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The Effect of Explanation and Solved Examples on Students' Transfer, Intrinsic Motivation and Cognitive Load in English Courses

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Abstract

Learning can only maintain its functional originality when it leads to permanent changes, and such changes are only possible if accompanied by self-explanation. The current study was conducted to investigate the effect of self-explanation and the solved examples on students' transfer, intrinsic motivation, and cognitive load in English courses. It was an experiment in the form of a 2×2 generalized random block design. The population consisted of all 8th-grade students in Semnan, Iran, from whom 120 students were selected applying random sampling – by considering a figure for each student, writing each figure on a piece of paper, putting all inside a pack, mixing them together, and drawing one piece out each time to get 120 candidates. Teaching English was done using the "Solved Examples" method. The instruments applied to collect the data included the Intrinsic Motivation Questionnaire by Kuvaus and Dysvik (2009), the Cognitive Load Questionnaire by Paas and van Merrienboer (1993), and the researcher-made questionnaire of near and far transfer. The statistical analysis of the data was conducted using the Two-way Analysis of Variance (ANOVA). The findings indicated that the format of presenting content (ordinary and erroneous solved examples) and self-explanation are correlated significantly with the near and far transfer, cognitive load, and intrinsic motivation (P<0.01). Based on the obtained results, it can be argued that self-explaining and presenting solved examples are useful strategies to enhance students' transfer, intrinsic motivation, and cognitive load in learning English, and can be included in the curriculum of schools to empower students in solving intellectual problems.

Keywords: Cognitive Load, Intrinsic Motivation, Self-explanation, Solved Examples, Transfer

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Introduction

Learning and education are among the main priorities of any education system and aim at increasing students' attainment through scientific and educational activities. However, meaningful and useful learning can only be formed when it is influenced by processes that are intrinsic and based on cognitive activities (Velaayatee, Kan'aanee, & Ramezaanee, 2013). Processing various educational and scientific methods and activities require a certain amount of cognitive load. The cognitive load is a theory that has led to significant studies on designing curriculum and cognitive activities for students (Chen et al., 2018).

According to the cognitive load theory, human beings have a cognitive structure comprised of sensory recorders, active memory, and long-term memory. The main problem in education according to the principles of the cognitive load theory is that while the long-term memory has unlimited capacity, the active memory is quite limited in terms of saving and information processing potential (Wynder, 2018). Two factors influence the capacity of the active memory while learning; the internal cognitive load, and the external cognitive load. The internal cognitive load is determined according to the complexity of the materials being learned, while the external cognitive load depends on the form of education (e.g., written, dramatic, practical, etc., and the performance of various activities (e.g., problem-solving and presenting examples) (Aali, Khorami, & Eslami, 2019).

Motivation is considered the strongest propulsive force in educational diligence. Intrinsic motivation indicates situations where individuals freely involve themselves in activities that they consider enjoyable and interesting. People with intrinsic motivation experience interest, pleasure, and the feeling of expertise and control while doing work (Calderon, 2020).

One of the indicators of educational and learning efficiency is the ability to transfer the learned material to others. Acquiring knowledge is useless if an individual cannot transfer such information to new situations. Applying the information, knowledge, and skills acquired in a particular situation to new situations or problems is considered transfer (Ghanbari et al., 2017). Thus, learning transfer is considered a major and vital component of the learning process, and as a way to prevent the harms related to the reduced performance (Wilson & Soblo, 2020). The transfer has been classified into several groups, and four classes of this concept have been investigated in the current study: general transfer, particular transfer, positive transfer, and negative transfer.

Teachers and educational planners have to identify materials with high cognitive load to improve learners' education and come up with convenient strategies to eliminate unnecessary cognitive load. One of the solutions proposed to reduce mental involvement and unnecessary cognitive load is the use of professional or educational examples (i.e., solved examples). Example-based learning is a well-known, broad, and effective approach to teaching new content to learners (Renkl, 2014). Presenting educational solved examples leads to the teaching of abstract principles, which are essential for learning and focus learners' attention on the information required to understand the schemata instead of unnecessary items (Tempelaar et al., 2020). Since the solved examples technique is not sufficient to guarantee the attainment of favorable learning outcomes, combining it with techniques that increase cognitive load can be effective in the enhancement of learning. A technique that can be effective in increasing cognitive load is self-explanation (Ghanbari, Hassanabadi, & Kadivar, 2016).

