Chapter 8
Scripted Collaborative Learning Using the Modified Jigsaw Method: An Empirical Study

Abstract Free collaboration cannot necessarily result in successful collaborative learning. This study explored scripted collaborative learning in the shared space facilitated by *Cmaptools*. The purpose of this study was to examine the effectiveness of the modified jigsaw method. In contrast with the traditional jigsaw method, the modified jigsaw can establish common ground and shared cognition. An experiment was conducted in the lab to evaluate the effects of the modified jigsaw. The experimental results indicated that the modified jigsaw was more effective than the traditional jigsaw in terms of enhancing group performance, task cohesion, and collective efficacy. The implications for practice and future studies are also discussed in detail.

Keywords Collaborative learning · Jigsaw · Group performance · Task cohesion · Collective efficacy

8.1 Introduction

Collaborative learning has been paid increasingly attention in recent years. The effectiveness of collaborative learning has been well documented in the literature (Fischer et al. 2007). However, the effectiveness of collaborative learning depends on many factors, including group size, age, gender, heterogeneity, prior knowledge, tasks features, and so on (Dillenbourg 2002). It is very obvious that both the external conditions and internal conditions have great impacts on the effectiveness of collaborative learning. However, the internal conditions are more important than external conditions. Therefore, Dillenbourg et al. (1995) migrated from external conditions to internal conditions and focused on internal factors as well as the actual collaborative learning processes. This means the social interactions among group members are the major concern in collaborative learning. As Johnson and Johnson (1987) noted, successful collaborative learning requires group members to interact with each other socially. These interactions among group members are very complex. A previous study reported that free collaboration cannot necessarily lead to productive

L. Zheng, *Knowledge Building and Regulation in Computer-Supported Collaborative Learning*, Perspectives on Rethinking and Reforming Education,
DOI 10.1007/978-981-10-1972-2_8

collaborative learning (Dillenbourg et al. 2009). Therefore, social interactions need to be structured in order to achieve successful collaborative learning outcomes.

Scripted collaborative learning is an effective method for structuring collaborative learning. Scripts are a set of instructions that specialize group formation, distribution of resources, role assignment, and sequences of activities (Fischer et al. 2007). A jigsaw is one well-known scripted method for collaborative learning. The jigsaw method structures collaborative learning into expert groups and jigsaw groups (Balestrini et al. 2014). First, a collaborative learning task is broken up into different sub-tasks. Second, the expert groups are assigned one sub-task and work together to complete it. Third, students who are assigned different sub-tasks form the jigsaw groups and share every sub-task (Aronson and Patnoe 1997). Thus, the jigsaw method promotes the interdependence of group members and cognitive elaboration by considering different perspectives (Hinze et al. 2002).

However, previous studies revealed that the jigsaw method reduced learners' common ground and hindered knowledge building among group members (Deiglmayr and Schalk 2015). Therefore, this study proposed the modified jigsaw method in order to establish common ground and help learners to gain more knowledge. The main difference between the modified jigsaw method and the traditional jigsaw lies in the first phase. With respect to the modified jigsaw, all of the group members need to complete all of the sub-tasks in the first phase. By comparison, group members only need to complete one sub-task in the traditional jigsaw. Therefore, the purpose of the modified jigsaw is to improve knowledge gains and establish common ground among group members.

In this study, we adopted the modified jigsaw script to conduct online collaborative learning. The purpose of this study was twofold. First, it aimed to explore the feasibility of the modified jigsaw method. Second, it examined the effectiveness of the modified jigsaw method in terms of group performance, task cohesion, and collective efficacy. The research questions are addressed as follows.

1. Is a modified jigsaw method more effective than the traditional jigsaw method in terms of improving group performance?
2. Is a modified jigsaw method more effective than the traditional jigsaw method in terms of promoting task cohesion?
3. Is a modified jigsaw method more effective than the traditional jigsaw method in terms of improving collective efficacy?

8.2 Literature Review

8.2.1 Scripted Collaborative Learning

Collaborative learning is a learner-centered approach that enable students to co-construct knowledge, skills, and attitudes by social interactions. Collaborative learning includes five basic elements, namely positive interdependence, individual

accountability, social skills, group processing, and social interactions (Johnson and Johnson 1987). In order to achieve successful and productive collaborative learning, these five factors are essential and crucial. Previous studies reported that collaborative learning can improve information retention, higher order thinking skills, interpersonal skills, and self-confidence (Lindquist 1997; Lorenzen 2003; Millis and Cottell 1997).

