (n = 44)

| | | Strongly disagree | Disagree | Slightly disagree | Slightly agree | Strongly agree | Strongly agree | Balances |
|---|---|---|---|---|---|---|---|---|
| *Favourable statements* | | | | | | | | |
| I1 | Frequency | 4 | 3 | 8 | 5 | 9 | 15 | 31.8% |
| | Percent | 9.1% | 6.8% | 18.2% | 11.4% | 20.5% | 34.1% | |
| | Cumulative % | 34.1% | | | 65.9% | | | |
| I2 | Frequency | 4 | 1 | 6 | 4 | 12 | 17 | 44.5% |
| | Percent | 9.1% | 2.3% | 13.6% | 9.1% | 27.3% | 38.6% | |
| | Cumulative % | 25.0% | | | 75.0% | | | |
| I3 | Frequency | 3 | 0 | 3 | 5 | 9 | 24 | 62.7% |
| | Percent | 6.8% | 0.0% | 6.8% | 11.4% | 20.5% | 54.5% | |
| | Cumulative % | 13.6% | | | 86.4% | | | |
| *Unfavourable statements* | | | | | | | | |
| I4 | Frequency | 27 | 6 | 3 | 2 | 2 | 4 | −59.1% |
| | Percent | 61.4% | 13.6% | 6.8% | 4.5% | 4.5% | 9.1% | |
| | Cumulative % | 81.8% | | | 18.2% | | | |
| I5 | Frequency | 17 | 8 | 5 | 4 | 6 | 4 | −33.3% |
| | Percent | 38.6% | 18.2% | 11.4% | 9.1% | 13.6% | 9.1% | |
| | Cumulative % | 68.2% | | | 31.8% | | | |
| I6 | Frequency | 22 | 6 | 4 | 5 | 3 | 4 | −44.6% |
| | Percent | 50.0% | 13.6% | 9.1% | 11.4% | 6.8% | 9.1% | |
| | Cumulative % | 72.7% | | | 27.3% | | | |
| Average balance for inquisitiveness | | | | | | | | 46% |

**Table 3** Frequency distribution and balances for open-mindedness (n = 44)

| | | Strongly disagree | Disagree | Slightly disagree | Slightly agree | Strongly agree | Strongly agree | Balances |
|---|---|---|---|---|---|---|---|---|
| *Favourable statements* | | | | | | | | |
| O1 | Frequency | 0 | 0 | 1 | 8 | 11 | 24 | 76.2% |
| | Percent | 0.0% | 0.0% | 2.3% | 18.2% | 25.0% | 54.5% | |
| | Cumulative % | 2.3% | | | 97.7% | | | |
| O2 | Frequency | 6 | 8 | 2 | 11 | 3 | 14 | 17.4% |
| | Percent | 13.6% | 18.2% | 4.5% | 25.0% | 6.8% | 31.8% | |
| | Cumulative % | 36.4% | | | 63.6% | | | |
| O3 | Frequency | 2 | 1 | 2 | 7 | 14 | 18 | 59.6% |
| | Percent | 4.5% | 2.3% | 4.5% | 15.9% | 31.8% | 40.9% | |
| | Cumulative % | 11.4% | | | 88.6% | | | |
| *Unfavourable statements* | | | | | | | | |
| O4 | Frequency | 15 | 5 | 5 | 6 | 5 | 8 | − 15.2% |
| | Percent | 34.1% | 11.4% | 11.4% | 13.6% | 11.4% | 18.2% | |
| | Cumulative % | 56.8% | | | 43.2% | | | |
| O5 | Frequency | 12 | 10 | 7 | 8 | 3 | 4 | − 27.9% |
| | Percent | 27.3% | 22.7% | 15.9% | 18.2% | 6.8% | 9.1% | |
| | Cumulative % | 65.9% | | | 34.1% | | | |
| O6 | Frequency | 13 | 6 | 10 | 10 | 4 | 1 | − 30.3% |
| | Percent | 29.6% | 13.6% | 22.7% | 22.7% | 9.1% | 2.3% | |
| | Cumulative % | 65.9% | | | 34.1% | | | |
| Average balance for open-mindedness | | | | | | | | 37.8% |

