

The Effect of Immediate and Delayed Feedback in Virtual Classes on Mathematics Students' Higher Order Thinking Skills

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Abstract

This research aimed to identify the effect of immediate and delayed feedback in virtual classrooms on mathematics students' higher-order thinking skills. To achieve the objective of the research, the experimental method was used. The research sample consisted of students from Mathematics Department, College of Science and Arts, Najran University in the course of Computer in Education. Fifty students were selected and distributed into two equal experimental groups randomly. The first experimental group studied the (Computer in Education) course through virtual classrooms using immediate feedback while the second experimental group studied through virtual classes using delayed feedback. The higher-order thinking skills test was used as the study instrument to collect data. The results showed that there were statistically significant differences between the mean scores of the participants in the two groups (the first and second experimental groups) in favor of the second experimental group. This indicates the effect of the delayed feedback on enhancing students' higher-order thinking skills. Therefore, this result may contribute to the study and practice of some forms of interaction and its impact on different learning outcomes in the context of virtual classrooms during the emerging corona pandemic and the future. In light of the current result, the researchers recommended enhancing the skills of faculty members to use immediate feedback in virtual classrooms, through targeted short training sessions. Also, they should be trained in using other methods of interaction to develop students' higher-order thinking skills and measure the extent of their impact.

Keywords: immediate feedback, delayed feedback, virtual classes, higher thinking skills.

INTRODUCTION

The COVID-19 pandemic has affected all aspects of life in the Kingdom of Saudi Arabia, especially the educational system. All educational institutions were closed and the distance learning process continued. The increase in using virtual classrooms as a form of distance education in universities has been associated with the continuation of the emerging Corona pandemic to reduce the transmission of infection on campus (Leidner et al., 2021).

The virtual classroom is an educational environment that relies on modern technology and information technology infrastructure. It aims to facilitate the smooth interaction between teachers and learners in the necessary time (Suwais & Alshahrani, 2018). By comparing virtual classes with traditional classes (face-to-face), several studies have proven that virtual classes have a significant impact on enhancing several learning outcomes (Al-Asmari, 2019; Al-qahtani, 2019a, 2019b; Asadi, Khodabandeh, & Yekta, 2019;

Hamouda, 2020). Despite this, there are still insufficient studies that focus on the interactions in virtual classrooms, which may have an impact on learning outcomes in virtual classrooms.

Feedback is one of the forms of interaction, which can be presented to learners after completing tasks and duties. It aims to inform the learner of his performance status compared to a specific goal and what he needs to do to reach that goal (Williams, 2012). Feedback is a critical component of the learning process. It is an integral part of most training programs (Bolton, 2006). In addition, the timing of feedback also plays an important role in improving learning (Kehrer, Kelly, & Heffernan, 2013). Feedback is more effective when it plays a role in correcting errors or misconceptions that the learner may acquire during teaching (Lemley, Sudweeks, Howell, Laws, & Sawyer, 2007).

Feedback can be as simple as writing some notes about the learner's response to a math test or homework, for example. The use of feedback (after correcting the test paper or reviewing the submitted assignment) helps the learner to find the correct answer, better understand the concepts and know why he made a mistake and how he can correct it (Smith & Higgins, 2006). Feedback is usually provided after the student responds to a question or after completing an exercise or exam. There is immediate and delayed feedback. Some see that immediate feedback is provided as soon as the learner answers a question or completes a task that enhances retention of the information learned. Others argue that delayed feedback that is withheld for a period is more appropriate for learning (Arbel, Hong, Baker, & Holroyd, 2017; Corral, Carpenter, & Clingan-Siverly, 2020; Hölte & Mecklinger, 2018; Kim & Arbel, 2019; Qi, Rajab, Haladin, Wang, & Fu, 2020).

E-learning environments in general are also suitable for developing higher-order thinking skills. These are skills seen as the "high end" of Bloom's (or any other) classification. They include analysis, synthesis and evaluation (Brookhart, 2010). Higher-order thinking skills

are one of the students' abilities that must be developed through teaching and learning (Retnawati, Djidu, Kartianom, & Anazifa, 2018). Therefore, researching the methods of interaction during the presentation of the educational material in different ways and its impact on the development of higher-order thinking skills is a key to successful learning. Therefore, the current study attempts to bridge this gap by revealing the impact of immediate and delayed feedback in virtual classrooms on developing higher-order thinking skills for mathematics students in the College of Science and Arts.

