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The impacts of individual and collaborative learning of worked out examples on problem-solving transference and cognitive load

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ABSTRACT

This study aimed to compare the individual and collaborative learning of worked out examples in terms of impacts on cognitive load and transference of problem solving. To meet the aim, an experimental design with pretest-posttest and control group was used. Participants were 40 students in third grade from a guidance school. They were randomly assigned to two experimental groups (each group included 20 students). One group studied the worked out example (Thales theorem as seen in textbook of 3rd grade of guidance school) individually and the other group collaboratively. Cognitive load Measurement Scale and Transfer-test tasks were used for measuring variables. Finally, data were analyzed using independent sample T-test. Statistical analyses indicated that mean of transference scores of collaborative group was significantly higher than individual group, but mean of cognitive load in collaborative group was significantly lower than individual group. Results of the current study were consistent with Cognitive load theorem. It confirmed that some transitional activities such as negotiation are useful for learning and should be increased but some transitional activities like ways of discussion are harmful.

Keywords: individual learning, collaborative learning, transference, cognitive loa

INTRODUCTION

Extensive studies have been conducted about Collaborative Learning, and its efficacy and usefulness has been approved by many researchers. Collaborative learning is a widely used educational approach in which students work in small groups to achieve a common goal. In these groups, students are responsible for their learning and others, too. So, the success of one student helps the other one's success (Gokhale, 1995). Collaboration process includes discussion, argumentation, and reflection on task in progress, and results in deep processing of information and more rich and meaningful learning (Kirschner, Paas, & Kirschner, 2009a). In other words, collaborative learning refers to acquiring knowledge, skills, and functional capabilities of an interdependent collection of people through interaction and experience (Kozlowski & Ilgen, 2006). Knowledge and skills of each member transfer to other members through discussion. Specially, if group members have different areas of interest and proficiency, there will be more opportunities for associations, strategies and new operations. Exposure to different viewpoints results in increasing quantity and quality of generating ideas in group (Paulus & Yang, 2000). Collaborative learning is effective if the learning outcomes of N numbers of group members are higher than total learning results of N numbers of individual learners.

Studies which compare individual performance with group performance, show that in simple tasks such as recalling information, group performance is lower than individual (Kirschner, Paas, & Kirschner, 2009b; Andersson &

Ronnberg, 1995). However, studies show that in more complex tasks such as problem solving task, group performance is better than individual performance (kirschner et. al., 2009b; Laughlin, Bonner, & Miner, 2002; Kirschner, Paas, & Kirschner, 2011). This superiority of performance can be attributed to group interaction process that special knowledge of one member will distributed among others through process of communication and collaboration. Students who work alone are often confused and show this confusion by asking question or getting help (Baker, Corbett, Koedinger, Wagner, 2004). One solution to reduce aberrant behavior of asking help from others is using collaborative learning.

For explaining why collaborative strategies are better in learning difficult tasks, Kirschner and his colleagues (2009a) used cognitive load theory (Sweller, 1999; Van Merrinboer & Ayres, 2005). According to this theory, group has greater capacity of working memory, compared with an individual. In cognitive load theory, capacity of working memory plays an important role in learning. Working memory is limited in terms of information storage and information processing (Cowan, 2001). In complex tasks such as problem solving, most working memory resources are allocated to problem solving, and do not spent in learning. So, problem solving approach generates extraneous cognitive load. Moreover, the complexity of learning content refers to intrinsic cognitive load and as task complexity is higher, intrinsic cognitive load is higher. If intrinsic or extraneous cognitive load is high, the valuable resources of limited working memory are not sufficient for learning task and small capacity of this memory remains for activities related to deep learning (germane cognitive load) (Sweller, Ayres, & Kalyuga, 2011). Kirschner, Paas, & Kirschner (2010) believe that in complex tasks, high intrinsic or extraneous cognitive load can be divided among group members to remain more space of individual's working memory (processing capacity) for activities related to deep learning (germane cognitive load).