There are two types of collaboration activity. One is free collaboration, the other is scripted collaboration. In terms of free collaboration, the collaborative learning activity is unstructured. However, some researchers posited that free collaboration cannot engage all group members in collaborative learning (Demetriadis et al. 2009; Liu and Tsai 2008) and that it can lead to low phases of critical thinking (Aviv et al. 2003). Scripted collaboration is structured but may cause inflexibility and increase cognitive load (Dillenbourg and Jermann 2007). This study focused on scripted collaboration so as to make collaborative learning processes more structured.

A collaboration script is a set of instructions that indicate how group members interact and collaborate with each other (O'Donnell and Dansereau 1992). A script also specializes the mode of collaboration. Dillenbourg (2002) indicated that most scripts include a linear sequence of phases and every phase is specialized to the task, group, mode, and timing requirements. There are different types of scripts, including induced scripts, instructed scripts, trained scripts, prompted scripts, and follow-me scripts (Dillenbourg 2002). Aronson et al. (1978) posited that the best-known collaboration script is the jigsaw. The following section will illustrate the jigsaw in detail.

8.2.2 Jigsaw

The jigsaw was first proposed by Aronson in the 1970s (Aronson et al. 1978). The procedure of jigsaw includes three steps. First, learners are divided into different groups. Every group member is assigned a specific sub-topic which is to be learned individually. Second, the group members in different groups who are assigned the same sub-topic form the 'expert group'. The expert group members discuss the sub-topics and solve the problems. They become experts in that sub-topic after they have studied it. Third, the expert group members break up and go back to their former groups. They share what they have learned and teach the rest of the group the expert sub-topics (Berger and Hänze 2015; Looi et al. 2008). Thus, all of group members learned all sub-topics.

The characteristics of the jigsaw method include the following. First, learners form home groups and expert groups so that they can discuss the same topics and share their discussions with others. Second, home groups are formed by students who have different levels in learning achievements. Every student in home groups is responsible for one sub-topic. The members who learn the same sub-topics form the expert group (Aronson and Patnoe 1997). Therefore, the main difference between jigsaw and other collaborative learning strategies is that jigsaw enables

every member to be responsible for one part of the task involved in the collaborative learning (Huang et al. 2014). It is clear that two crucial elements of collaborative learning are closely related to jigsaw (Looi et al. 2008). One is positive interdependence, another is individual accountability. Positive interdependence refers to "what helps one group member helps all group members and what hurts one group member hurts all" (Lai and Wu 2006). Individual accountability is defined thus, "the team's success depends on the individual learning of all team members" (Slavin 1987). Therefore, jigsaw can promote knowledge interdependence and individual accountability in collaborative learning.

Jigsaw has been widely applied to many subjects including literature, science, and social studies (Slavin 1995). The positive influence and the effectiveness of jigsaw have been well documented in previous studies. Jigsaw has been shown to inspire students' motivation (Hänze and Berger 2007; Johnson and Johnson 2009) and create a cooperative climate (Aronson and Patnoe 1997). Jigsaw can increase learning performance and promote interpersonal communication skills (Slavin 1989). Jigsaw can also help students to think independently, express clearly, and explore actively (Huang et al. 2014).

However, there are found to be some disadvantages with the jigsaw method. First, jigsaw decreases the amount of shared knowledge and common ground since every group member only learned about one sub-topic, which hinders knowledge sharing and integration (Buchs et al. 2004; Deiglmayr and Spada 2011). Common ground is very crucial for productive and successful collaborative learning (Beers et al. 2005; Noroozi et al. 2013). Second, learners who adopted the jigsaw method have been found to acquire less knowledge than learners using other collaborative learning methods (Berger and Hänze 2009; Moreno 2009). Third, Deiglmayr and Schalk (2015) posited that strong knowledge interdependence cannot optimally help learners to benefit from collaborative learning. Therefore, this study adopted the modified jigsaw method to overcome the abovementioned disadvantages.

