

Effectiveness of an Instructional Intervention in Developing Critical Thinking Skills

Role of Argument Mapping in Facilitating Learning of Critical Thinking Skills

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Abstract: This paper is focused on how argument mapping (AM) software can be helpful for developing critical thinking (CT) skills of initial teacher educators. The study discusses the usefulness of argument mapping software for lessening the cognitive load of students. The main study is conducted to test the effectiveness of an instructional intervention for the development of critical thinking skills. The effectiveness includes an assessment of the implementation process as well. The instructional intervention is comprised of computer supported (audio-video lectures and argument mapping) and non-computer supported (Communities of Inquiry discussions and concept mapping on paper) learning materials thought to enhance the CT skills of initial teacher educators in a public teacher education university in Pakistan. The teaching programme based on seven principles has several elements for teaching critical thinking of which one is computer supported visual representation (argument mapping). In this paper, the focus is on participants' accounts of the usefulness of visual representation (argument mapping) feature for the provision of critical thinking. The analysis shows the positive influence of computer-supported argument mapping in increasing student interest in learning CT. However, the belief that argument mapping increases critical thinking could not be determined in this study for design issues. Students found that AM help them lessening cognitive load while helping in structuring thoughts. The results from observations and interview responses are discussed for the implications of argument mapping in mainstream teaching at college/university level with regards to teaching critical thinking skills. The paper briefly discusses the possibility of placing cognitive load theory on instructional interventions explains a lot about complex learning environments, element interactivity and learning. Therefore, if rightly executed, visualization tools as part of teaching strategies for CT may increase the critical thinking skills.

1 INTRODUCTION

This study's intention is to improve the quality of classroom teaching and learning in postgraduate teacher education programs in a public teacher education institution. The objectives of this study are 1) an emphasis on a mixed (explicit and embedded) intervention (Ennis, 1991; Abrami *et al.*, 2008) implementation approach such as to investigate the extent that the intervention is effective or not, 2) to obtain real classroom data about how critical thinking skills instructional intervention elements are implemented meaning what happens in an actual classroom environment. This paper focuses on the importance and role of visualization tools as part of CT instructional interventions. This study focuses on

the role of visualization tools, cognitive load theory and argument maps in assisting the critical thinking intervention design primarily related to lessen extraneous (the way information or tasks are presented) and germane (the work put into creating a schema) cognitive load (Paas, Renkl and Sweller, 2003) of the learners.

2 LITERATURE REVIEW

2.1 Cognitive Load and Learning of Critical Thinking

Cognitive load is the amount of effort that an

activity poses on working memory at a point in time (Moody, 2004). Cognitive load theory is well known for explaining cognitive processes and instructional designs. Its importance is known for improving speed and accuracy of understanding and deep understanding of information content (Moody, 2004). At the same time, it considers the structure of information and the cognitive architecture that allows to understand and learning, learner and instructional designs interactions. This allows for a unique opportunity to understand complex learning schemas, the role of working memory, long term memory and why some materials are difficult to learn and many more (Paas et al., 2003; Cooper, 1998). There an extensive amount of work available from Sweller, 1988; 1994; 1999, Paas et al., 2004, Paas and Ayres, 2014 Nonetheless, cognitive load theory is not void of flaws and counter arguments about its usability and correctness for example see Moreno (2010) and De Jong (2010).

2.2 Cognitive Modelling Tools

Cognitive tools by definition are tools, means or instruments that are used to improve the cognitive powers of learners during their thinking, problem-solving and learning (Jonassen *et al.*, 1997; Pea, 1985; Salomon, Perkins and Globerson, 1991). According to Derry and Lajoie (1993, p. 5) “the appropriate role for a computer system is not that of a teacher/expert, but rather, that of a mind-extension cognitive tool” or what Jonassen (1994;1995) calls mind tools. Cognitive tools, according to Derry and Lajoie (1993) are unintelligent tools, relying on the learner to provide the intelligence. To lever this need of visualising complex thought processes, technology proves handy to support human cognition with a range of interfaces available (Lajoie and Derry, 2013). Cognitive tools are categorised into two main sections cognitive teaching strategies (non-computer based) and cognitive modelling tools (computer based). This section discusses methods of reasoning, judgement, problem solving, procedures and processes of cognitive activity that help in learning high order thinking skills.