According to cognitive load theory, learners in collaborative groups are considered as information-processing systems (Tindale & Kameda, 2000). These groups are composed of several limited working memory, which create collaborative working spaces. Valuable knowledge and information related to task which each individual has, will be broadcasted (retrieving and interpreting information), being discussed (encoding and description of information), and recalled (information customization and storing) consciously and actively (Tindale & Sheffey, 2002). Therefore, there is no need to obtain all knowledge and processing available information by all group members at the same time. With increasing communication and coordination among group members, intrinsic cognitive load will be distributed among unlimited working memory of group which is composed of several group members' working memory (Sweller, Merrienboer, & Paas, 2011; Kirschner, Paas, & Kirschner, 2009b; Ohtsubo, 2005). Kirschner, Paas, Kirschner & Janssen (2010) called this group feature as distribution advantage. On the other hand, learners in group should spend some of their limited cognitive resources (mental effort) for transmitting information and coordinating their actions which is not necessary in individual learning (Kirschner, Paas, & Kirschner, 2011; Kirschner, Paas, & Kirschner,2009a). Kirschner and his colleagues (2011) have called this feature as transactional activities which result in increasing extraneous cognitive load. Based on cognitive load theory, some transactional activities such as negotiation are beneficial for learning and should be increased but some transactional activities such as discussion ways are harmful for learning. Therefore, using collaborative learning in difficult tasks results in enjoyment of distribution advantage and useful transactional advantages; but detrimental transactional activities are involved in simple tasks (Sweller, Ayres, & Kalyuga, 2011). Using distribution advantage and information processing among members and avoiding harmful transactional activities are the indicator of group learning efficiency which is called collaborative working memory effect in cognitive load theory (Kirschner et. al., 2010; Sweller, Ayres, & Kalyuga, 2011; Kirschner, Paas, & Kirschner, 2009a; & Kirschner, Paas, Kirschner & Janssen, 2010).

Although, until recently it was thought in cognitive load theory that cognitive load principles should be based on features of human cognitive architecture, one implication of collaborative working memory for cognitive load theory is that functional features of pervasive cognitive architecture changes in collaborative learning (Kirschner, Paas, Kirschner & Janssen, 2010). In the case of detrimental transactional activities, (e.g. ways of discussion and truancy) Sweller, Ayres and Kalyuga (2011) believe that it can be solved by training learners.

Findings of recent studies about collaborative learning of workedout examples are contradictory (Chi, Roy & Hausmann, 2008; Craig et. al., 2009; Kirschner et. al., 2010; Rummel & Spada, 2005; Rummel et. al., 2009). Kirschner and his colleagues (2010) found that individual learning of worked out examples is more effective than collaborative learning of them, but in learning through problem solving, collaborative method leads to better results. They consider the high cognitive load of problem solving method as main cause of this phenomenon. In contrast, Chi and colleagues (2008), Rummel & Spada (2005), and Rummel Spada & Hauser, (2009) found that collaborative learning (compared with individual learning) of solved problems is more effective. Retnowati, Ayres and Sweller (2010) found that although learners prefer collaborative learning of worked out examples to individual learning, but there is no significant difference in terms of performance in (far and near transfer test) between two groups of individual and collaborative learning. They consider voluntariness of collaboration and redundancy as main causes of the lack of superiority of collaborative to individual learning. Integrating data gathered from group members and information from worked out examples (as they are from two different resources) result in increasing cognitive load. Kirschner and colleagues (2009) suggested four accounts for the uncertainty of results in this field. First, group processes have been measured instead of measuring directly learning outcomes. Second, rigorous randomized controlled trials have been rarely performed. Third, poor goals have been identified. And forth, individual performance of group members has not been measured. As Kirschner and colleagues (2009b) believed that high level of detrimental transactional activities leads to collaborative learning have no superiority on individual learning, so they transfer only some of necessary information to learners of collaborative group. It means that only one third of necessary information is available for each member. Their results show that individual groups were more efficient in recalling test but members of collaborative groups were more successful. They consider low harmful transactional activities as main cause of this superiority. Some researchers believe that collaborative learning is useful for difficult tasks (Laughlin, Hatch, Silver, & Boh, 2006) but individual learning is useful for simple tasks (Andersson & Rönnberg, 1995). Kirschner, Paas, Kirschner (2011) found that in simple tasks, cognitive load of individual learning group was lower than collaborative learning group but the results were the reverse in difficult tasks. This interaction was also true for learning time and efficiency scores but not for performance scores. They concluded that individual learning was more efficient than collaborative learning in simple tasks, but in complex tasks using working memory of group members and sharing cognitive load among members compensate the cognitive load resulting from information transference (Kirschner and colleagues, 2011). As the students were not allowed to use pencil and paper during reading phase, questions have only one right answers.Questions were designed so that reduce the effects of transitional activities, and also difficulty in determining the hardiness level of task (according to different previous knowledge of members), generalization of findings are accompanied with uncertainty in real learning situations. Furthermore, this topic is relatively new and there is limited information about it. So, considering the various findings in this field, this study aimed to investigate the individual and collaborative learning of workedout examples in terms of impacts on cognitive load and transference of problem solving.

