The Design of a Collaborative Learning Environment in a Mobile Technology Supported Classroom: Concept of Fraction Equivalence

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Abstract. Knowledge of fraction equivalence is fundamental for building knowledge of fractions. This study aims to design a collaborative learning environment for developing the concept of fraction equivalence in classroom settings. According to the cognitive conflict theory, the key for developing a concept is to arouse a strong interest or an appropriate level of anxiety in learners in recognizing the anomaly clearly and reappraising the cognitive conflict situation deeply. A mobile learning environment for collaborative engagement is created in this study to encourage the resolution of cognitive conflict. Two situations are designed to stimulate reflection of learners about the concept of fraction equivalence: one is triggered by the anomaly between the learning peers and the other is triggered by the anomaly between the learner and the computer system, which has the authority of correctness in the situation. Two pedagogical tools for encouraging reciprocal tutoring in the collaborative learning environment are elaborated.

Keywords: cognitive conflict, collaborative learning, fraction equivalence, mobile learning

1. Introduction

Collaborative learning is a process that encourages learners to participate in the coordinated and synchronous learning activities with a number of other learners [1]. It emphasizes the concept “every learner learns from everyone else” [2, p.215]. This learning process provides learners with the opportunity to make contributions and appreciate the contributions of others.

There are four characteristics of collaborative learning: sharing knowledge among peers, sharing learning authority, mediation from teachers, and heterogeneous grouping of learners [3]. In collaborative learning, learners take the role of knowledge provider in sharing their own knowledge and learning strategies with other group members. Learners can be a source of knowledge, which is traditionally regarded as the figure of learning authority in the learning process. The sharing of knowledge among teachers and learners thus leads to the sharing of learning authority among teachers and learners. Learners are empowered with learning control to a greater extent in collaborative learning. Teachers play the role of facilitator in collaborative learning to provide mediation for learning in groups, such as the adjustment of information flow and interaction among groups and group members. The heterogeneous grouping of learners is important in collaborative learning. This grouping strategy allows reciprocal tutoring and knowledge exchange among learners with diverse perspectives, experiences, and backgrounds.
Collaborative learning is good for learners to develop knowledge and interpret communication skills. However, two obstacles decrease the effectiveness of the learning process: problems in class control during the active participation of learners and unsatisfactory participation of particular quiet learners [4]. Mobile learning, an emerging learning approach, can address these two obstacles of collaborative learning. Mobile learning refers to the use of mobile technologies for learning and teaching and is characterized as learning across space, time, topics, and technologies [5]. Mobile learning can assist collaborative activities across space and time, and can be used in traditional classrooms across topics and technologies. There are three attributes of existing mobile technologies that facilitate the design of collaborative learning activities in classroom settings.

Firstly, the visualization capability of mobile devices enables learners to disentangle cognitive loading to visualization tools. Learners are thus able to engage in activities that require deep learning of subject matter that requires visualization support [6]. With the help of mobile devices, abstract concepts can be visualized and manipulated through visual representations. Learners may share and communicate their ideas and knowledge through visual support in collaborative learning activities.

Secondly, most mobile devices are compatible with desktop computers. Software can be installed in mobile devices to perform required computation tasks. With the installation of appropriate software codes, such as coding for data-mining support in mobile devices, teachers are able to trace the progress and learning behavior of learners during learning tasks [6]. This also implies that with appropriate software design, teachers can make effective use of mobile devices to facilitate class control in collaborative learning activities, such as organizing and maintaining learners in heterogeneous groups and supervising the engagement of learners in collaborative tasks by generating questions and appropriate difficulties.

Thirdly, the anonymity in the communication with the use of mobile devices helps increase the participation of learners in collaborative learning activities by allowing them to express their ideas without revealing their identities to the class. The mobile device enables learners to privately work, reflect, and explore learning materials without fear of others observing the development of their work. Learners can share the final product of their work with the class when they feel it has reached a satisfactory level. This disembedding of private work and public sharing may enhance learning in traditional classrooms [7]. Even quiet learners can share in the immense satisfaction of participating and contributing ideas without the fear of making incorrect responses.

2. Cognitive Conflict

Understanding mathematical ideas often involves the restructuring of mathematical schema of learners. This restructuring process is intricately linked with the occurrence of cognitive conflict [8]. Cognitive conflict is a part of the psychological theory of cognitive change. It involves an inferred state of incompatibility between two interrelated component states within the cognitive process [9]. In general, cognitive conflict is a perceptual state in which one notices the discrepancy between an anomalous situation and a preconception [10]. Since the 1980s, cognitive conflict has been regarded as a fruitful teaching strategy because its nature of cognitive change induces introspection of learners towards the newly learnt conception that is incongruous with a preconception or erroneous misconception.

According to the cognitive conflict process model, there are three stages of engagement of cognitive conflict in learning [10]. The first stage is the preliminary...
in which an anomalous situation that is different from belief of learners of pre-existing conceptions is introduced. The second stage is the conflict stage, in which learners recognize and reappraise the anomalous situation with the expression of interest or anxiety in resolving the cognitive conflict. The third stage is the resolution stage, in which learners try to resolve cognitive conflict in any way that they can.