2.2.1 Concept Mapping

Concept mapping is a visual technique to organize information. It is presented in the form of nodes that are connected to circles or boxes; the relationship among concepts is usually depicted with a connecting line (Novak 2004; Novak and Cañas, 2006). Kim and Olaciregui (2008) used concept

maps in learning activity that employed reviewing and increasing concept map based information. Liu, Chen and Chang (2010) investigated effectiveness of concept maps as an aid in improving English reading comprehension. More recently Adesope and Nesbit (2013) used concept mapping for improving narrative reading. Studies have also shown concept maps helpful in increasing student achievement (Chiou, 2008). Lim, Lee and Grabowski (2009) established concept maps as effective instructional tools. They found students with high self-regulated skills gained more than those of with low self-regulated skills.

In another study by Cheema & Mirza (2013) the effects of concept mapping on academic achievement has been studied. These tools are seen to be effective in improving students’ performance in general science. The study also observed that the effects of concept mapping are positively related with academic achievement. Tan (2012) focuses on using Intel thinking Tools for the development of critical thinking skills of twenty teacher trainees. The results reveal an increase in the trainees’ critical thinking abilities in completing their assignments.. This implies that concept maps may work better with adult students to promote meaningful learning (Horton et. al., 1993) who will learn to use the software and meaning and use of boxes, symbols faster than young children. Buehl and Fives (2011) also shows effectiveness of concept maps in the discipline of Educational Psychology as instructional assessment tool.

2.2.2 Argument Mapping

According to van Gelder (2013), argument mapping (AM) has been prepared with the explicit intention of decreasing the mental load and to facilitate learning and development of critical thinking skills. Harrell (2008; 2011) researched over the effectiveness of visual representation for the development of critical thinking skills. The researcher used argument mapping within the context of an introductory philosophy course. The results of the study showed improvements in the critical thinking skills of students. In order to make argument mapping successful, students must be taught how to construct argument diagrams to aid in the understanding and evaluation of the arguments. The writer considers diagram mapping useful for developing general CT skills and discipline specific analytic abilities both. Dwyer, Hogan, and Stewart (2010; 2012; 2013) examined the effects of critical thinking in an e-learning course. The course was

taught through argument mapping in the discipline of psychology. The study follows a quantitative approach using quasi-experimental methods.

3 METHODOLOGY

3.1 Research Study Design

A sequential mixed method design is implied because the first, purpose is to see if a critical thinking skills intervention can facilitate increase in students CT skills. The second purpose, based on outcomes of the intervention effect, is a follow up qualitative study to validate how the implied method (i.e. intervention) have helped or failed to help in improving students’ critical thinking skills. Moreover, what other factors played a role in affecting the CT intervention implementation. This study uses a quan-qual mixed method research design (Creswell, 2008; 2009).

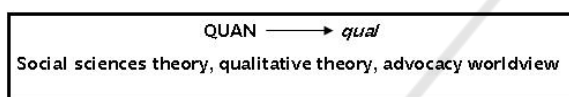


Figure 3.1a: Mixed method research design.

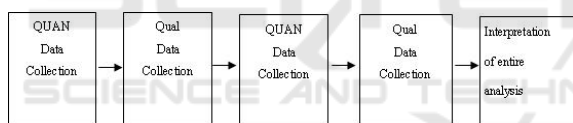


Figure 3.1b: Sequential explanatory design.

Figure 3.1a and 3.1b is the representation of the methodology employed. The image is from Creswell (2009) and explains the extent of using mixed methods research design where main path of inquiry remains quantitative therefore, bold and bigger, followed by a qualitative methods approach. Moreover, the data is collected in stages and quantitative and qualitative data is collected in sequence and exploratory manner, figure 3.1b shows the sequential explanatory design (Creswell, 2008). The first QUAN (main quantitative) phase of the research study follows a quasi-experimental two group pre-test post-test design to look at the effectiveness of an instructional intervention on students of an initial teacher education program. The second qualitative phase follows qualitative classroom observations, journal notes and interviews to explain the outcomes.

3.1.1 Argument Mapping Software

Freely available open source software ‘Argumentative’ is used for this study. The researcher acknowledges sourceforge.net for providing with free download. Figure 3.1.1 shows screen view of the mapping software.