MATERIALS AND METHODS

In this study, an experimental design with pretest-posttest was used.

Participants: Participants were 40 students in third grade from a guidance school. They were randomly assigned to two experimental groups (each group included 20 students). They participated in the study as part of their routine curriculum. No differences were expected in prior knowledge because all participants had followed the same math courses in previous sessions and the topic of this session was new for them.

Instruments:

a)Cognitive load Measurement Scale: To measure the participants' cognitive load, index of mental effort expended during the problem solving phase was used. For this purpose, the 9-point cognitive-load rating scale which developed by Paas (1992) was used in which participants were asked to rate on a scale ranging from very, very low effort (1) to very, very high effort (9) how much effort they do to solve a problem. This cognitive load measure has been proven to be valid and reliable as Paas (1992) has reported its coefficient of internal consistency (cronbach's alpha)as 0/90 and also Paas, Van Merriënboer (1994) as 0/82.

Generally speaking, this is a valid index for measuring cognitive load. Paas Van Merriënboer, & Adam (1994) has reported its validity as 0.81 using test-retest method and also Huang (2003) reported 0/84 using similar method. Stark, Mandl, Gruber & Renkl (2002) also reported Cronbach's Alpha as 0.89 for this scale using the same test-retest method.

b)Transfer-test tasks: In current study, the transfer of problem solving was measured as the learning outcome. Here, transfer means how well participants can apply their knowledge and skills acquired to new problem-solving situations. So, eight transfer-test tasks were designed which were the same as – in method and pattern – those in other studies like Renkl (2002), Renkl, Atkinson (2003), Renkl, Atkinson and Grob (2004) and Sweller (2006) and other researchers in this field.

Two scorers were selected for scoring transfer-test tasks. They were both teachers of third grade guidance school and were not informed of experimental conditions. All answer sheets were scored by both teachers. Correlation coefficient between scores of two teachers were 0/96 in transfer-test task (P<0/001). Final score of each participant was the average of scores by two teachers.

Procedure:
The study was done in three phases of pretest, training and assessment. As work style was different in two groups, guidelines provided for them were different, too. In the first step, the study's goal was explained for participants by the researchers. Individual group were asked to be quiet and do not perform any reasoning and action during the process of reading and answering the questions that lead to distraction of their friends. Collaborative group were asked to sit down in a circle and allow members to fully express their ideas. They were asked to choose a person to take notes during discussions and present a summary for members at the end. Members should all collaborate in discussion and express their ideas. The second step, was presenting educational content to subjects. At this stage, subjects studied the educational contents related to their group and do their tasks depending on which groups they belong to. While practicing (worked out examples), participants of collaborative group resolved in group (collaboratively) the previously worked out examples.

In the third step, after studying educational content, participants answered to cognitive load measurement scale. After that, in forth step, the transfer-test tasks were administered and participants were asked to read the presented problems carefully and do their utmost in resolving presented problems. In this step, they couldn't refer to educational content because it was out of their reach.

Intervention (material): the content of worked out examples was Thales Theorem presented in math textbook of third grade guidance school. At first two questions using Thales Theorem has been resolved step by step and Thales Theorem was stated. After that two questions related to Thales theorem was administered to participants as practice and they were asked to solve it.

Participants in collaborative learning group were asked to, while studying worked out examples, communicate their findings with other members. In individual learning group, each participant studied the content of worked out examples individually.

RESULTS

In order to compare cognitive load during study, test and problem solving transference in two groups, independent sample T-test was used. Statistical analysis showed that there is significant difference between collaborative learning group and individual group in transfer (T(38): 4.071, Sig: .000 , d: .63), cognitive load during studying reworked out examples (T(38): 3.571, Sig: .001, d:1.23) and cognitive load during test (T(38): 4.389, Sig: .000, d: .86).