8.3 Methodology

8.3.1 Participants

In this study, a total of 36 undergraduates voluntarily participated. All the participants were recruited by posters on campus. Among the 36 undergraduates, 34 of them were female and only two of them were male, with 35 % of them majoring in educational technology and the rest in pedagogy. They were randomly assigned into an experimental group and a control group. Half of them participated in the experimental group and half of them were in the control group. However, one student did not complete the task because he could not login to the system. Finally, only 17 undergraduates were in the control group and 18 in the experimental group.

8.3.2 Collaborative Learning Task

The topic of the collaborative learning task originated from educational statistics. The following is the description of the task.

The teacher Zhao has been a teacher for 30 years in an elementary school. Now, she is also a maths teacher of two classes in Grade 3. At the end of the semester, two classes took a maths examination.

- Sub-task 1: Please help the teacher Zhao to analyze the scores of two classes by different statistical methods and statistical charts.
- Sub-task 2: The school had an opportunity to attend an international summer camp. Only one student can attend this summer camp. Now three students applied to attend it. Please help the teacher find two solutions to how to select only one student.
- Sub-task 3: Please analyze whether there is any significant difference in learning achievements between the two classes.

The final group product included the solutions of the abovementioned problems and a concept map closely related to educational statistics.

8.3.3 Measuring Tools

The measuring tools in this study included the pre-test, post-test, and questionnaires of task cohesion and collective efficacy.

The pre-test and post-test aimed to examine prior knowledge and group performance. The test items of the pre-test were the same as the post-test. There were five open-ended questions in both the pre-test and post-test, giving a perfect score of 50. Both the pre-test and post-test were evaluated by two raters.

The questionnaire of task cohesion and collective efficacy were developed by Zheng et al. (2014). The questionnaire of task cohesion consisted of seven items with 5-point Likert scale, such as "Every group member made great contribution to the collaborative learning task". The Cronbach's α value of the task cohesion questionnaire was 0.862, indicating good reliability.

The questionnaire of collective efficacy consisted of 10 items with a 5-point Likert scale. For example, "Our group can complete the most difficult task during collaborative learning processes". Cronbach's α value for the collective efficacy questionnaire was 0.866, implying good reliability.

8.3.4 Procedure

This experiment was conducted in the labs in one university in order to examine the effectiveness of the modified jigsaw script. Figure 8.1 shows the procedure for the

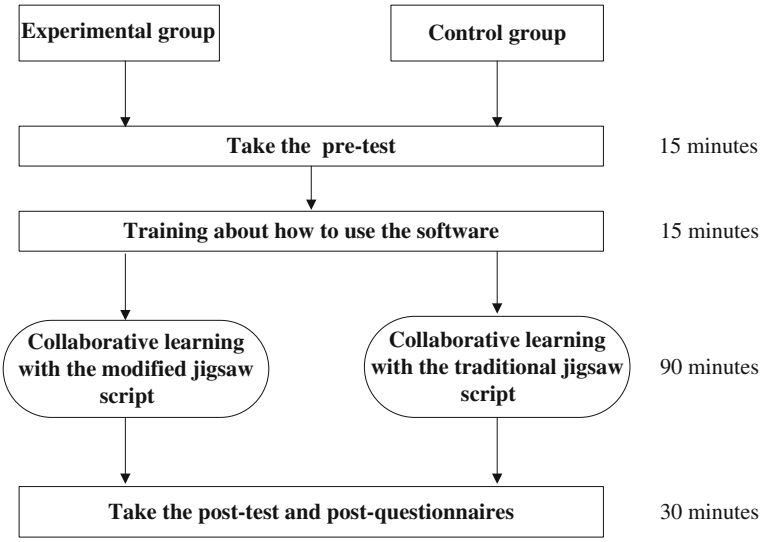

Fig. 8.1 The experimental procedure

experiment. Before the experiment, 35 participants were administered to the pre-test to examine their prior knowledge. After that, training regarding how to use *Cmaptools* was conducted for 15 min. Subsequently, the experiment group conducted online collaborative learning with the modified jigsaw, and the control group conducted online collaborative learning with the traditional jigsaw script. This phase lasted for about 90 min. Finally, all the participants took the post-test and post-questionnaires for 30 min.