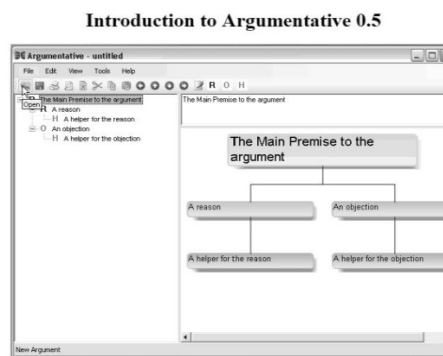


Figure 3.1.1: Argumentative software interface.

The figure 3.1.1 shows the interface that student used to practice CT directed argument mapping.

3.2 Critical Thinking Skills Interventions

A mixed approach (Ennis, 1998) is used to teach critical thinking. The mixed approach CT “is taught as an independent track within specific subject matter” (Ennis, 1991; Abrami *et al.*, 2008). Independent track is ‘explicit’ where learners are made aware that they are being taught CT elements and how to think. Learning materials and teaching strategies are used to categorically unravel elements of CT. On the other hand, ‘embedded’ means when it is engrained in existing curriculum and subject specific topics are modified for deep learning while applying the rules and elements of thought learned via explicit approach. Together, these are known as mixed approach to teach CT, for detail see Ennis (1991) and Abrami *et al.* (2008). The first two weeks comprises of explicit teaching of CT as an independent thread and the last two weeks included embedded teaching of CT within the Educational Psychology subject matter. This was supported practising the argumentation skills by argument mapping software. As per mixed approach, the second half of instructional intervention is related to deep subject matter related practice into thinking critically. This thread of the lesson plans is longer than explicit CT teaching lesson (videos and collaborative tasks of paper pencil concept mapping)

and utilizes the visual representation tool (argument mapping software) to help students' lessen cognitive load.

4 FINDINGS ABOUT THE EFFECTIVENESS OF VISUALIZATION TOOLS

The findings for effectiveness of visualization tools (concept maps and argument maps) will be drawn on standard classroom observations, research journal notes (taken during the intervention implementation) and seven semi-structured interviews of the participants at the end of the intervention. During the intervention it was observed that student worked more attentively and with increased interest on class tasks that's involved preparing concept maps on curriculum or general topics. They worked in small groups (two to four) groups to brainstorm ideas on topics and prepare simple concept maps.

For argument mapping we asked the participants "What design features of instruction e.g. discussion in community of inquiry, audio-video lectures on critical thinking, learning with argument mapping software, discussions in broader and deeper meaning of curricular topics did you find most useful?" following are the excerpts from qualitative data. The data were analysed using critical analysis of the text using thematic analysis approach.

Argument mapping plays a role in enhancing students interest in learning and facilitating in lessening the cognitive load those students felt while learning CT. A student expressed learning with [technology] argument mapping as an interesting and different experience. To this student argument mapping was helpful to structure the line of argument, claims or evidence, how this can be applied to other subjects as well [transferability of CT skills]. Argument mapping also helped to improve the writing of this student.

"Learning with argument mapping (Promptly), it was different and interesting meaning we never thought of information that it is relevant or credible, no we don't. It improved my writing and it motivated me for learning".

Another student expressed that working with argument mapping helped to develop a critical aspect in thinking. The student felt motivated through argument mapping [use of technology] even when they were not interested in learning, computer enhanced argument maps helped to see the structure

of thought and kept students interest. Learning in technology enhanced environment was also liked because teacher was there to guide, there was proper planning and materials were readily available.

"I can criticize and handle a topic, situation. Motivated through computer lab work, that experience it was motivational as well because we could see the structure of thought, and we also saw teacher as a guide and instructor. There was proper planning, software was available and we were given all the materials, that phase was motivating".

Learning in groups was liked by this student as this student thinks we learn socially with other fellows. Learning argument mapping was easy due to it being hands on and activity based. The reading exercise was not liked by this student because she does not like to read however discussion were of interest and the student thinks we [she/he] learn a lot from discussions.

"We learned to think critically in groups. With my fellows, I could not make it with our friends because it was tough. I found learning argument mapping was easy because we did it practically, by our hands in front of us and by our mind".

The class teacher found the design of the instruction very useful however there were some problems. The students in teacher's opinion are unable to take the responsibility of learning for themselves, they are not used to it although on the contrary the teaching is going to change in Pakistan but it will take time. These kinds of learning experiences are not common yet students worked eagerly. They will need more practice and drill on it, with practice students will perform better on argument mapping. The teacher stresses the importance of methodology [instructional plan] and design features especially communities of Inquiry, collaboration and argumentative software and expresses his interest in future use of this method [CT embedded instruction].