systematic. Only Statement S5, formulated to express an unfavourable disposition, showed a positive balance of 22.6% (Table 3) which demonstrates a pull against systematicity. This meant that most of the participants agreed (63.6%) that they made hasty decisions. Statement S2 recorded the highest balance score in the survey. The average balance for this habit of mind (42.1%) indicates that the participants had a positive disposition toward systematicity.

### Truth-seeking

Truth-seeking is the habit of pursuing the truth in an honest and objective manner (Facione et al. 1995). Truth-seekers strive to be well-informed and they do not shy away from asking demanding questions; they give serious consideration to facts and reason, even if these are at odds with their own beliefs (Facione et al. 1995). The antithesis of truth-seeking is intellectual dishonesty (e.g. in the use of information) (Facione 2000).

The participants' responses to the six statements are summarised in Table 5.

The balances of four of the six statements shows an inclination towards truth-seeking (Table 5): the three favourably framed statements and Statement T6. Statement T2 ranked the strongest towards truth-seeking with a balance of 74.1% (in total, 90.9% agreed with this statement), suggesting that most of the participants were sensitive to their own bias when grading learners' work. Statement T2 also scored the third strongest balance in the survey, indicating a strong sense of honesty and objectivity among the participants. Statement T6 ranked the second strongest toward truth-seeking with a balance of −73.4%—most of the participants (90.9%) disagreed with this unfavourably framed statement, revealing that the participants allowed learners to argue with them. This demonstrated that the participants had the humility and honesty to consider that their thinking and perhaps their teaching may be flawed. A person who is disposed to thinking critically is prepared to engage with challenging questions and to consider evidence as truth even if it challenges their most cherished beliefs. This is one of the defining characteristics of truth-seeking. The average balance for this habit of mind (37.9%) indicates that the participants had a positive disposition toward truth-seeking.

### Analyticity

Analyticity is the tendency to use reasoning and evidence in the solving of problems; it is the inclination to foresee the potential consequences of choices, actions and ideas; and to be constantly alert to what happens next and, if needed, to intervene (Facione et al. 1995). Perkins et al. (1993) refer to a "planful and strategic" disposition, which involves the habit of planning and approaching things in a calculated and step-wise manner; and the ability to predict possible outcomes. The opposite of analyticity is to be inattentive (e.g. to the implications of imminent problems) (Facione 2000).

Table 6 summarises the participants' responses to these six statements.

The participants' responses leaned towards analyticity through all six statements (Table 6): the balances of the three favourable statements were positive and the balances of the three unfavourable statements were negative. Statement A2 ranked the strongest towards analyticity with a balance of 74% (in total, 95.5% agreed with this statement), suggesting that most of the participants preferred people to provide reasons for their arguments. Statement A2 also recorded the fourth highest balance score in the survey. The