Figure 8.2 shows the procedure taken during the traditional jigsaw. For example, let us take the three groups. In the first phase, every group member (M1, M2, and M3) in home group A, B, and C individually learned about one sub-task. In the second phase, the three members who completed the same sub-task in groups A, B, and C formed the expert group and conducted collaborative learning. Thus, three expert groups were formed. Every expert group discussed and solved one sub-task. In the third phase, all the members went back to their home group and conducted collaborative learning again. They shared what they learned about one sub-task and were taught the other sub-tasks by their peers.

Figure 8.3 shows the procedure taken during the modified jigsaw. In the first phase, every group member (M1, M2, and M3) in home groups A, B, and C individually learned about three sub-tasks. In the second phase, the members (M1) of the three groups formed the first expert group and conducted collaborative learning. The members (M2) of the three groups formed the second expert group, and the members (M3) of the three groups formed the third expert group. They conducted collaborative learning to share what they learned from the three sub-tasks. In the third phase, all of members went back to home group to conduct collaborative learning again and complete three sub-tasks.

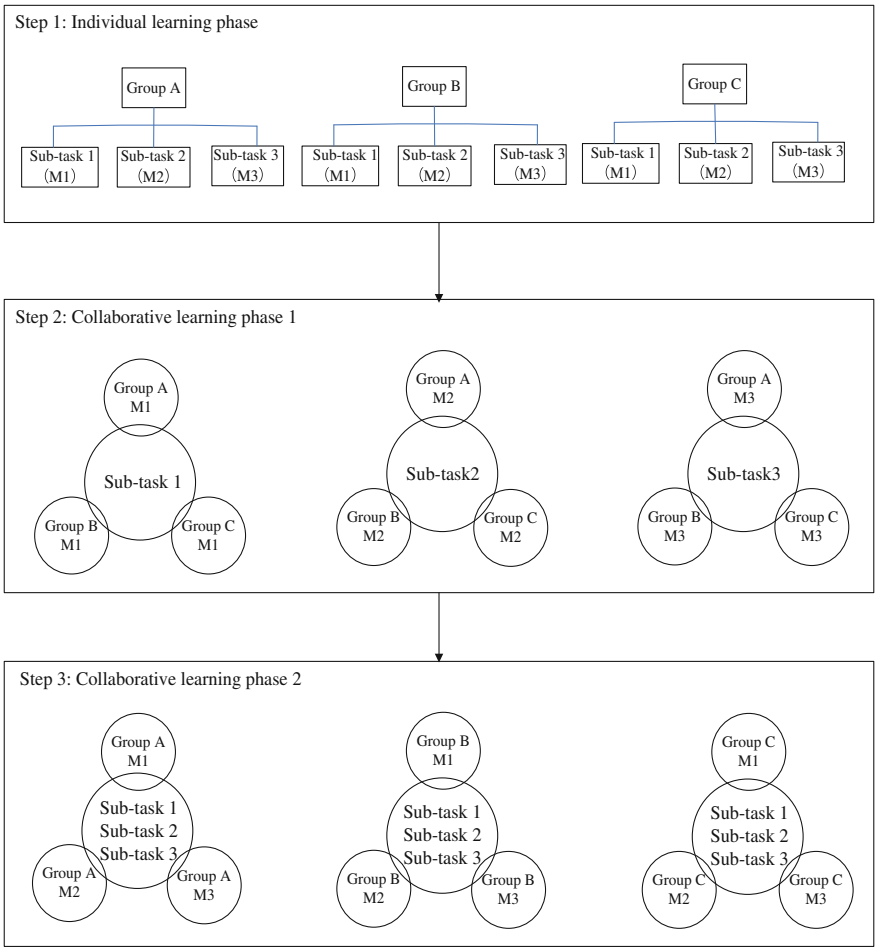

Fig. 8.2 The procedure of the traditional jigsaw method

8.4 Results

8.4.1 Analysis of Group Performance

One of the research purposes in this study was to examine the influence of the modified jigsaw scripts on group performance. The Levene test was performed to examine the homogeneity of variance (Conover 1998) and the Shapiro–Wilk test for examining the normality of distribution (Shapiro and Wilk 1965).

