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IT Teachers' Experience of Teaching–Learning Strategies to Promote Critical Thinking

Roxanne Bailey and Elsa Mentz
North-West University (Potchefstroom Campus), Potchefstroom,
North West Province, South Africa

roxannephd2014@gmail.com; elsa.mentz@nwu.ac.za

Abstract

Information Technology (IT) high school learners are constantly struggling to cope with the challenges of succeeding in the subject. IT teachers, therefore, need to be empowered to utilize appropriate teaching–learning strategies to improve IT learners' success in the subject. By promoting critical thinking skills, IT learners have the opportunity to achieve greater success in the most difficult part of the curriculum, which is programming. Participating IT teachers received once-off face-to-face professional development where some teachers received professional development in critical thinking strategies while other IT teachers received professional development in critical thinking strategies infused into pair programming. To determine how teachers experience these suggested strategies, teachers participated in initial interviews as well as follow-up interviews after they had implemented the suggested strategies. From the interviews, it became evident that teachers felt that their learners benefited from the strategies. Teachers in the pair programming infusing critical thinking strategies focused more on the pair programming implementation than on the totality of pair programming infused with critical thinking. Although teachers were initially willing to change their ways, they were not always willing to implement new teaching–learning strategies.

Keywords: Critical thinking, Information Technology education, Pair programming, Teaching–learning strategies, Programming.

Introduction

In the South African context, Information Technology (IT) is an elective subject that learners in high school can take in Grade 10 to 12. The subject is divided into five core areas of which software development (computer programming) makes up 60% (Department of Basic Education, 2012). Learners taking IT struggle mostly with the software development side of the subject, as computer programming is generally seen as a difficult task (Robins, Rountree, & Rountree,

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2003). In the light of the main challenge being programming, it is important for IT teachers to shift their focus from teaching IT learners the memorization of programming syntax to equipping learners with the necessary skills conducive to successful computer programming. One suggested strategy for promoting computer programming skills is developing critical thinking skills.

Critical thinking skills can be developed by implementing several teaching–learning strategies of which deliberate critical thinking strategies as well as cooperative learning are only a few. The research problem informing this article is the fact that the IT curriculum provides no specific teaching–learning strategies although learners are expected to be developed into critical and creative individuals who can successfully achieve the set objectives of the subject (Department of Basic Education, 2012). In the current study we attempted to empower IT teachers with teaching–learning strategies that they can implement in order to promote critical thinking in their classes. The article reports on IT teachers' experience of the implementation of suggested critical thinking strategies in their classes by implementing a qualitative research design within an interpretivist research paradigm. A phenomenological research methodology was implemented as the researchers' main objective was to understand the IT teachers' experience.

Relevant Literature

Defining Critical Thinking

Critical thinking has its foundations in the work of philosophers like Socrates, Plato and Aristotle. Gutek (2009) notes that Socrates used questioning to facilitate learning in his students. During these sessions, his students were required to question, criticize and redevelop definitions (Gutek, 2009). Although Socrates was the master of Plato and Aristotle, these latter two philosophers also adapted strategies that served as pioneering work for critical thinking. Plato focused his teachings on getting students to distinguish between true and false claims (Leigh, 2007) whereas Aristotle emphasized the ability to identify different viewpoints (Halx & Reybold, 2005). In later years, Dewey (1910) developed his reflective thinking, which served as the first close definition of critical thinking and critical thinking is often used interchangeably with the term reflective thinking. In 1956, Benjamin Bloom and his colleagues formulated a taxonomy to illustrate the cognitive domain (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). This taxonomy closely relates to critical thinking. According to Bloom et al. (1956), this taxonomy is used to set learning objectives for intellectual abilities and skills, which they continue to say is synonymous with critical thinking, reflective thinking or problem solving.

More recently, several different views of critical thinking came to the fore in the body of scholarship (Bloom et al., 1956; Ennis, 1964; Glaser, 1941). The most cited definition of critical thinking and the one used in this study is that of Facione (1990). Facione (1990, p. 3) defines critical thinking as a “purposeful, self-regulatory judgment that results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criterion-logical, or contextual consideration upon which that judgment is based.”