**Table 4** Frequency distribution and balances for systematicity (n = 44)

| | | Strongly disagree | Disagree | Slightly disagree | Slightly agree | Strongly agree | Strongly agree | Balances |
|---|---|---|---|---|---|---|---|---|
| *Favourable statements* | | | | | | | | |
| S1 | Frequency | 1 | 3 | 5 | 12 | 12 | 11 | 41.5% |
| | Percent | 2.3% | 6.6% | 11.4% | 27.3% | 27.3% | 25.0% | |
| | Cumulative % | 20.5% | | | 79.5% | | | |
| S2 | Frequency | 0 | 1 | 2 | 4 | 8 | 29 | 77.9% |
| | Percent | 0.0% | 2.3% | 4.5% | 9.1% | 18.2% | 65.9% | |
| | Cumulative % | 6.8% | | | 93.2% | | | |
| S3 | Frequency | 4 | 6 | 5 | 6 | 11 | 12 | 26.5% |
| | Percent | 9.1% | 13.6% | 11.4% | 13.6% | 25.0% | 27.3% | |
| | Cumulative % | 34.1% | | | 65.9% | | | |
| *Unfavourable statements* | | | | | | | | |
| S4 | Frequency | 20 | 12 | 5 | 1 | 1 | 5 | −53.6% |
| | Percent | 45.5% | 27.3% | 11.4% | 2.3% | 2.3% | 11.4% | |
| | Cumulative % | 84.1% | | | 15.9% | | | |
| S5 | Frequency | 3 | 5 | 8 | 6 | 15 | 7 | 22.6% |
| | Percent | 6.8% | 11.4% | 18.2% | 13.6% | 34.1% | 15.9% | |
| | Cumulative % | 36.4% | | | 63.6% | | | |
| S6 | Frequency | 29 | 8 | 3 | 3 | 0 | 1 | −75.6% |
| | Percent | 65.9% | 18.2% | 6.8% | 6.8% | 0.0% | 2.3% | |
| | Cumulative % | 90.9% | | | 9.1% | | | |
| Average balance for systematicity | | | | | | | | 42.1% |

**Table 5** Frequency distribution and balances for truth-seeking (n = 44)

| | | Strongly disagree | Disagree | Slightly disagree | Slightly agree | Strongly agree | Strongly agree | Balances |
|---|---|---|---|---|---|---|---|---|
| *Favourable statements* | | | | | | | | |
| T1 | Frequency | 1 | 1 | 2 | 7 | 16 | 17 | 62.6% |
| | Percent | 2.3% | 2.3% | 4.5% | 15.9% | 36.4% | 38.6% | |
| | Cumulative % | 9.1% | | | 90.9% | | | |
| T2 | Frequency | 2 | 0 | 2 | 2 | 10 | 28 | 74.1% |
| | Percent | 4.5% | 0.0% | 4.5% | 4.5% | 22.7% | 63.6% | |
| | Cumulative % | 9.1% | | | 90.9% | | | |
| T3 | Frequency | 3 | 3 | 4 | 6 | 13 | 15 | 43.8% |
| | Percent | 6.8% | 6.8% | 9.1% | 13.6% | 29.5% | 34.1% | |
| | Cumulative % | 22.7% | | | 77.3% | | | |
| *Unfavourable statements* | | | | | | | | |
| T4 | Frequency | 6 | 3 | 9 | 11 | 5 | 10 | 13.6% |
| | Percent | 13.6% | 6.8% | 20.5% | 25.0% | 11.4% | 22.7% | |
| | Cumulative % | 40.9% | | | 59.1% | | | |
| T5 | Frequency | 5 | 5 | 10 | 8 | 4 | 12 | 12.9% |
| | Percent | 11.4% | 11.4% | 22.7% | 18.2% | 9.1% | 27.3% | |
| | Cumulative % | 45.5% | | | 54.5% | | | |
| T6 | Frequency | 29 | 7 | 4 | 1 | 2 | 1 | −73.4% |
| | Percent | 65.9% | 15.9% | 9.1% | 2.3% | 4.5% | 2.3% | |
| | Cumulative % | 90.9% | | | 9.1% | | | |
| Average balance for truth-seeking | | | | | | | | 37.9% |

average balance for this habit of mind (38.6%) indicates that the participants had a positive disposition toward analyticity.

### CT self-confidence

CT self-confidence is an inclination to trust one's own reasoning processes: to believe in the robustness of one's own rational thoughts and judgment, and to have confidence in one's ability to engage reflective thinking in order to solve problems and make decisions (Facione et al. 1995). The antithesis of CT self-confidence is mistrust of reason (e.g. an aversion to use sensible reason when solving problems) (Facione 2000).

The participants' responses to the six statements are summarised in Table 7.