Self-explanation is an explanatory technique through which learners explain themselves whatever they have learned and as a result, they are involved in active learning (Rittle-Johnson, 2017). Encouraging learners to explain scientific ideas while studying is an effective tool for improving learning and transfer it to different knowledge areas (Johnson, 2010). Studies have shown that a combination of educational explanations, solved examples, and self-explanation is more effective than solving problems without any control and guidance and results in improved learning and motivation (Dunloski, Badali, Rivers, & Rawson, 2020; Renkl, 2014). Very few studies have been conducted on the application of solved examples in homework with a weak structure, and no study has so far been conducted to compare the incomplete and ordinary solved examples. Due to the importance of "self-explanation" in the field of education and learning and the fact that the simultaneous impact of both concepts on such variables as "learning transfer", "intrinsic motivation", and "cognitive load" has not been investigated, reviewing the studies conducted in the field indicated that there is a research gap and the subject has not been taken into consideration. Thus, the current study was designed and conducted to investigate the effect of explanation and solved examples on students' transfer, intrinsic motivation, and cognitive load in learning English.

Method

The current study used an experimental methodology in the form of 2×2 generalized random blocks where there were two factors including explanations in two levels (1. self-explanation, 2. Educational explanations) and solved examples in two levels (1. ordinary, 2. incomplete). To study various combinations of these variables, it was essential to design four groups in the form of self-explanation – ordinary, self-explanation – incomplete, educational explanation – ordinary, and educational explanations – incomplete, and investigate them. In the current study, in addition to the simple effects of the independent variables, their mutual effects were investigated, as well. Participants
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Participants

The population of the study included all 8th-grade students in Semnan, Iran, who enrolled in schools in the 2018-19 academic year. Within the population, 1219 students attended public schools, while 137 students attended private ones. Since the independent variables included explanation (1. Self-explanation and 2.

Educational explanation) and solved examples (1. Ordinary and 2. Incomplete), 30 students were randomly assigned for each level, and the total size of the sample was set at 120 students. The entry criteria of the study were attending the 8th grade, being female, and providing an informed consent form to take part in the study. In addition, lack of interest to participate, receiving educational or medical treatment concurrent with this study, and taking part in special programs or festivals (e.g., Kharazmi Festival) were the exit criteria.

Instruments

The following questionnaires were applied in the current study:

The Intrinsic Motivation Questionnaire (IMQ): To assess intrinsic motivation, the 6-item questionnaire developed by Kuvaus and Dysvik (2009) was implemented. Participants in the study responded on a 5-point Likert scale from 1: completely disagree to 5: completely agree. The questionnaire has high validity due to being standardized. The Cronbach-Alpha calculated for this questionnaire is 0.83, which is very convenient (Barati & Oreyzi Samani, 2016).

The Cognitive Load Questionnaire: This questionnaire measures the mental scaling of cognitive load, and has been designed by Paas and van Merrienboer (1993). At the end of each session, students were asked to respond to the questions "how much mental effort have they made on solving the problems" (how much difficult were the examples and practices to them) on a 7-point scale from 1: very low mental effort to 7: very high mental effort. The Cognitive Load Questionnaire was distributed among the respondents to assess their cognitive load while taking an exam after the problems were solved. In the study of Paas and van Merrienboer, the Cronbach-Alpha values obtained for the cognitive load measurement scale were reported as 0.90 and 0.82, respectively (Abdi & Rostami, 2018).

The Far and Near Transfer Tests: These tests included three questions on far transfer and three questions on near transfer. The questions of the near transfer tests were quite similar to the discussed problems in terms of appearance and structure, while the questions in the far transfer test were quite different from such problems (Tabatabaee, Ejei, Hassanabadi, & Abdous, 2013). In the current study, far and near transfer were assessed the consequences of learning. The near transfer was assessed using 2 problems (very similar in terms of structure to the problems discussed in the training stage), while the far transfer was assessed using 2 other problems (very different in terms if structure to the problems discussed in the training stage and also more difficult).

Estimation of the Difficulty Level of the Transfer Test: The level of difficulty of the far and near transfer tests was calculated using the method proposed by Nitko (2001). In this method, the difficulty index of an open-ended question is obtained by dividing the score of that question with the range of possible scores for that question, and the resulting number will range between 0 and 1. In the current study, the mean of each 3 questions in the near transfer and far transfer tests was calculated for the total group of the participants (N = 120). Then, the calculated mean values were divided by the possible range of the scores for that particular question. The possible range for each question was 2. Then, the resulting number was multiplied by 100, and the difficulty index of the questions was obtained as illustrated in the following Table.

Table 1.