"I found this design of instruction very useful and very fine. This was totally new thing for students, they worked on it eagerly but they would need more practice and drills on this work. So, I think with more practice they can perform well on this argumentative software. It's really useful and workable strategy to enable the students work in COI, collaboration, to work on argumentative software".

5 DISCUSSION

The results and discussion of this paper is limited to the qualitative data only. Argument mapping is a part of teaching strategies of an instructional intervention. The effectiveness of each teaching strategy is not separately measured due to the design limitation. The feedback on instructional design is gathered at the end through interviews asking direct question about design features of instruction. The findings from participants' accounts suggest that argument mapping does facilitate in visualising thinking, increasing interest, building opportunities for collaboration and group work and learning to build 'valid, credible' arguments. The students found this approach useful because it help them to think independently as well as thinking with their fellows. This is in agreement with Brown and Freeman (2000) and Kim and Reeves (2007) that such teaching strategies can have direct or indirect on development of CT skills.

One main expression that almost all participants conveyed that it was hard to teach and be taught this way and that learning critical thinking is tough (Willingham, 2008, van Gelder et al., 2004). This is not a surprise to us due the novelty of the structured teaching programme in this context. Additionally, research literature has many examples of evidence that high order learning skills pose challenge to its learner and argument mapping helps avoiding cognitive load (van Gelder, Bissett, and Cumming, 2004).

However, this study finds the usefulness of argument mapping among participants to look at information in a different way and learning with AM easy due to its hands on practice feature and leaving the learner do the thinking while only facilitating in visualizing the structure of thought. This extends Jonassen (1995) and Derry and Lajoi (1993) thesis that the role of computer tools is that of a mind extension and not that of teacher/expert.

It seems argument mapping work as a mind extension tool for these students but needs more practice. This is consistent with van Gelder, Bissett, and Cumming, (2004) Davies (2011; 2012). The students and class teacher also showed interest in use of more such technologies in mainstream teaching.

The learners may need to attend to each of the elements and interactions between the elements individually (e.g., audio-video lesson, class activities, discussion on curriculum embedded topics and preparing argument maps). Kalyuga *et al.*, (2003) and Sweller, Ayres, and Kalyuga, (2011a; 2011b)

have researched on reversal effects and the interactions between levels of expertise and the isolated or interaction elements effect in their work.

If implemented effectively, AM can be utilized to gain increased effect sizes in critical thinking skills interventions and improving the results of instructional interventions. Interventions that have complex materials and put high cognitive load on learner's minds may not bring significant results over a short time as the learners will need to go through exploratory phase, and then they will reach understanding.

6 CONCLUSIONS/FUTURE WORK

The following conclusions can be drawn from the data in terms of role of argument mapping software for facilitating learning of critical thinking.

- a) Technology can be a positive adds on while teaching complex constructs like CT however the users' familiarity, likeness and expertise of handling technology may have a negative effect rather than positive. One needs to be careful or give training in advance before introducing technology supported teaching – learning techniques.
- b) Argument mapping help in increasing students' interest and motivation. It facilitates the cognitive processing of thinking among students.
- c) The quality of delivery of the intervention components may be a major factor for the failure of critical thinking skills interventions. Interaction effect of complex elements can be another reason for low effect sizes in critical thinking research.

Argument maps are used as part of a multiple components consisting teaching programme. The study did not measure the effectiveness of AM and cognitive load separately. The findings of this research are based on qualitative data and a small sample therefore, generalisations cannot be made. However, one can conclude for this sample and context on a n exploratory level argument maps facilitate learning and construction of arguments by providing the user the flexibility and structure to thought that may lessen cognitive load. For teacher educators, curriculum and courses should be prepared with an explicit interest and emphasis on critical thinking skills and argument mapping tools. More practice and learning opportunities with

computer supported argument mapping should be part of critical thinking skills related instructional interventions.

Future work may explore and measure the effect of argument mapping in developing CT as part of instructional intervention. Moreover, the relationship between learning of critical thinking, cognitive load the role of argument mapping in facilitating to lessen the load and improving CT needs to be explored. Overall the data from classroom observations, research journal and participants' interview demonstrated the usefulness of argument mapping in facilitating learning as instructional technology tools.

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