Table 7 shows that the balances of the three favourable statements were positive and that the balances of the three unfavourable statements were negative, indicating that the participants leaned towards CT self-confidence through all six statements. Statement S-c4, an unfavourably framed statement, ranked the strongest towards CT self-confidence with a balance of −69.6%, indicating that the participants were confident in their own reasoning. Statement S-c2 ranked the second strongest with a balance of 68%, suggesting that the participants valued their ability to understand learners' ideas and designs. The average balance for this habit of mind (46.5%) indicates that the participants had a positive disposition toward CT self-confidence.

### Mature judgment

Mature judgment is the habit of making sensible decisions. Facione et al. (1995) point out that a person with maturity of judgement will approach decision-making with an awareness that there are problems that are ill-structured, and that there are situations for which there are multiple options. Such problems and situations require complex judgments based on standards, contexts and evidence for which there is no certainty. The opposite of mature judgment is being simplistic (e.g. naively dualistic) (Facione 2000) and cognitive immaturity.

The participants' responses to the six statements are summarised in Table 8.

Table 8 displays a positive pull towards mature judgment through five of the six statements, indicating that the participants were inclined to be judicious in their decision making. Statement M3, a favourably framed statement, is against mature judgment with a balance of −2.2%. The balance of this statement (M3) is close to the midpoint (0%), which lies between −100% and = +100%. This means that there was a nearly balanced spread of responses between the level of Agree and Disagree scale options. A possible reason may be that the participants, as a collective, had different opinions about the statement or were unsure of how to interpret the statement. The average balance for this habit of mind (36.7%) indicates that the participants had a positive disposition toward mature judgment.

**Table 6** Frequency distribution and balances for analyticity (n = 44)

| | | Strongly disagree | Disagree | Slightly disagree | Slightly agree | Strongly agree | Strongly agree | Balances |
|---|---|---|---|---|---|---|---|---|
| *Favourable statements* | | | | | | | | |
| A1 | Frequency | 2 | 2 | 4 | 9 | 16 | 11 | 45.3% |
| | Percent | 4.5% | 4.5% | 9.1% | 20.5% | 36.4% | 25.0% | |
| | Cumulative % | 18.2% | | | 81.8% | | | |
| A2 | Frequency | 1 | 1 | 0 | 4 | 15 | 23 | 74.0% |
| | Percent | 2.3% | 2.3% | 0.0% | 9.1% | 34.1% | 52.3% | |
| | Cumulative % | 4.5% | | | 95.5% | | | |
| A3 | Frequency | 4 | 1 | 4 | 8 | 15 | 12 | 42.2% |
| | Percent | 9.1% | 2.3% | 9.1% | 18.2% | 34.1% | 27.3% | |
| | Cumulative % | 20.5% | | | 79.5% | | | |
| *Unfavourable statements* | | | | | | | | |
| A4 | Frequency | 12 | 12 | 5 | 5 | 4 | 6 | −25.7% |
| | Percent | 27.3% | 27.3% | 11.4% | 11.4% | 9.1% | 13.6% | |
| | Cumulative % | 65.9% | | | 34.1% | | | |
| A5 | Frequency | 16 | 10 | 6 | 6 | 3 | 3 | −40.1% |
| | Percent | 36.4% | 22.7% | 13.6% | 13.6% | 6.8% | 6.8% | |
| | Cumulative % | 72.7% | | | 27.3% | | | |
| A6 | Frequency | 9 | 7 | 8 | 5 | 7 | 8 | −4.5% |
| | Percent | 20.5% | 15.9% | 18.2% | 11.4% | 15.9% | 18.2% | |
| | Cumulative % | 54.5% | | | 45.5% | | | |
| Average balance for analyticity | | | | | | | | 38.6% |