The Difficulty Coefficients of the Questions in the Near and Far Transfer Tests

Far transmission					**Near transfer**			
Index	Far transfer test	Question 3	Question 2	Question 1	Near transfer test	Question 3	Question 2	Question 1
Mean	820/	650/	790/	02/1	91/3	10/1	32/1	49/1
Difficulty level	33/37	5/21	5/39	51	83/63	51	66	5/74

Table 1 indicates that the difficulty level of the near transfer test was lower than the ones in the far transmission test. The convenient difficulty range of the questions in the two tests was 0.3 (30) - 0.7 (70), and values below 0.3 and above 0.7 were considered difficult and easy, respectively. The study was conducted after providing the students with required explanations, making sure that their information and identity will be kept private, and obtaining their written consent form. The obtained data were analyzed using the IBM SPSS22 in terms of the descriptive (mean, SD, Min, Max) and inferential (analysis of variance) statistics.

Procedure

Regarding the conduct of the study, the timing of the experiment was set in a way that the examinees were able to study similar subjects and solve their problems in advance. The researcher obtained the teacher's approval to teach the following sections. Thus, the timing of attending classes was rather conforming to the presence in the hall, and the teaching content and later the related tests were provided to students with convenient spatial distance. The issue concerning which group received what content was completely random. The study was conducted in three general stages including the pre-test, test, and post-test. In the first stage of the study, the examiner described the goal of the study by explaining that the sheets contained a topic related to the English course, and invited them to focus. The participants were asked to avoid starting any distracting argument or action while answering the questions. They were asked to read carefully and do whatever had been asked them on the sheets. In addition, they were explained that there is no time limit.

The second stage was presenting the examinees with educational content. In this stage, the examinees received content specific to their group. In the third stage, the cognitive load questionnaire, which attempted to assess the mental endeavor made by students while working on the educational content, was distributed among the participants. After responding to the questionnaire in the fourth stage, the transfer questionnaire was distributed, and the students were asked to read the problems carefully and try their best to solve them.

At this stage, they were told that striking through the text is acceptable, and they should reply as much as they can even if they are unable to solve a problem completely. They were asked to write any solution that came to their minds in response to each solution. While answering the problems of the transfer test, the examinees could not access the educational materials since they had been collected after the study. In the fifth step, after performing the transfer test, the Questionnaire of Cognitive Load was distributed among the respondents to assess their cognitive load while solving the problems of transfer, and later the respondents filled the Motivation Questionnaire. In the end, they were appreciated for their taking part in the study. To control the time, the respondents were given enough time to study and explain the educational material, and they were told explicitly that there is no time limit at any stage. The time set to perform the test and respond to the questionnaires was 45 minutes.

Findings

In the current study, 120 eighth grade students in Semnan, Iran, participated. Table 2 provides the descriptive statistics and the variables of the study. The calculated values obtained for the Mean and SD of the cognitive load of learning, near transfer, far transfer, and intrinsic motivation were 5.16±2.19, 5.0±22.99, 3.30±1.58, and 17.30±4.35, respectively. The results of skewness and kurtosis confirmed that the distribution of the scores obtained for the variables is normal.

Table 2.
The Descriptive Investigation of the Research Variables

Variable	Minimum score	Maximum score	Mean±SD	Variance	Skewness	Standard error of skewness	Kurtosis	Standard error of kurtosis
Cognitive load	1.00	9.00	2.19±5.16	4.82	-0.03	0.26	-0.67	**0.53**
Near transmission	3.25	7.25	0.99±5.22	0.99	0.07	0.26	-0.74	**0.53**
Far transmission	1.00	7.25	1.58±3.30	2.50	0.92	0.26	0.02	**0.53**
Intrinsic motivation	11.00	27.00	4.35±17.30	18.99	0.48	0.26	-0.73	**0.53**

The descriptive statistics related to testing the interactive impact of explanation and solved examples on near transfer have been presented in Table 3.