In terms of the pre-test, the results demonstrated that the *p*-values for the Levene test and the Shapiro–Wilk test were 0.647 and 0.294, respectively. This indicated that the data of pre-test had homogenous variances following a normal distribution

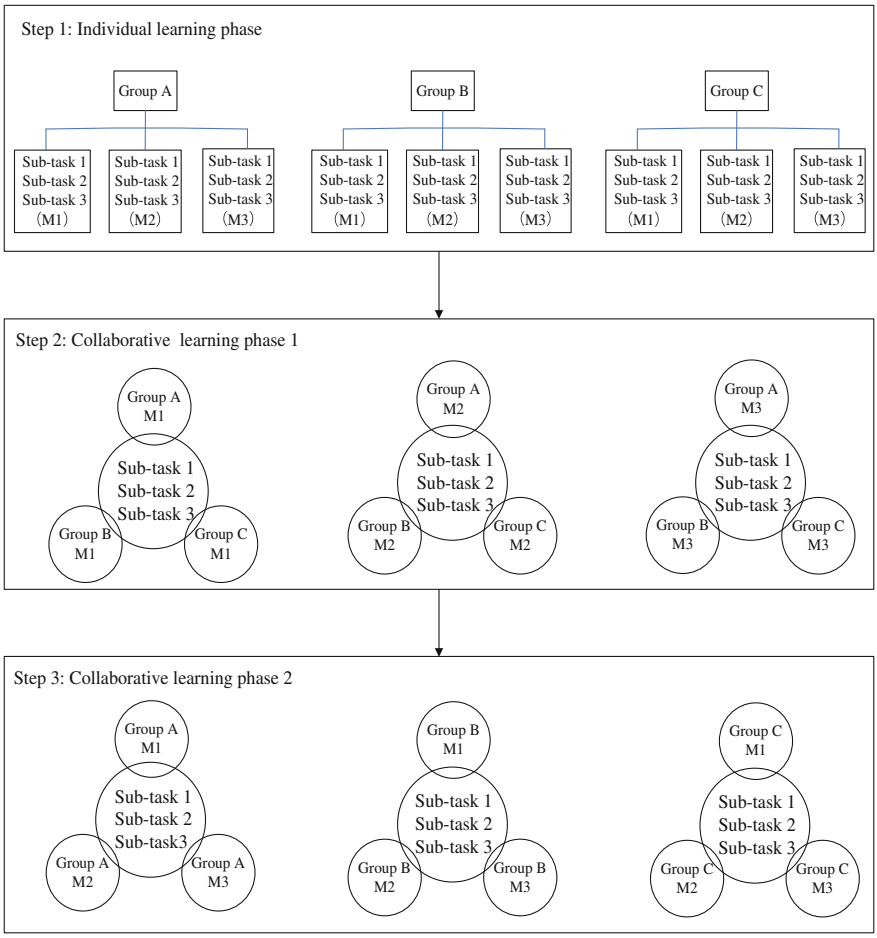

Fig. 8.3 The procedure of the modified jigsaw method

of data. With respect to the post-test, the results showed that the *p*-values for the Levene test and the Shapiro–Wilk test were 0.853 and 0.560, respectively. This indicated that the data of post-test had homogenous variances following a normal distribution of data. Therefore, the data could be analyzed with analysis of covariance (ANCOVA).

The findings indicated that the mean values and standard deviations of the pre-test for the experimental group were 12.78 and 7.07, and 13.12 and 6.61 for the control group, respectively. In terms of the pre-test, it was found that there was no significant difference between the experimental group and control group ($t = 0.147$, $p > 0.05$). This result indicated that the experiment group and control group had equivalent prior knowledge.

Table 8.1 shows the result of ANCOVA for the post-test. The result indicated that there was a significant difference in post-test between the experimental group and control group ($F = 4.38$, $p < 0.05$). That is to say the groups who conducted the modified jigsaw demonstrated better learning performance than those who conducted the conventional jigsaw approach.

8.4.2 Analysis of Task Cohesion

Since it was a new experience for the students to conduct the modified jigsaw activity, it was very interesting to examine task cohesion. Table 8.2 shows the *t*-test result for task cohesion. The means and standard deviations of the task cohesion were 3.94 and 0.71 for the control group, and 4.68 and 0.37 for the experimental group. It was very clear that there was significant difference in task cohesion between the experimental group and control group ($t = -3.819$, $p < 0.01$). These results indicated that the modified jigsaw can improve task cohesion.

8.4.3 Analysis of Collective Efficacy

Table 8.3 shows the *t*-test result for collective efficacy. The means and standard deviations of the collective efficacy were 3.51 and 0.64 for the experimental group and 4.23 and 0.43 for the control group.