Importance of Critical Thinking

Hyslop-Margison (2003), Halpern (2003) and Tiwari, Lai, So, and Yuen (2006) emphasize the importance of critical thinking skills as it is seen as one of the most important skills to be successful in life. Critical thinking skills contribute to educational goals and are pivotal in today's globalized society as individuals are no longer required to know their place (figuratively speaking) but to determine their own position (Ten Dam & Volman, 2004). Apart from our globalized society, information is easily available, creating a window for untrustworthy information (Lorenzo & Dziuban, 2006). Learners therefore need to be equipped with the skills to evaluate and criticize information and to make judgments regarding such information.

Critical thinking development has been prescribed in several curricula around the world (Australian Curriculum Assessment Authority, 2011; United Kingdom Department of Education, 2013). In South Africa, this is no different, as is evident in the Strategic Plan for 2011 to 2014 where the

Department of Education (2011) states that learners need to be prepared by schools to think critically, as emphasized by Belluigi (2009) and Lombard and Grosser (2008).

In IT, critical thinking skills hold several benefits. Sosu (2013) explains that critical thinking focuses on problem solving where individuals are required to come up with solutions; therefore, critical thinking supports problem identification. Problem solving forms the basis of computer programming, and therefore it is not unexpected that Fagin, Harper, Baird, Hadfield, and Sward (2006) found that critical thinking supports computer programming. McMahon (2009) found that there is a statistical significant correlation between critical thinking skills and computer skills.

Developing Critical Thinking Skills

Development of critical thinking skills does not necessarily occur naturally and should therefore be practiced explicitly (Fisher, 2005). Although critical thinking should be developed explicitly, specific factors should be considered. Myers and Dyer (2004) determined that neither intellect nor gender plays a role in critical thinking development. Regarding whether critical thinking development should occur explicitly or be embedded in the curriculum, Marin and Halpern (2011) found that both approaches equally support the development of critical thinking skills. Apart from the factors to be considered when attempting to develop critical thinking skills, one of the most important factors during the development of critical thinking skills is the role of the facilitator.

The facilitator needs to model critical thinking skills him/herself in order to inspire individuals to develop critical thinking (Snyder & Snyder, 2008; Van Gelder, 2001). Just as important as modeling critical thinking in the classroom, is the need for teachers to teach learners the theory of critical thinking in order to create more awareness of critical thinking. Lau (2011) and Asleitner (2002) both emphasize the importance of discussing critical thinking with learners. In order to develop critical thinking skills, Brookfield (2012) suggests implementing the following strategies as a method of modeling critical thinking in the classroom.

- Speaking in tongues

The central idea of the speaking in tongues strategy is to allow individuals to encounter several different perspectives to describe a certain topic (Brookfield, 2012). This can be achieved by either putting up posters with different perspectives around the classroom or having individuals group together and letting groups represent different perspectives.

- Assumptions inventory

Teachers can compile an assumptions inventory to explain to individuals why specific theories were presented as well as which assumptions informed the material during the lesson. The learners can also have an opportunity to compile their own assumptions inventory, noting which assumptions informed their decisions.

- Devil's advocate

By playing devil's advocate, the teacher has the opportunity to present counterarguments against individuals (Brookfield, 2012). Furthermore, it allows teachers to model critical analysis and elicit its several perspectives.

- Ending a lesson with questions

Teachers are required to allow learners to write down several questions that were posed to them during the lesson. This can be done during the last 10 minutes of the lesson where individuals write down questions and share those they deem important.

Apart from Brookfield's (2012) strategies, the Socratic method is another possible strategy that can be implemented to develop critical thinking skills. The Socratic method is a pedagogical method that investigates the truth through analytical discussion (Schiller, 2008). This analytical discussion can be directed by using specific questions.

Another strategy suggested to develop critical thinking in a classroom is cooperative learning. Cooperative learning promotes discussion, an important concept to develop critical thinking (Boghassian, 2006). In the IT class, pair programming as cooperative learning strategy appears to be a valuable strategy for the acquisition of programming skills (Mentz & Goosen, 2013)

The Study

Study Question

This article reports on South African IT teachers' experience regarding the implementation of intentional critical thinking instruction in their Grade 10 IT classes. The following question guided the research: How do IT teachers experience suggested teaching–learning strategies to promote critical thinking?