**Table 7** Frequency distribution and balances for CT self-confidence (n = 44)

| | | Strongly disagree | Disagree | Slightly disagree | Slightly agree | Strongly agree | Strongly agree | Balances |
|---|---|---|---|---|---|---|---|---|
| *Favourable statements* | | | | | | | | |
| S-c1 | Frequency | 2 | 2 | 2 | 8 | 15 | 15 | 53.7% |
| | Percent | 4.5% | 4.5% | 4.5% | 18.2% | 34.1% | 34.1% | |
| | Cumulative % | 13.6% | | | 86.4% | | | |
| S-c2 | Frequency | 1 | 1 | 2 | 6 | 11 | 23 | 68.0% |
| | Percent | 2.3% | 2.3% | 4.5% | 13.6% | 25.0% | 52.3% | |
| | Cumulative % | 9.1% | | | 90.9% | | | |
| S-c3 | Frequency | 4 | 1 | 3 | 12 | 12 | 24 | 41.5% |
| | Percent | 9.1% | 2.3% | 6.8% | 27.3% | 27.3% | 27.3% | |
| | Cumulative % | 18.2% | | | 81.8% | | | |
| *Unfavourable statements* | | | | | | | | |
| S-c4 | Frequency | 28 | 10 | 0 | 2 | 2 | 2 | −69.6% |
| | Percent | 63.6% | 22.7% | 0.0% | 4.5% | 4.5% | 4.5% | |
| | Cumulative % | 86.4% | | | 13.6% | | | |
| S-c5 | Frequency | 11 | 7 | 11 | 8 | 5 | 2 | −25.7% |
| | Percent | 25.0% | 15.9% | 25.0% | 18.2% | 11.4% | 4.5% | |
| | Cumulative % | 65.9% | | | 34.1% | | | |
| S-c6 | Frequency | 7 | 16 | 5 | 8 | 1 | 7 | −20.3% |
| | Percent | 15.9% | 36.4% | 11.4% | 18.2% | 2.3% | 15.9% | |
| | Cumulative % | 63.6% | | | 36.4% | | | |
| Average balance for CT Self-confidence | | | | | | | | 46.5% |

**Table 8** Frequency distribution and balances for mature judgment (n = 44)

| | | Strongly disagree | Disagree | Slightly disagree | Slightly agree | Strongly agree | Strongly agree | Balances |
|---|---|---|---|---|---|---|---|---|
| *Favourable statements* | | | | | | | | |
| M1 | Frequency | 5 | 2 | 4 | 3 | 9 | 21 | 46.1% |
| | Percent | 11.4% | 4.5% | 9.1% | 6.8% | 20.5% | 47.7% | |
| | Cumulative % | 25.0% | | | 75% | | | |
| M2 | Frequency | 2 | 0 | 4 | 9 | 12 | 17 | 55.9% |
| | Percent | 4.5% | 0.0% | 9.1% | 20.5% | 27.3% | 38.6% | |
| | Cumulative % | 13.6% | | | 86.4% | | | |
| M3 | Frequency | 6 | 8 | 9 | 9 | 5 | | −2.2% |
| | Percent | 13.6% | 18.2% | 20.5% | 20.5% | 11.4% | 15.9% | |
| | Cumulative % | 52.3% | | | 47.7% | | | |
| *Unfavourable statements* | | | | | | | | |
| M4 | Frequency | 13 | 9 | 4 | 9 | 0 | 9 | −18.8% |
| | Percent | 29.5% | 20.5% | 9.1% | 20.5% | 0.0% | 20.5% | |
| | Cumulative % | 59.1% | | | 40.9% | | | |
| M5 | Frequency | 30 | 5 | 3 | 1 | 2 | 3 | −67.4% |
| | Percent | 68.2% | 11.4% | 6.8% | 2.3% | 4.5% | 6.8% | |
| | Cumulative % | 86.4% | | | 13.6% | | | |
| M6 | Frequency | 17 | 4 | 8 | 10 | 3 | 2 | −34.1% |
| | Percent | 38.6% | 9.1% | 18.2% | 22.7% | 6.8% | 4.5% | |
| | Cumulative % | 65.9% | | | 34.1% | | | |
| Average balance for mature judgment | | | | | | | | 36.7% |

## Discussion

The average balances of all seven habits of mind leaned towards the positive. Figure 1 visually depicts the average balances of all the habits of mind.