Theoretical background

Virtual classrooms

The virtual classroom is a technology product (Asadi et al., 2019). It is an online learning environment that is unrestricted, affordable, flexible, functional and easily accessible (Alhawiti, 2017). Also, students tend to participate in online virtual classes more than traditional classes due to some factors such as travel difficulties and cost. In addition, online interactions help increase student participation and enhance their ability to understand the material easier and faster (Asadi et al., 2019). The virtual classroom offers multiple opportunities for practice and improvement (Taylor, Deshpande, Markelz, McKinnon, & Scheeler, 2019). Virtual classes are based on cognitive load theory, which refers to the effort required to combine new information with prior knowledge into meaningful mastery (Kalyuga & Liu, 2015). They rely on social learning theory where students are affected by social interactions with their peers face to face in the traditional environment as well as with their peers in the virtual environment (Miller & Morris, 2016). These two theories are related to student achievement and grade point averages in the virtual classroom (Maier, 2019).

Feedback

Several studies have found that feedback plays an important role in learners' performance and achievement. Several studies have been

conducted to address the impact of different types of feedback, whether in public education or at universities. For example, Lemley (2005) explored the effect of different types of feedback on cognitive achievement. The results showed that students who received immediate feedback performed significantly better on the final exams of the course. In contrast, students who received delayed feedback completed the course in significantly less time. Quinn's (2014) study also investigated the effect of differences in the timing of corrective feedback on oral production on second language learning and learners' reactions to comments. The results showed that learners preferred instant feedback. However, immediate feedback may limit learners' independence while delayed feedback may cause anxiety or embarrassment.

Yasanaga (2016) noted that providing immediate and delayed feedback had a significant impact. They enable learners to use the target function more accurately. The experimental groups that received immediate or delayed feedback outperformed the control group that received the direct correction. Yekta & Dafe'ian's (2016) study addressed the effect of immediate and delayed feedback on the depth of knowledge. The results indicated that the delayed feedback from the teacher was significantly more successful than the immediate feedback in increasing the depth of vocabulary knowledge.

Higher-order thinking skills

The abilities to analyze, construct, and evaluate are often referred to as higher-order thinking skills. They are the student's ability to think at a higher level (Ichsan et al., 2019). The assessment of higher-order thinking skills measures the top three levels of Bloom's Taxonomy, i.e. analysis, synthesis, and evaluation. These skills include processing and implementing information, searching for connections between different information, using the information to solve problems, and critically reviewing ideas and information (Widana et al., 2018). Higher-level thinking occurs when students acquire new knowledge and store it in memory, and then link this

knowledge with prior knowledge to achieve a specific goal.

In other words, higher-level thinking occurs when a person obtains new information, retains, organizes and relates it to existing knowledge, and passes that information to solve a problem. In higher-level thinking, students tend to use logic rather than simply remembering and memorizing formulas. Therefore, students master the concepts and can solve more complex math problems (Pratama & Retnawati, 2018). Ichsan et al. (2019) showed that learning should be directed towards increasing higher-order thinking skills through learning to develop different media, educational materials, learning models and strategies. Students with higher thinking abilities are better at answering guided practice questions compared to intermediate and lower students (Yuliati & Lestari, 2018).

Statement of problem

In light of the general closure of higher education institutions in the Kingdom of Saudi Arabia because of the spread of the new epidemic of Corona as a non-pharmacological measure, this research emerged. Najran University provided its employees with virtual classes that were linked to the Blackboard system. Distance education has also been accredited to provide educational courses at universities. Virtual classes were used to present the "Computer in Education" course in the Mathematics Department of the College of Science and Arts in the second semester of the academic year: 2020/2021. It should also be noted here that this course depends primarily on higher-order thinking skills. The virtual classes also provide feedback of all kinds (immediate and delayed), in addition to the whiteboard, chat room, sharing applications, and live video and audio broadcasting (Al-Qahtani, 2019b). As mentioned in the introduction, the previous literature proved the effectiveness of virtual classrooms compared to traditional classrooms. Therefore, the next step is to investigate the effectiveness of different variables in virtual classes. Online feedback also helps improve teaching and learning processes. The online feedback system is an

electronic learning tool that helps students to be more motivated (Gikandi, 2021). The results of previous studies on the effectiveness of both immediate and delayed feedback varied (Arbel et al., 2017; Corral et al., 2020; Hölftje & Mecklinger, 2018; Kim & Arbel, 2019; Qi et al., 2020).