Study Design

The current study was underpinned by the qualitative research design, using an interpretivist paradigm with a phenomenological research methodology. This design and methodology were informed by the fact that the main objective of the study was to understand IT teachers' experience. Participating IT teachers were arranged into two groups. One group underwent professional development focused on implementing critical thinking instruction in the IT classroom whereas the other group underwent professional development focused on the infusion of critical thinking instruction into pair programming for implementation in the IT classroom. For data collection, IT teachers participated in two semi-structured one-on-one interviews: one before the implementation of the critical thinking strategies and the other after the implementation. Once interviews had been transcribed verbatim, they were analyzed using qualitative data analysis methods like coding, categorizing the codes, and placing categories into specific themes.

For this study, the credibility of findings was done by, as Creswell (2009) describes, asking a peer debriefer to review the transcripts and to ask questions regarding the study to ensure that they would be relevant to persons other than the researcher. Transferability was established by making use of some of Gibbs' (2007) suggested strategies. The strategies were to check transcripts, carefully defining codes, and cross-checking codes with an objective person.

Sample

IT as a school subject is not presented by many schools in South Africa, making the geographical distance between schools fairly big. For this study, a convenient sample was implemented where IT teachers from three provinces in South Africa were selected. The three provinces were selected based on the distance from the researchers as well as the programming language presented in the province (provinces in South Africa are permitted to select either Delphi or Java as the official programming language to teach in their schools). Although twenty IT teachers from each province were asked to participate, only 24 in total opted to participate in the broader doctoral study within which this study fell. Of the 24 participating teachers, only 21 completed the research. Of the 21 teachers, **seven** teachers were randomly selected for the deliberate critical thinking instruction, **three** were randomly selected for the pair programming infused with critical thinking instruction, **five** were randomly selected for implementing only pair programming, and **six** were in the control group. This article solely describes the two groups that were focused on critical think-

ing instruction (critical thinking instruction group and the instruction group dealing with critical thinking infused into pair programming); thus, seven who were asked to implement deliberate critical thinking instruction in their classes and three who were asked to implement critical thinking infused into pair programming in their classes.

Intervention

This article reports on IT teachers involved in two separate interventions aimed at developing IT learners' critical thinking skills. One intervention was focused on deliberate critical thinking instruction only whereas the other intervention was focused on pair programming infused with critical thinking instruction. IT teachers in both groups were asked to implement the interventions in their Grade 10 IT classes for approximately four to six weeks.

Critical thinking instruction

Teachers in the critical thinking instruction intervention group attended a once-off face-to-face professional development session where one of the researchers visited the teacher and had a discussion regarding the suggested critical thinking instruction. The professional development session lasted approximately one hour after school, due to ethical commitments that prohibited the professional development sessions from taking place during school hours. The suggested strategies for critical thinking instruction were Brookfield's (2012) strategies (speaking in tongues, assumptions inventory, devil's advocate, and questioning) as well as the Socratic method. Along with the professional development session, IT teachers also received a manual explaining each strategy in detail as well as giving teachers examples of how to implement the strategies in their classes. Additional resources for IT learners were included in the professional development pack. These resources included:

- a DVD with an animation of two programmers (one being a critical thinker constantly questioning before, during and after programming; the other being a non-critical thinker who dives headlong into programming without any planning beforehand or questioning during programming or without any evaluation); and
- a key ring with cards illustrating the six categories of the Socratic questions was also given to teachers to hand out to their learners to direct their questioning during the implementation of the Socratic method.

Pair programming infusing critical thinking instruction

Teachers involved with pair programming infused with critical thinking instruction attended a once-off face-to-face professional development session on pair programming as well as the suggested critical thinking instruction (as given to teachers in the critical thinking instruction intervention group). The professional development session lasted approximately one and a half hours after school due to ethical commitments that prohibited the professional development sessions from taking place during school hours. The pair programming professional development was adapted from Mentz and Goosen (2013). Teachers received a manual explaining pair programming as well as the critical thinking instruction in detail. The manual contained examples of how IT teachers could implement pair programming with critical thinking infused. During the pair programming professional development, IT teachers received several resources to be shared with the IT learners:

- a DVD with an introduction to pair programming;
- the same DVD as the critical thinking instruction intervention group with the animation of the two programmers;

- a key ring with four things to remember (Listen, Respect, Don't be intimidated, Communicate); and
- the same key ring as the critical thinking instruction intervention group with the six categories of Socratic questioning was given to the teachers to hand out to their learners.