Table 3.
The One-Way Analysis of Variance on the Impact of Explanation, Solved Examples, and Their Interactive Impact on Near Transfer

Variables (treatments)	Sum of squares	Degree of freedom	Mean of squares	F	P-value	Eta squared
Modified model	42.171	3	14/057	29/591	0/0001<	0/539
Solved example	3.301	1	3/301	6/948	0/01	0/084
Explanation	38.851	1	38/851	81/784	0/0001<	0/518
Solved example*explanation	0.020	1	0/020	0/041	0/840	0/001
error	36.103	76	0/475			

The findings indicated that the type of solved example ($F=6.94$, $P<0.005$, $\eta^2=0.08$) and explanation ($F=81.78$, $P<0.005$, $\eta^2=0.51$) have a significant effect on far transfer, while the interactive impact of the type of solved examples and explanation ($F=0.04$, $P=0.840$, $\eta^2=0.00$) on far transfer is not significant. The mean obtained for near transfer in ordinary solved examples (5.2±02.38) was below the mean obtained for near transfer in the erroneous solved examples (5.43±3.34), and the difference was found to be significant ($P<0.005$). In addition, the mean obtained for the near transfer in the educational explanation (4.53±2.37) was found to be below the value obtained for near transfer in the self-explanation group, and the difference was found to be significant ($P<0.05$).

The interactive impact of explanation and solved examples on far transfer

The impact of solved examples ($F= 130.41$, $P<0.005$, $\eta^2= 0.63$), explanation (=141.31, $P<0.005$, and $\eta^2=0.65$), and the interactive impact of solved examples and explanation ($F=37.44$, $P<0.005$, $\eta^2 = 0.33$) on far transfer were found to be significant. The mean of far transfer in the group of ordinary solved examples (2.1±38.09) was found to be below the mean obtained for far transfer in the group of erroneous examples (4.21±2.21), and this difference was found to be significant (P,0.05). In addition, the mean of far transfer in the group of educational explanations (2.35±1.41) was below the mean of far transfer in the group of self-explanation (4.3±25.11) and this difference was found to significant. ($P<0.05$).

The interactive impact of the type of solved examples and explanation on the cognitive load while studying

The impact of the type of solved examples ($F=107.04$, $P<0.005$, $\eta^2=0.58$) and explanation ($F=124.32$, $P<0.005$, $\eta^2 = 0.62$) on the cognitive load while studying was found to be significant, but the interactive impact of the type of solved examples and explanation ($F= 0.09$, $P=0.764$, $\eta^2 = 0.00$) on the cognitive load while studying was not significant. The mean of cognitive load while studying in the group of solved examples (3.1±87.15) was below the mean of cognitive load while studying for the group of erroneous examples (6.45±2.44) and this difference was found to be significant ($P<0.05$). In addition, the mean of cognitive load while studying for the group of educational explanations (3.1±77.43) was below the mean of cognitive load while studying in the group of self-explanation (6.55±1.35) and this difference was found to be significant ($P<0.05$). The mean of educational explanations (5.10±1.16) in the group of erroneous solved examples was above that of the ordinary solved examples (2.11.16) in the group of erroneous solved examples was above that of the ordinary solved examples (2.1±45.05). In addition, the mean of self-explanation in the group of erroneous examples was found to be above the ordinary solved examples (5.1±30.03).

The interactive impact of the type of solved examples and explanation on intrinsic motivation

The impacts of the type of solved examples ($F=9.71$, $P<0.05$, $\eta^2 = 0.11$) and explanation 9F=83.10, $P<0.005$), $\eta^2 = 0.52$) on intrinsic motivation were found to be significant. In addition, the interactive impact of the type of solved example and explanation on intrinsic motivation ($F= 13.41$, $P<0.005$, $\eta^2 = 0.15$) was also found to be significant. The mean of educational explanations (14.55±2.68) in the group of ordinary solved examples was above the mean of educational explanations obtained for the group of erroneous solved examples (14.2±20.30). In addition, the mean of self-explanation in the group of erroneous examples (22.3±40.26) was found to be higher than the mean of self-explanation obtained for the group of ordinary solved examples (18.3±5.11).

Discussion

The current study was conducted to investigate the impact of explanation and solved examples on students' transfer, intrinsic motivation, and cognitive load while learning English. The findings indicated that the interactive impact of the type of solved examples and explanations on transfer is not significant. In addition, students with lower levels of knowledge managed to perform better and experience lower cognitive load in the test of near transfer after receiving educational explanations, but this did not affect the far transfer. In general, students who had received educational explanations performed better in the exams and experienced lower cognitive control. This was in line with the findings of Ghanbari et al. who found out that the impact of the different levels of explanation on the cognitive load while learning depends on learners' previous knowledge (Ghanbari et al., 2017). This finding can be justified because this group of students, processing has been conducted through thinking about the additional explanations and the reasons for the presentation of each step of the problem. On the other, using self-explanation was not found to be effective since self-explanation creates an exogenous cognitive load by interrupting the process of learning in the form of creating and writing the explanation text (Johnson & Mayer, 2010).