Cognitive conflict has three types of potential: constructive, destructive, and meaningless potential. When learners clearly recognize an anomaly and reappraise a cognitive conflict situation deeply with the expression of strong interest or appropriates anxiety, the cognitive conflict has constructive potential. When learners do not recognize an anomaly or simply ignore it with an expression of bad feeling, such as frustration or rejection, the cognitive conflict is regarded as destructive. When learners recognize an anomaly but accept it passively without interest and cognitive reappraisal, the cognitive conflict shows meaningless potential. Early studies have shown that the induction of constructive cognitive conflict promotes positive outcomes in classroom learning [11]. The creation of constructive cognitive conflict in learning largely depends on interdependency among learners. Hence, the creation of constructive cognitive conflict is closely related to the collaborative learning process that provides learners with ample opportunity to learn from peer-discussion.

The concept of fraction equivalence is regarded as one of the most difficult topics in mathematical learning because of its abstract nature [12]. Knowledge of fraction equivalence is fundamental for building knowledge of fraction operations, such as adding or subtracting fractions with unlike denominators [13]. The construction of this mathematical knowledge is often accompanied by the occurrence of cognitive conflict [12]. As research findings have indicated that technology supported graphical modeling helps with the learning of fractions [12, 13, 14, 15], this research aims to design a collaborative learning environment for developing the concept of fraction equivalence in a mobile technology supported classroom. A mobile learning environment for collaborative engagement is created in this study to encourage the resolution of cognitive conflict and reciprocal tutoring in classroom settings.

3. Design of the Mobile Learning Environment for Collaborative Engagement

3.1 Mobile Technology Supported Classroom

Collaboration is a coordinated, synchronous activity through a continued attempt to construct and maintain a shared conception of a problem [1]. In this study a series of synchronous interactions in a mobile technology supported classroom is designed to encourage learners to engage in learning tasks, and a mobile platform is established for immediate interaction between learners in collaborative pairs. Figure 1 depicts the mobile technology supported classroom for learning the concept of fraction equivalence in pairs.

The learning activity of fraction equivalence takes place in a wireless-networked classroom. The mobile device that is used in this learning activity is a pocket PC because of its portability and relatively large screen. The teacher and learners are provided with a pocket PC. The pocket PC of teacher is pre-installed with the interface for managing the pair grouping and the organizing of learning activities. The pocket PC of learners is pre-installed with a graphical tool for learning fraction equivalence. The learners interact in pairs through a server that is connected to a SQL database. The server acts as a grouping coordinator of grouping requests from teachers and a communication coordinator of synchronous interactions between paired learners.
3.2 Pedagogical design for collaborative learning: Two situations for reflection

Successful collaborative learning tasks should allow learners to achieve meaningful engagement, negotiation, self-reflection, shared understanding, and mutual agreement. The scale of grouping, the type of interaction, and the task of collaborative learning are critical factors for achieving these goals. To facilitate in-depth discussions among group members for developing the concept of fraction equivalence, learners are grouped in pairs with fellow classmates to conduct fraction comparison tasks. After logging onto the system, learners are placed in a context in which they decide the equivalence of fractions with the support of graphical representations of the fractions. One learner is designated question-setter, while the other is the question-replier. The learners alternate playing the two roles. There are three steps in this learning activity.

Step 1 is the process of question-setting. In this step, the learners in the role of question-setter set and send out questions about the equivalence of two fraction expressions. The learners have to state whether the two fraction expressions that they are equivalent to the aid of graphical representation of the two fraction expressions at the top of the interface. Once the learners are satisfied with the question set, they can click the “Confirm” button to send out the question to their partners through the server.

Step 2 is the process of question-reply. In this step, the learners in the role of question-replier receive questions from their partners. When they receive the two fraction expressions, they have to decide on the equivalence of the two fraction expressions with the help of the visual representations of the fractions. After the learners have indicated their decisions, they click the “Confirm” button to send out their answers to the server.

Step 3 is the process of judgment. In this step, the computer system plays the role of learning authority to assess the correctness of the questions that are set by the question-setters and the answers that are provided by the question-repliers. The computer system sends messages of “Correct” and “Incorrect” for the right and wrong question answers.

There are two possible types of cognitive conflict that are engendered in the learning activity for the achievement of learning by reflection: one is triggered by the anomaly between the learning peers, and the other is triggered by the anomaly between the learner and the computer system. When one member of a pair of learners provides the correct question or answer, while another member gives the wrong question or answer, the computer system displays the message “Please Discuss” (see Figure 2a). This generalizes the first type of cognitive conflict – it invites learners to share understanding, and engage in self-reflection and negotiation through collaborative interaction.
When both members agree to finish their discussion, they have to click the "Discussion Finished" button (see Figure 2b) to inform the computer system. The computer system then generates the message "Correct" or "Incorrect" for the question-setter and question-replier (see Figures 3a and 3b). These authority judgments create the second type of cognitive conflict when they differ from the judgments of the learners. This offers learners a second opportunity to engage in self-reflection and to share understanding through a post-task discussion.