All ten teachers in the two experimental groups were encouraged to contact the researchers at any time if additional assistance was required.

Study Results

Through the coding of the interviews, several themes emerged: critical thinking: knowledge and misconceptions, importance of critical thinking in the classroom, initial state of critical thinking in the classroom, and teachers' experience of critical thinking in the classroom. The following sections will discuss the themes in greater detail.

Critical Thinking: Knowledge and Misconceptions

During initial interviews it became evident that IT teachers define critical thinking quite differently from each other. Some teachers related critical thinking to problem solving:

... it is how they [learners] discern how to solve a problem... (Teacher 1)

So critical thinking comes up with ways of solving that problem...(Teacher 3)

... methodology one can implement in terms of problem solving, analysis and certain steps one can take when solving a specific problem...(Teacher 10)

One teacher emphasized the importance of equipping IT learners to think out of the box so as to motivate them to do their own research which he felt would develop their critical thinking. Another teacher related critical thinking more appropriately to questioning and posing alternatives:

My understanding of critical thinking is that it's more than just pros and cons. It's being able to look at it from every possible angle, both negative and positive, your intuition, your feeling without having to justify...(Teacher 9)

Critical thinking as defined by Facione (1990) includes much more than mere problem solving. As noted by Teacher 10, analysis plays an important role in critical thinking and, as Teacher 9 rightly pointed out, critical thinking includes weighing several perspectives; however, all ten teachers omitted the importance of justifying the decision made. Although the participating teachers differed in defining critical thinking, they were all in accordance that critical thinking is important in the IT classroom.

Importance of Critical Thinking in the IT Classroom

Critical thinking is considered one of the most important skills needed to attain computer programming skills successfully. In accordance with Fagin et al. (2006), teachers in this study viewed critical thinking as an important aspect of IT. As highlighted by Teacher 1, *IT learners will not be able to complete at least 30% of their exams if they do not possess critical thinking skills*. Teacher 2 noted that he regretted that no one had ever taught him how to think critically and that he was only taught programming syntax, causing a gap between his knowledge and the application of programming skills. Since some teachers connect critical thinking skills with problem solving, a number of the teachers emphasized how learners will not be able to solve problems without critical thinking skills:

... you're always problem solving. You're always thinking logically. If you can't think logically, you can't do IT, that's the bottom line (Teacher 6)

One of the teachers noted that he felt it was his responsibility in the IT class to teach learners the critical thinking skills necessary for success in the subject.

I tell the kids when they come into my class they should know how to read and write but I'm going to teach them how to think (Teacher 9)

Although all ten of the teachers agreed that critical thinking is important, none of them deliberately initially focused their classes on developing their IT learners' critical thinking.

Initial State of Critical Thinking Development in the IT Classroom

Some teachers noted that they speak to their learners about critical thinking methods, but, when referring to what their definition of critical thinking was, it was evident that they did not define critical thinking appropriately and therefore could not speak effectively to their learners about critical thinking. One teacher explained that he taught critical thinking through question analysis as *we do question analysis, whereby we try to determine the scope of the question, the requirements and possible ways to solve the question (Teacher 4)*. This method of developing critical thinking may have an effect on learners' critical thinking but is not deliberate critical thinking development, which Fisher (2005) emphasizes as important when attempting to develop critical thinking skills. Two other teachers confirmed this method of non-intentional critical thinking development when both of them regarded critical thinking development as something that just occurs naturally within their classes.

It just sort of happens in the class (Teacher 5)

I always throw out little questions here and there to get the guys to think. I don't like to just give the answers right away. I like to drop the little seed and let them do the thinking (Teacher 6)

Teachers' Experience of Critical Thinking Instruction

IT teachers in the group who implemented critical thinking instruction only in terms of the suggested strategies (speaking in tongues, assumptions inventory, devil's advocate, questioning, and the Socratic method) generally responded positively to the teaching-learning strategies.