Another finding of the study showed that the mean of educational explanations in the group of erroneous solved examples is higher than that of the group of ordinary solved examples. Furthermore, the mean of self-explanation in the group of erroneous solved examples was found to be higher than that of the group of ordinary solved examples. The impact of the type of solved examples, the impact of explanation, and the interactive impact of the solved examples on far transfer were found to be significant. The man of far transfer in the group of ordinary solved examples was smaller than that of the group of erroneous solved examples, and this difference was to be significant. In addition, the mean of far transfer in the group of educational explanations was found to be smaller than that of the self-explanation group, and this was significant. This finding is in line with the study by Ghanbari et al. (2017) where it was shown that learners with higher levels of knowledge who had received educational explanations performed better compared to the self-explanation group. Based on this finding, if the goal is to assess performance in solving far transfer problems, using self-explanation by people who have higher levels of knowledge does not necessarily enhance learning performance. In addition, this was in line with the findings of Renkl (2014) who argued that the quality of explanation is a determining factor in the efficiency of leering and emphasized that self-explanation should be focused on fundamental principles – and not superficial issues (Renkl, 2014). Thus, it appears that explanations produced by students did not have the required quality to enhance their conative load. On the other hand, it is possible that these students experienced learning enrichment due to their particular learning conditions and were faced with deep learning. Thus, it is possible that they lacked the required schemata to solve far transfer solutions and they have benefitted more from educational explanations while solving this set of problems.

The mean of educational explanations in the group of erroneous solved examples was higher than that of the ordinary solved examples. Furthermore, the mean of self-explanation in the group of erroneous examples was higher than that of the group of ordinary solved examples. The impact of the type of solved examples and the impact of explanation on cognitive load while studying was significant, but the interactive impact of the type of solved examples and explanation on cognitive load while studying was not significant. The mean of the cognitive load while studying in the group of ordinary solved examples was below that of the group of erroneous solved examples, and this difference was found to be significant. In addition, the mean of the cognitive load while studying in the group of erroneous solved examples was below that of the self-explanation group, and this difference was found to be significant. In this regard, the current study is in line with the study by Hasaanabadi and Nuri (2008) where presenting educational explanations to enhance leering and reduce the cognitive load of learners with lower levels of knowledge has been described as useful. This finding emphasizes that learners in the early stage of learning need to construct schemata regarding the subject being taught; thus, using techniques of self-explanation in making convenient scaffolding and attaining better performance in complicated tasks that have been constructed dynamically is essential for learning situations and learners' cognitive characteristics (Hassanabadi & Nuri, 2008). The study by Ghanbari et al. indicated that using self-explanation compared to situations where the explanation is in the form of production or writing reduced learners' cognitive load and enhanced their performance in solving examples (Ghanbari et al., 2017). This was confirmed by Johnson and Mayer (2010) as well.

The mean of educational explanations in the group of ordinary solved examples was higher than that of the erroneous solved examples. In addition, the mean of self-explanations in the group of erroneous solved examples was found to be higher than that of the ordinary solved examples. This was found to be in line with the findings of Darvish Baqal et al. (2013). In investigating the impact of educational packages on students' motivation, Ghadampour, Khalilpour, and Rezaeian (2019) found that presenting and teaching according to metacognitive packages increase students' intrinsic motivation and educational achievement, and this is in line with the current study.

Conclusion

As to explaining the findings in the current study, it can be argued that students who get familiar with different models of problem-solving through the application of educational packages have a higher intrinsic motivation to continue their studies. In addition, such students understand and perceive educational materials deeply and improve their capabilities with higher motivation and this results in meaningful learning among them. Thus, it can be claimed that intrinsic motivation is a natural type of motivation that emerges spontaneously from an individual's needs to become competent. External events cannot produce intrinsic motivation in human beings, but they can be applied to enhance intrinsic motivation (Darvish Baqal, 2013). Findings of the current study indicated that explanation and solved examples have interactive impacts on far and near transfer, cognitive load, and intrinsic motivation while studying. The impact of the type of solved examples, explanation, and the interactive impact of the type of solved examples and self-explanation on intrinsic motivation were found to be significant. Therefore, it is suggested that the explanation and the presentation of solved examples be included in the curriculum of schools to empower students in solving scientific problems. The current study suffered from several limitations, and it is hoped that future studies will eliminate them. First, as the study was conducted only on 8th-grade students, the generalizability of the findings is unclear to other grades. Second, the study was conducted on a small sample of students. Third, the solved examples implemented in the current study were only taken from a lesson in the 8th-grade junior high school English book.

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Conflicts of Interest

No conflicts of interest declared.

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