Table 1: Means and standard deviations of the dependent variables in the learning and test phase

Variables	Groups			
	Individual learning (n:20)		Collaborative learning (n:20)	
	M	SD	M	SD
Cognitive load of studying worked examples	2.425	.86	3.36	.80
Cognitive load of transfer test	3.025	.70	2.025	.74
Problem solving transfer	5.51	1.82	7.40	.98

Table1 shows that mean of transfer and cognitive load when reading in collaborative group is significantly higher than mean of transfer and cognitive load in individual groups. But mean of cognitive load when testing in collaborative group is significantly lower than mean of transfer and cognitive load in individual group. Statistical analysis shows that d value is higher than average in all dependent variables.

CONCLUSION

Mean of cognitive load through reading and transfer time in collaborative group were higher than individual group. But, it was contrary in the case of exam. According to cognitive load theory, if learner report a lot of mental effort through learning the content and also his performance in transfer-task test is high, the experienced cognitive load is a germane type. In addition, the cognitive load during test has remarkable contribution to detecting the type of cognitive load (Tuovinen and Paas, 2004). It means that, if cognitive load is high at the time of the study, reported cognitive load at the time of exam is low, and performance is high in transfer-task test, the cognitive load of that educational method will be of germane type.

As it was mentioned in introduction, the main cause for the superiority of collaborative learning group over individual learning group is that intrinsic and extraneous Cognitive load are distributed among group members and each person's capacity of processing increases for relevant cognitive load (Kirschner and colleagues, 2008).

Furthermore, the argument takes place in group is a germane activity which results in deep learning (Kirschner, Paas, and Kirschner, 2009).

Results of the current study are consistent with findings of chi and colleagues (2008), Rummel and Spada (2005), Rummel, Spada, and Hauser (2009). These researchers found that collaborative learning of worked out examples are more efficient. However, these are not consistent with Kirschner and colleagues (2010) which found that individual learning of worked out examples are more efficient than collaborative one but learning through problem solving, while using collaborative method, leads to better results than individual method. They believe that this issue is due to high cognitive load of problem solving. In contrast, Retnowati, Ayres and Sweller (2010) found that despite learners prefer group study to individual study of worked out examples, but there is no significant difference between these two groups in terms of performance in near and far transfer-task test. It is natural that as the difficulty level of educational content is high or in other words, learning task is very difficult and sophisticated, cognitive load is more than limited capacity of working memory. In the present study, the learning content (Thales theorem) is of high difficulty, so, consistent with cognitive load theory, the cognitive load is more than limited capacity of working memory.

Based on cognitive load theory, some transitional activities such as negotiation are useful for learning and should be increased but some transitional activities like ways of discussion are harmful. One feature of the current study was originality of its educational content and real and natural condition of administration in classroom. It was administered precisely based on the class syllabus, as the class reached to Thales Theorem. In other words, in a real class the Tales Theorem was taught through solved example method, instead of teaching by permanent math teacher. So, it implies that previous problems of ecological validity were improved and therefore it has of great generalization capability.

One theoretical implication of this study is that in the difficult and complex issues, an individual's limited working memory can be increased through collaborative learning, but researchers, in the future should consider the artificial aspects of experiment in effects of cognitive load caused by learning tasks on efficacy and efficiency of collaborative learning.

REFERENCES

[1]Andersson, J., & Ronnberg, J. *Applied Cognitive Psychology*, **1995**. 9,199–211.

[2]Baker, R.S., Corbett, A.T., Koedinger, K.R., Wagner, A.Z. Off-Task Behavior in the Cognitive Tutor Classroom: When Students "Game The System". *Proceedings of ACM CHI* **2004***: Computer-Human Interaction,***2004**. 383-390.

[3]Chi, M. T. H., Roy, M., & Hausmann, R. G. M. *Cognitive Science,* **2008**. *32,* 301–341.

[4]Cowan, N. *Behavioral and Brain Sciences*.**2001**.24, 87–114.

[5]Craig, S. D., Chi, M. T. H., & VanLehn, K. *Journal of Education & Psychology*.**2009**. 101, 779–789.