Implementation of critical thinking instruction

Although seven of the teachers committed themselves to implementing the strategies as discussed during the professional development sessions, only a few teachers implemented it deliberately.

Teacher 1 noted that she mostly enjoyed the questioning and Socratic method (questions indicated on the key rings):

That questioning, tell me why you are doing it that way? What would the outcome be if you rather use a while-loop? (Teacher 1)

That critical thinking [Socratic questions on key rings] really helped as any program can be broken down into those steps and as long as you ask yourself those questions and use that key ring... (Teacher 1).

Teacher 6 as well as Teacher 7 preferred the devil's advocate strategy and Teacher 7 added that the speaking in tongues strategy did not work for her.

Teacher 2 implemented all four strategies as asked; however, he felt that the speaking in tongues strategy had the best effect on his IT learners' learning:

I think that speaking in tongues [stood out the most], because if I understand it correctly it's where you give the learner one answer to a problem but then you also give him two other answers so he can decide himself and then look at the consequences of the decision on the program he has written and see for himself. I think they learn much better (Teacher 2).

Three of the seven teachers felt that the strategies created awareness of their teaching–learning strategies, and they did not implement the critical thinking instruction deliberately but rather felt it sufficient to carry on teaching as usual. As Teacher 5 describes, he did not feel the deliberate implementation of the teaching–learning strategies would work but ... *in coaching them [the learners], one tries to bring in the critical thinking without having to explicitly tell them to look at the key ring ...*

Advantages and disadvantages of critical thinking instruction

With the implementation of the critical thinking instruction, the IT teachers noted some advantages and disadvantages as experienced in their classrooms. A number of the teachers commented on the positive feedback they received from the learners regarding the resources that were included in the critical thinking instruction. Teacher 2 specifically commented on the fact that he felt his learners were gaining greater knowledge using the critical thinking strategies as compared to his previous teaching–learning strategies. Teacher 6 noted that he experienced more interaction in his classes: *Maybe with the bit I've done it's still early days, but if I carry on, which I'm going to be doing, because it seems to work and it does make the class more interactive instead of just being one-sided.*

A number of teachers commented on the fact that they did not feel critical thinking instruction was given enough time; however, one of these teachers did not implement the critical thinking instruction regardless of the time. Teachers also commented on the fact that they did not have enough time during classes to get through the set curriculum and to do additional teaching–learning strategies as evident in Teacher 2's comment: *If I could give my honest opinion, it is a bit time-consuming to fit it into the curriculum.* Teacher 5 also noted that the school term during which the strategies were to be implemented was already heavily loaded with additional responsibilities which he had to meet.

Teachers' Experience of Critical Thinking Instruction Infused Into Pair Programming

IT teachers in the group dealing with critical thinking instruction infused into pair programming implemented pair programming (as developed by Mentz, Van der Walt, & Goosen, 2008) using the critical thinking strategies (speaking in tongues, assumptions inventory, devil's advocate, questioning, and the Socratic method). From the interviews with the three teachers involved in this implementation, several themes emerged.

Implementation of critical thinking instruction infused into pair programming

Although teachers received a manual explicitly explaining how pair programming can be implemented in such a way that the critical thinking strategies are infused into it, it did however become evident that teachers still saw these strategies as different entities. As Teacher 8 explained: ... *but the major one that we looked at was the pair programming*. Teacher 9 noted that he also implemented pair programming, but infused questioning. For Teacher 10, who, at the time of the study, had been implementing pair programming without critical thinking strategies for two years, it was tough to change the strategy as his learners were already accustomed to pair programming without specific critical thinking instruction.

Teacher 8 also commented on the fact that the curriculum load and the time given to work through the curriculum forced her to put the implementation of the pair programming infused with critical thinking instruction aside.

Advantages and disadvantages of critical thinking instruction infused into pair programming

Participating teachers pointed out several advantages and disadvantages, which they observed during the implementation of pair programming infused with critical thinking instruction.

The people who get distracted a lot, they were almost held accountable, having someone with them and I swear there's like one student in particular that does nothing, and I teamed him up with the top guy in the class because I know this one that doesn't really do anything is really bright and I'VE NEVER SEEN HIM GO LIKE THAT BEFORE (Teacher 8).