4. Design for Resolution of Cognitive Conflicts

4.1 The status of groups of learners in learning the concept of fraction equivalence

The aim of this study is to equip learners with basic knowledge of fraction equivalence through collaborative learning in a mobile technology supported classroom. It emphasizes the knowledge sharing of learners with graphical support in the learning process. The different learning progress of individual learners determines the learning progress of each
group. Figure 4 depicts the status of groups of learners in the process of learning the concept of fraction equivalence.

![Diagram showing learning statuses](image)

Figure 4: The status of groups of learners in the process of learning the concept of fraction equivalence.

Case 1 is expected to occur commonly at the beginning of the learning process. In this case, both members of a group have a preconception or misconception about the equivalence of two fractions. The learners always set and reply to questions incorrectly, and the computer system always gives a feedback that the correct answer is incorrect. In this situation, learners always encounter both the first and second type of cognitive conflict. The groups of learners in this situation fall into learning status 1. Case 2 and Case 3 occur when one of the group members begins to grasp the concept of fraction equivalence better than his or her partner. The learner who has developed the correct concept of fraction equivalence begins to set correct questions and make responses to questions. His or her counterpart cannot always achieve this status. In these cases, learners in this situation have the first type of cognitive conflict and the learners who have developed the concept of fraction equivalence will continue to experience the second type of cognitive conflict, in which an anomalous situation exists between the learner and the computer system. The groups of learners in these cases are in learning status 2. Case 4 occurs when both learners in a group have a good understanding of the concept of fraction equivalence. The group members always set and reply to questions correctly. In this case, cognitive conflict rarely occurs. The groups in this case achieve learning status 3. This is the learning goal of all of the groups. Some groups go through learning status 1 and 2 to reach learning status 3 and some of the groups go directly from learning status 1 to 3. The groups in learning status 2 are heterogeneous groups in this study.

4.2 Design for encouraging reciprocal tutoring

The ultimate goal of this design is to help all of the groups of learners to attain learning status 3 through the learning activities in the collaborative learning environment. In regard, the groups in learning status 1 and 2 require the attention and mediation of teachers to promote productive knowledge sharing. In this collaborative learning environment, teachers play the role of mediator, rather than the authority on the judgment of correctness of arguments between group members and thus the induction of more cognitive conflict. Hence, the role of the teacher is to encourage reciprocal tutoring, which can be achieved more productively in a heterogeneous group context. This may enhance the productivity of arguments between group members and thus the induction of more cognitive conflict. To realize this goal, two pedagogical tools are designed to encourage the reciprocal tutoring of learners. The first is the re-grouping of group members, and the second is the changing of the modes of question-setting. Figure 5 shows the interface of these tools.
the pocket PC of teacher for the re-grouping of learners and the changing of the mode of question-setting.

Teachers who observe groups that are working in learning status 1, in which both group members struggle with a concept over a period, can use the first pedagogical tool to swap a member from the group in learning status 1 with a member from a group in learning status 3. This helps to achieve more heterogeneous groups in the learning environment, which in turn helps to encourage prolific reciprocal tutoring.

Teachers who detect groups that are working in learning status 2, in which one of the group members consistently designs incorrect questions, can use the second pedagogical tool to designate another learner as the sole question-setter by changing the mode of question-setting from “Turn-Taking” to “Designation”. This creates an environment that allows the learners with better understanding to tutor learners who are still developing the concept.

Once it is speculated that all of the groups have attained learning status 3, in which the learners have a good understanding of the concept of fraction equivalence, teachers can change the mode of question-setting to “Random” for the entire class so that the role of question-setter is assigned randomly by the computer system. The “Random” question-setting mode provides the opportunity for learners to explore the concept further in a relaxed mode of inquiry. This helps to consolidate the learning outcomes of learners.

5. Conclusion

This study aims to design a collaborative learning environment for developing the concept of fraction equivalence in mobile technology-supported classroom settings. In this study learners are asked to group into pairs and to join in a synchronous learning activity with the use of pocket PCs in a wireless-networked classroom environment. Two situations for the generation of cognitive conflict are designed to stimulate the reflection of learners to develop new concepts: one is triggered by the anomaly between the learning peers, while the other is triggered by the anomaly between the learner and the computer system that has the authority of correctness in the situation. Reciprocal tutoring is considered as the key strategy in this study that helps learners to resolve cognitive conflict. Thus, the role of the teacher in the classroom in this design is to act as a facilitator to mediate and to promote the sharing of knowledge and learning authority by helping learners to form heterogeneous
groups and by adopting different modes of question-settings in these groups. The use of mobile technologies to encourage collaborative learning is a promising research direction that deserves research effort to study its effect on classroom learning environments. A number of researchers have begun to study cases on learning the concept of fraction equivalence in a mobile-supported collaborative learning environment. Further work on large-scale studies in investigating whether learners recognize and reappraise the anomalies and how they attempt to resolve the cognitive conflict in the learning process will be attempted after the pilot case study.

References