Figure 1 illustrates that CT self-confidence recorded the highest balance (46.5%), followed by inquisitiveness (46%). Mature judgment recorded the lowest balance (36.7%) with open-mindedness indicating the second lowest balance (37.8%). The direction and strength of the participants' *disposition toward CT* were calculated by adding the balances of each habit of mind (Fig. 1) and then dividing it be seven (the number of habits of mind). The answer (40.8%) shows that this sample had a positive disposition toward CT. This means that these teachers were internally motivated to think critically and that they were more likely to habitually engage and foster CT skills and the disposition toward CT in the classroom.

With regard to the biographical profile, it is interesting to note that although more males than females participated in the study, the disposition toward CT aggregate balance scores indicate that the female participants outperformed the male participants. While the direction indicate a positive disposition toward CT for both males and females, the strength differs (46.4% vs. 42.3%), with females recording a higher aggregate balance score. Also, the habits of minds balance scores show that females outperformed males in four of the seven habits of mind: Inquisitiveness (63.1% vs. 41.1%); Mature Judgment (50.3% vs. 36.7%); Systematicity (48.2% vs. 40.9%) and Open-mindedness (46.1% vs. 42.5%). The male participants outperformed the female participants in Truth-seeking (46.6% vs. 29.0%) and marginally in Analyticity (40.6% vs. 40.4%). Males and females recorded the same balance score for CT Self-confidence (47.7%).The reason(s) for this finding is unknown as it was not the intention to investigate the causes of the differences between male and female performances in this study. Further research into this issue is important as this may have pedagogical implications: if the sampled teachers model their habits of mind in their manner of teaching, the female teachers, for example, may be more inclined to foster a spirit of inquisitiveness in the classroom than their male counterparts do. Male teachers, on the other hand, might emphasise truth seeking more than the female teachers do. Once the reasons for these differences are understood, they can be addressed during, for example, pre-service teacher training.

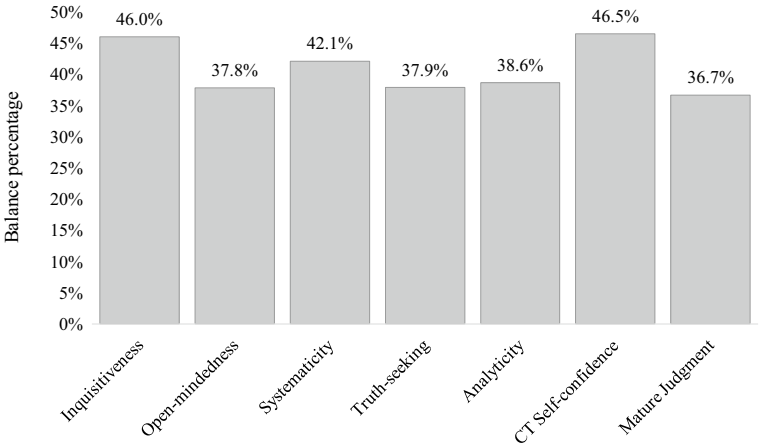



**Fig. 1** Average balances of all the habits of mind

A review of the literature has revealed some studies on dispositions toward CT, but no research was found that focused specifically on technology teachers' habits of mind. It was therefore difficult to determine whether these findings were unique to this sample without an equivalent population or context for comparison. However, a study conducted by Mcbride et al. (2002) who investigated (pre-service) Physical Education students' disposition toward CT, found a positive inclination on six of the seven habits of mind—it was only truth-seeking to which this sample was not positively disposed. In their study, inquisitiveness recorded the highest mean score, followed by analyticity and CT self-confidence (Mcbride et al. 2002). These habits of mind also ranked highest in the current study, although the order was different. In another study, Facione et al. (1995) investigated the disposition toward CT using a sample of college freshmen from a private university. They found that these students showed strengths in open-mindedness and inquisitiveness. The study also revealed a weakness in systematicity and a resistance to truth-seeking, prompting a recommendation that the fostering of a positive disposition toward systematicity and truth-seeking should become goals of their programmes (Facione et al. 1995).