Teacher 10 noted that he found *the greatest advantage is when it comes to exam times or test times, they can easily recall*. This supports the notion of Mentz and Goosen (2013) that pair programming increases the learning process.

As a disadvantage, Teacher 8 mentioned that some learners became frustrated because they were paired up with slower learners as the pair as a whole was consequently not moving as fast as the other pairs in class. The teacher explained to the learners that they would not be paired up with the same individual for every task, and after that she noted that the learners were satisfied that they would not have to work with learners holding them back throughout. Mentz and Goosen (2013) also emphasize the importance of changing partners especially to curb the frustration that may occur.

Teachers' Experience of Professional Development

All ten teachers noted that they appreciated the professional development sessions; however, Teacher 5 noted that the suggested strategies refreshed his memory more than what it exposed him to something new. Teacher 1 expressed her gratitude for being involved in the study and receiving the additional resources. Teacher 6 noted that he enjoyed the professional development:

Something I had never thought about before, I had heard the words going around about critical thinking, ..., but for me, I never really gone into what it was all about until you came along and I thought, "ok, what is it all about, let me actually have a look."

Regarding the fact that teachers received a manual during the professional development, Teacher 7 and Teacher 9 both said that they appreciated the manual and would refer back to it for ideas:

For me as a teacher I've got something that I can refer to and it's a resource for me...(Teacher 9)

Conclusion

In IT classes, the development of critical thinking is a necessity in order to equip learners with the skills to complete the three years of IT at school level successfully. Although critical thinking can be developed regardless of intellect or gender (Myers & Dyer, 2004), it is most efficiently developed when implemented explicitly (Marin & Halpern, 2011). The current study aimed at determining IT teachers' experience of implementing deliberate critical thinking strategies in their Grade 10 IT classes as IT learners are required to become critical and creative thinkers in order to master the subject successfully.

From this study, it was apparent that the strategies proposed to the teachers were not necessarily the deciding factor in terms of whether the strategies would be implemented successfully but rather the teacher's disposition toward the implementation of new teaching–learning strategies. The two groups of IT teachers involved in this study did not all discuss critical thinking with their learners beforehand, which Lau (2011) regards as an important aspect to be considered when attempting to promote learners' critical thinking skills.

In the two groups investigated in this study, it seemed clear that teachers who were asked to implement pair programming infused with critical thinking focused their attention on the implementation of pair programming and not necessarily on the infusion of critical thinking instruction into pair programming. The teachers in this group did however experience the pair programming positively and noted that they enjoyed implementing it in their classes.

The group that was asked to implement only the critical thinking instruction felt that their learners benefited from some of the aspects of the critical thinking instruction. Not all teachers implemented the strategies as suggested, as evident from comments such as *I did not change any of my strategies* (Teacher 5). Teachers who did however implement the strategies that were suggested to them in the professional development session reported much success, and noted that the speaking in tongues and devil's advocate strategies (Brookfield, 2012) bore most fruit.

Most of the IT teachers were positive that they would continue using the critical thinking strategies, but not necessarily explicitly as instructed. IT teachers are often overloaded with additional commitments and, therefore, do not always have the additional time it may take to plan and facilitate the suggested strategies explicitly. From this study, it became clear that IT teachers may initially be willing to implement new teaching–learning strategies in their classes, but when theory meets practice, they seem reluctant.

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Biography



Roxanne Bailey is a PhD student in Computer Science Education (CSE) in the Faculty of Education Sciences at the North-West University (NWU) (Potchefstroom Campus), South Africa. Roxanne's research mainly focuses on critical thinking, cooperative learning and Self-Directed Learning and the empowerment of Information Technology teachers. She has received several scholarships (national and international) for her research.



Elsa Mentz is a professor in Computer Science Education (CSE) in the Faculty of Education Sciences at the North-West University (NWU) (Potchefstroom Campus), South Africa. In her endeavors as established researcher, she mainly focuses on cooperative learning in CSE as well as the fostering of SDL skills in the Computer Science classroom. She has received national and international funding for her research projects. Elsa has also been actively involved in the training of IT teachers for the past fourteen years.