[6]Gokhale, A. A. *Journal of Technology Education.***1995**. *7,* 22–30.

[7]Huang, G. J. *Computers and Education,* **2003**.*40(3),* 217–235.

[8]Kirschner, F., Paas, F., & Kirschner, P. A. *Educational Psychology Review*, 21, 31e42.**2009a**. doi:10.1007/s10648-008-9095-2.

[9]Kirschner, F., Paas, F., & Kirschner, P. A. Individual and group-based learning from complex cognitive tasks: effects on retention and transfer efficiency. Computers in Human Behavior, 25, 306e314. **2009b**. doi:10.1016/j.chb.**2008**.12.008.

[10]Kirschner, F., Paas, F., & Kirschner, P. A. *Applied Cognitive Psychology*. Advance Online Publication. **2010**.doi:10.1002/acp.1730.

[11]Kirschner, F., Paul, F., & Kirschner, P. A. *Computers in Human Behavior,* **2011**. 27(1): 53-57.

[12]Kirschner, F., Paas, F., Kirschner, P. A., & Janssen, J. Effects of instructional format on individual and collaborative learning efficiency: Solving conventional problems versus studying worked examples,**2010**. Manuscript submitted for publication.

[13]Kozlowski, S. W. J., & Ilgen, D. R. *Psychological Science in the Public Interest*, **2006**.7(3), 77-124.

[14]Laughlin, P. R., Bonner, B. L., & Miner, A. G. *Organizational Behavior and Human Decision Processes,***2002**. 88, 602–605.

[15]Laughlin, P. R., Hatch, E. C., Silver, J. S., & Boh, L. *Journal of Personality and Social Psychology*, **2006**.90, 644-651.

[16]Ohtsubo, Y. *Applied CognitivePsychology,* 19, 1219e1233. **2005**.doi:10.1002/acp.1162.

[17]Paas, F. *Journal of Educational Psychology,* **1992**. *84,* 429–434.

[18]Paas, F. & van Merrienboer, J. *Journal of EducationalPsychology,* **1994**. *86(1)*, 122-133.

[19]Paas, F. G. W. C., Van Merriënboer, J., J.G., & Adam, J. J. *Perceptual and Motor Skills,* **1994**.*79,* 419-430.

[20]Paulus, P. B., & Yang, H. C. *Organizational Bahavior and Human Decision Processes,***2000**.*82*, 76-87.

[21]Renkl, A. *Learning and Instruction*, **2002**. *12*, 529-556.
[22]Renkl, A., & Atkinson, R. K. *Educational Psychologist,* **2003**. *38,* 15–22.
[23]Renkl,A., Atkinson,R.K.,&Grobe .C .S. *Instructional Science*,**2004**.*32*,59-82.
[24]Retnowati, E., Ayres, P., & Sweller, J. *Educational Psychology,* **2010**. *30*, 349–367.
[25]Rummel, N., & Spada, H. *Journal of the Learning Sciences,* **2005**. *14*(2), 201-241.
[26]Rummel, N., Spada, H., & Hauser, S. International Journal of Computer-Supported Collaborative Learning, **2009**,4, 69–92.
[27]Stark, R., Mandl, H., Gruber, H., & Renkl, A.. *Learning and Instruction*, **2002**.*12*, 39-60.
[28]Sweller, J. (**1999**). Instructional design in technical areas. Melbourne: ACER Press.
[29]Sweller, J., Van Merriënboer, J. J. G., & Paas, F. G. W. C. *Educational Psychology Review,* **1998**. *10(3),* 251-296.
[30]Sweller, John .The worked example effect and human cognition. *Learning and instruction* , **2006**. *16*,165-169.
[31]Sweller, J., Ayres, P. & Kalyuga, S. Cognitive load theory. **2011**. New York: Springer
[32]Tuovinen, J. E., & Paas, F. *Instructional Science*,**2004**. *32*, 133-152.
[33]Tindale, R. S., & Kameda, T. *Group Processes and Intergroup Relations*,**2000**.3, 123-140.
[34]Tindale, R. S., & Sheffey, S.. *Group Processes and Intergroup Relations*, **2002**. 5, 5-18.
[35]Van Merriënboer, J. J. G., & Ayres, P. *Educational Technology, Research and Development*, .**2005**.53, 5–13.