In a curriculum, which aims to develop critical thinking—such as in the South African curriculum—CT skills and the disposition toward CT should be cultivated together. The ill-structured nature of the problems presented in the Technology Practical Assessment Tasks offer many opportunities to achieve this. An example of how CT can be nurtured in South African Technology classrooms was found in the research conducted by Van Niekerk et al. (2010). In their study, which focussed on initial idea generation during the early phases of the prescribed design process, learners had to compare various possible solutions to a problem by evaluating (CT skill) and discussing the advantages and disadvantages of each idea. They found that the learners demonstrated a willingness to expand their existing knowledge with new information (i.e. Inquisitiveness), thus acquiring insights that helped them to motivate their choice of a selected solution (i.e. Truth-seeking, and perhaps, Mature Judgment) (Van Niekerk et al. 2010).

An interesting aspect pointed out by Facione et al. (1995) is that there seems to be a strong and positive relationship between the disposition toward CT and a career. A faculty which, for example, values objectivity and fair-mindedness in learners can adjust their programmes and assessment techniques to place greater emphasis on fact-finding, courageous questioning, and objective analysis (Facione et al. 1995). Dwyer et al. (2017: 47) support this notion and add that a sound understanding of the way in which students and educators conceptualise CT dispositions may "facilitate the building of complementary and integrative models of CT dispositions that reflect the full range of perspectives in University teaching environments." While the current study indicates that the sample was positively disposed toward CT and some trend similarities were found in corresponding studies, further research is needed to establish which dispositions should be emphasised in order to address the dispositional needs in technology education.

## Limitations of the study

One limitation of the study is the small sample size which likely resulted from the data collection staretegy that was used. In spite of the advantages offered by Web-based surveys—such as the potential to target teachers over a wide geographic area; fast data collection; the direct capturing of data in the system means it is imediately available for analysis; and reduced costs—response rates for Web-based surveys are lower than rates obtained

by other methods (Ary et al. 2010). There are many reasons why Web-based surveys have such a low response rate. For example, only those who have access to the Internet and associated technology can participate in such studies. Other possible reasons for the low response rate relevant to this study include:

- The high cost of Internet data in South Africa could have deterred teachers from participating.
- The spam filters may have detected the hypertext/hyperlink in the email and prevented the email from reaching the users inbox.
- Some of the government technology facilitator and principles may not have forward the email to the teachers.
- The teachers may have simply deleted the email without reading it. Teachers are overburdened with administrative duties and often just do not feel like completing such a survey. There is no way of knowing how many teachers ultimately received the email.

Another limitation of a Web-based survey is that some individuals are more likely than others to complete online surveys, leading to a systematic bias (Wright 2005). In this study, it is possible that the teachers who are positively disposed to CT were more inclined to respond to the invitation to participate in the study, contributing to the positive finding.

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## References

American Philosophical Association. (1990). *Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction. Recommendations prepared for the committee on pre-college philosophy*. California State University, Fullerton. ERIC Doc. No. ED 315-423.

Ary, D., Jacobs, L. C., & Sorensen, C. (2010). *Introduction to research in education*. Belmont: Wadsworth.

Beyer, B. (1990). What philosophy offers to the teaching of thinking. *Educational Leadership, 47*(5), 55–60.

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., et al. (2012). Defining twenty-first century skills. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and teaching of 21st century skills*. Dordrecht: Springer.