Therefore, the problem of the current research can be expressed through the following question: What is the effect of immediate and delayed feedback in virtual classrooms on mathematics students' higher-order thinking skills?

Significance of the study

The results of the current research are expected to contribute to the following:

- Taking advantage of the virtual classrooms within the Blackboard system to overcome the effects of epidemics that may hinder the regularity of the educational process.

- Employing both types of feedback (immediate and delayed) in virtual classrooms to help develop higher-order thinking skills.

- Employing modern technologies in university education to achieve the goals of the teaching and learning processes.

- Motivating faculty members to maximize the benefit of virtual classrooms when adopting distance education by taking advantage of feedback.

Objectives of the study

This study aimed to identify the effect of immediate and delayed feedback in virtual classrooms on developing mathematics students' higher-order thinking skills in the College of Science and Arts.

Key terms of the study

The current research covered a number of terms identified based on previous literature, as follows:

Feedback: A form of interaction, which can be presented to learners after completing tasks and assignments (Williams, 2012). The procedural feedback in the current research is defined as a

picture of the interaction between the teacher and the learner through the virtual classroom after completing the tasks and duties.

Virtual classes: A learning environment that is based on modern technology and IT infrastructure and aims to facilitate seamless interaction between teachers and real-time learners (Suwais & Alshahrani, 2018). The current research will adopt this definition as a procedural definition of the virtual class.

Higher thinking skills: the higher end of Bloom's taxonomy (or any other taxonomy), and include analysis, synthesis, and evaluation (Brookhart, 2010). The current research will adopt this definition as a procedural definition of higher-order thinking skills.

Methods

The current research used the experimental method. It aims to identify the effectiveness of an independent variable on a dependent variable through a quasi-experimental design for two experimental groups as shown in Table 1.

Table 1. *Quasi-experimental design*

Group	Pretest	Treatment	Posttest
Experimental group (1)	Higher order thinking skills test	Immediate feedback through virtual classes	Higher order thinking skills test
Experimental group (2)		Delayed feedback through virtual classes	

Population and sample of the study

The final research sample included (50) students in the sixth academic level who are registered in the "Computer in Education" course. By dividing them randomly into two equal experimental groups of (25) students in each group. While the first experimental group studied the "Computer in Education" course through virtual classes using immediate

feedback, the second experimental group studied the same course via virtual classes using delayed feedback.

To ensure the homogeneity of the two research groups, one-way analysis of variance ANOVA was used for the pretest of higher-order thinking skills, and the result was as follows:

Table 2. *The significance of the differences between the two experimental groups in the pretest of higher-order thinking skills*

Source of variance	Sum of squares	df	Mean	F	Sig (taliel-2)
Between groups	17.82	1	17.82	3.27	0.251 Insignificant
Within groups	328.7	48	6.97		
Overall	346.52	49			

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Table 2 shows that the results of the statistical processing indicated that the percentage value was (3.27). It is insignificant at (0.05). This means that there was no statistically significant difference at (0.05) between the pretest of both experimental groups in higher-order thinking skills before conducting the research experiment.

The study variables

The current research includes two variables:

- Independent variable: feedback (immediate and delayed) in virtual classes.
- Dependent variable: Higher-order thinking skills.

Instrument of the study

-Higher-order thinking skills test

To achieve the objective of the current research, a test for higher-order thinking skills was prepared in the "Computer in Education" course. The wording of the test items was based on the desired results from the course. The academic level of the participants was also taken into consideration when drafting the test items. The final test version included (20) multiple-choice items. By presenting the test to the experts (specializing in mathematics curricula and educational technology), the validity of the test was confirmed. They were asked to check the suitability of its questions to measure higher-order thinking skills as well as the clarity and linguistic integrity of the questions, and any other suggestions. The test was initially applied to (10) students from the Mathematics Department of the College of

Science and Arts at Najran University as an exploratory sample from outside the study sample. The objective of the application to the exploratory sample was to determine the time required to complete the test, its validity and reliability. The estimated time was about (19) minutes as well as the reliability (through Cronbach's Alpha coefficient) was set at (0.89). This indicates that the results when applying the test to the main study sample will be reliable.