The *t*-test result indicated that there was significant difference in collective efficacy between the experimental group and control group ($t = -3.936$, $p < 0.01$). This finding revealed that the modified jigsaw can improve collective efficacy.

Table 8.1 ANCOVA result of the post-test

Group	*N*	Mean	Standard deviation	*F*	*p*
Control group	17	15.76	7.73	4.38*	0.04
Experimental group	18	20.00	8.48		

*$p < 0.05$

Table 8.2 *t*-test result for task cohesion

Group	*N*	Mean	Standard deviation	*t*
Control group	17	3.94	0.71	−3.819**
Experimental group	18	4.68	0.37	

**$p < 0.01$

Table 8.3 *t*-test result for collective efficacy

Group	*N*	Mean	Standard deviation	*t*
Control group	17	3.51	0.64	−3.936**
Experimental group	18	4.23	0.43	

**$p < 0.01$

8.5 Discussion

This study examined the effectiveness of the modified jigsaw method in terms of group performance, task cohesion, and collective efficacy. The result demonstrated that the modified jigsaw method can significantly improve group performance in contrast with the traditional jigsaw method. This finding was consistent with Deiglmayr and Schalk (2015) who reported that the groups who learned using the modified jigsaw method acquired better learning performance than those who learned with the traditional jigsaw method. This result conformed with the study by Huang et al. (2014), which found that a jigsaw-based collaborative learning approach improved learning outcomes for mobile situated learning.

The finding also indicated that the modified jigsaw method was more effective than the traditional jigsaw method with respect to task cohesion. Task cohesion in this case refers to the group members' commitment to the group task (Wang and Hwang 2012). In terms of the modified jigsaw, it provided the opportunity for every group member to complete all of the sub-tasks. Thus, all the group members were obliged to complete all sub-tasks. The same task was helpful for establishing common ground and a shared understanding of the subject matter. Therefore, the modified jigsaw enhanced task cohesion further.

The result also demonstrated that the modified jigsaw method was more effective than the traditional jigsaw method with regard to collective efficacy. Collective efficacy is a group's shared beliefs in its ability to achieve goals (Bandura 1997). Previous studies indicated that collective efficacy had a positive effect on group processes (Bandura 2000; Lee and Farh 2004). Klassen and Krawchuk (2009) posited that collective efficacy was a socially shared cognition that progressed over time. In contrast with the traditional jigsaw, the modified jigsaw method improved collective efficacy because all of the group members had the same task and goals. Therefore, they had a shared belief that they could achieve the expected goals.

This study has some implications for teachers and practitioners. First, social interactions among group members are very crucial and important for successful collaborative learning. The learning outcomes of collaborative learning depend on how members interact with one other. Therefore, teachers should design elaborately the interaction processes before collaborative learning commences. There are many types of interactive strategies, such as brainstorming, jigsaw, peer assessment, and so on. Teachers should select the appropriate strategies according to the learning objectives and learning content. Second, common ground and shared cognition can facilitate social interactions during collaborative learning. Therefore, teachers need to design effective strategies to establish common ground and promote

convergence. Many shared collaborative leaning tools are very appropriate for providing shared space, which is a pre-condition for collaborative learning to some extent. Third, task features had an influence on collaborative leaning outcomes. Weak task interdependence can also improve learning performance, group cohesion, and collective efficacy.

This study was constrained by several limitations. First, the sample size was small both in the experimental group and control group. Therefore, caution should be made when generalizing these research results. Future studies will expand the sample size to examine the effectiveness of the modified jigsaw method. Second, this study was conducted in the lab so as to ensure the validity of the experiment. Future studies will adopt the modified jigsaw method in natural learning settings. Third, this study only designed one task related to educational statistics. Future studies will design different kinds of tasks so as to explore the relationships between task features and interactive strategies.

8.6 Conclusion

This study investigated the impacts of the modified jigsaw method on group performance, task cohesion, and collective efficacy. The modified jigsaw is an effective method to script collaborative learning. The findings of this study revealed that the modified jigsaw can improve group performance, task cohesion, and collective efficacy. Therefore, the modified jigsaw is more effective than the traditional jigsaw. This study also implied that interactions among learners are a central issue for productive collaborative learning. Future studies will conduct the modified jigsaw in different learning contexts, such as in mobile learning environments.

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