Department of Basic Education. (2011). *National curriculum statement: Curriculum and assessment policy statement (CAPS)*. Technology Grades 7–9. Pretoria: Government Printing Works.

Dewey, J. (1910). *How we think*. Boston: D.C. Heath & Co.

Dwyer, C. P., Hogan, M. J., Harney, O. M., & Kavanagh, C. (2017). Facilitating a student-educator conceptual model of dispositions towards critical thinking through interactive management. *Educational Technology Research and Development, 65,* 47–73.

Dwyer, C. P., Hogan, M. J., & Stewart, I. (2015). The effects of argument mapping-infused critical thinking instruction on reflective judgement. *Thinking Skills and Creativity, 16,* 11–26.

Ennis, R. (1996). Critical thinking dispositions: Their nature and assessability. *Informal Logic, 18*(2), 165–182.

Ennis, R. (2018). Critical thinking across the curriculum: A vision. *Topoi: An International Review of Philosophy, 37*(1), 165–184.

Facione, P. A. (1990). *The delphi report: Executive summary; critical thinking: A statement of expert consensus for purposes of educational assessment and instruction*. California: California Academic Press.

Facione, P. A. (2000). The disposition toward critical thinking: Its character, measurement, and relationship to critical chinking skill. *Informal Logic, 20*(1), 61–84.

Facione, P. A. (2015). *Critical thinking: What it is and why it counts* (pp. 1–30). Insight Assessment.
Facione, P. A., Sánchez, C. A., Facione, N. C., & Gainen, J. (1995). The disposition toward critical thinking. *The Journal of General Education, 44*(1), 1–25.
Field, A. (2009). *Discovering statistics using SPSS* (3rd ed.). London: Sage Publications Ltd.
Halpern, D. F. (2014). *Thought and knowledge: An introduction to critical thinking* (5th ed.). New York: Psychology Press.
Jonassen, D. H. (1997). Instructional design models for well-structured and iII-structured problem-solving learning outcomes. *Educational Technology Research and Development, 45*(1), 65–94.
Jonsson, A., & Lindén, S. (2009). *The quest for the best consumer confidence indicator. European economy - economic papers* (Vol. 372). Brussels: European Commission Directorate-General for Economic and Financial Affairs.
Mcbride, R. E., Xiang, P., & Wittenburg, D. (2002). Dispositions toward critical thinking: the preservice teacher's perspective. *Teachers and Teaching: Theory and Practice, 8*(1), 29–40.
Paul, R. W. (1995). *Critical thinking: How to prepare students for a rapidly changing world*. Santa Rosa, CA: Foundation for Critical Thinking.
Paul, R. W. (2012). *Critical thinking: What every person needs to survive in a rapidly changing world* (4th ed.). Tomales, CA: Foundation for Critical Thinking.
Perkins, D., Jay, E., & Tishman, S. (1993). Beyond abilities: A dispositional theory of thinking. *Merrill-Palmer Quarterly, 39*(1), 1–21.
Schooner, P., Nordlöf, C., Klasander, C., & Hallström, J. (2017). Design, system, value: The role of problem-solving and critical thinking capabilities in technology education, as perceived by teachers. *Design and Technology Education: An International Journal, 22,* 60–75.
Siegel, H. (1999). What (good) are thinking dispositions? *Educational Theory, 49*(2), 207–221.
Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times*. San Francisco, CA: Jossey-Bass.
Van Niekerk, E., Ankiewicz, P., & De Swart, E. (2010). A process-based assessment framework for technology education: A case study. *International Journal of Technology and Design Education, 20*(2), 191–215.
Watson, L. (2015). What is inquisitiveness. *American Philosophical Quarterly, 52*(3), 273–287.
Wright, K. B. (2005). Researching Internet-based populations: Advantages and disadvantages of online survey research, online questionnaire authoring software packages, and web survey services. *Journal of Computer-Mediated Communication, 10*(3). https://doi.org/10.1111/j.1083-6101.2005.tb00259.x.

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