Materials and procedures

The research sample studied the "Computer in Education" course through virtual classes in the Blackboard system that Najran University provides to its employees. The first experimental group studied via virtual classes using immediate feedback. The second experimental group studied via virtual classes using delayed feedback. A group was also created on WhatsApp that included all students participating in the first experimental group in addition to the lecturer. Each student had to indicate that he submitted his weekly assignment via a WhatsApp group. Then, the lecturer checks the Blackboard system immediately. Then, he evaluates the weekly assignment and provides the student with immediate feedback through the assignments icon in the grades center. Each student, in turn, has to respond through the WhatsApp group and notify the lecturer that he had received the notes. On the other hand, students participating in the second experimental group receive the delayed feedback at the end of the week through the assignments icon in the grades center as well.

Statistical processing

One-way analysis of variance ANOVA was used to ensure the homogeneity of the two research groups. T. test for independent samples was used to analyze the results of the higher-order thinking skills test (posttest). Eta Square (η^2) was used to measure the size of the impact of feedback (immediate and delayed) on higher-order thinking skills.

Results

To answer the current research question, the results of the dimensional higher-order thinking skills test for the two study groups were extracted. Then, statistical analysis was conducted through a t-test for independent samples. After that, the eta square (η^2) was used to calculate the size of the impact of the feedback (immediate and delayed) on the development of higher-order thinking skills. Table 3 shows the results of the t-test.

Table 3. *The significance of "t" for the difference between the scores of the students of the two research groups in the higher-order thinking skills test*

Group	N o.	Me an	Stand ard devia tion	Mean differ ence	t	Level of signific ance
Experi mental 1	25	14.9	3.256	3.8	5.14	0.037 Significant
Experi mental 2	25	18.7	2.971			

According to Table 3, it is evident that the value of "t" for the difference between the mean scores of the students of the two experimental groups in the higher-order thinking skills test were (5.14). The table also shows that the means scores of the students of the first group (immediate feedback) reached (14.9) while the means scores of the students of the second experimental group (delayed feedback) reached (18.7), and thus the value of "t" is statistically significant. In such cases, the statistical significance is directed in favor of the group that has the higher average, the second experimental group. The means of (18.7) is an

increase over the first experimental group with a mean difference of (3.8).

By calculating the value of Eta square (η^2) for the difference between the mean scores of the two experimental groups, this result can be confirmed by determining the size of the impact of feedback (immediate and delayed) in enhancing higher-order thinking skills. It reached ($\eta^2 = 0.346$), a large value. Based on this result, it can be confirmed that the use of delayed feedback in virtual classrooms had a significant impact on the higher-order thinking skills of mathematics students in the "Computer in Education" course compared to immediate feedback.

Discussion

In this research, the higher-order thinking skills of students of the Mathematics Department at the College of Science and Arts at Najran University were verified in the course "Computer in Education". The results showed that there were statistically significant differences between the means scores of the participants in the two groups (the first and second experimental) in favor of the second experimental group. This indicates the effect of delayed feedback on enhancing students' higher-order thinking skills. Therefore, this result may contribute to the study and practice of some forms of interaction and its impact on different learning outcomes in the context of virtual classrooms during the emerging Corona pandemic in the future.

The researchers believe that there were some factors supportive of this result. The delayed feedback left time between the submission of assignments and evaluation. This provided the participating students with the opportunity to think adequately and make some analyses and comparisons. During this time, students could also search for different answers and different ways of doing assignments and then skillfully choose the best. Also, providing feedback to students allowed them to identify their weaknesses, discover their mistakes, and then correct them. It should be noted here that the low effectiveness of immediate feedback in the

current research may be because learners have been provided with the mistakes they made. Thus, their attention was focused on how to correct them. They did not take time to rethink what they had done or how they could improve their tasks. This finding supports the findings of the studies of Sinha (2012), Sinha & Glass (2015), and Yekta & Dafe'ian (2016). They pointed to the fact that delayed feedback outperformed immediate in reinforcing different learning outcomes. The results of this research also differ from the results of other studies such as Kehrer et al. (2013), Khradmand and Sayadiyan (2016), and Quinn (2014). They indicated that immediate feedback was superior to delayed feedback in enhancing different learning outcomes.

Recommendations

In light of the current results, the researchers presented the following recommendations and proposals:

- Enhancing the skills of faculty members to use immediate feedback in virtual classrooms through targeted training in short training sessions.
- Using other methods of interaction to develop students' higher-order thinking skills and measure the extent of their impact.
- Investigating the effect of immediate and delayed feedback in other environments such as comparison between male and female students.
- Using delayed feedback to develop other different learning outcomes.
- Researching to ensure the effectiveness of other interaction methods in developing higher-order thinking skills.

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