Influences of Use of Flipped Classroom Models on the Learning Outcomes of Students Majoring in Road and Bridge Engineering Technology

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Abstract—The new "Internet+" teaching mode during the COVID-19 pandemic has guaranteed the smooth learning progress of university students in China. High-efficiency reconstruction of time and space for knowledge teaching and internalization based on informationalized teaching mean is an important approach to online learning. A flipped classroom is a teaching mode that is formed through bottom-up exploration. Combined with teaching practical situations, the flipped classroom realizes the transformation from the teacher-centered mode to the student-oriented mode successfully and has important value to the teaching of professional core courses, which are difficult to be learned. In this study, 80 freshmen majoring in Road and Bridge Engineering Technology at Yellow River Conservancy Technical Institute in Henan Province of China were selected as research objects, and *Road Survey Design and Lofting* was chosen as the teaching course. Under these circumstances, a teaching experiment comparison was designed. The experimental group used flipped classroom technology based on Attention, Relevance, Confidence, and Satisfaction (ARCS) motivation model theory, while the control group used the traditional teaching mode. Research results demonstrate that before the experiment, the learning outcomes of two groups in *Road Survey Design and Lofting* were basically consistent (P=0.908>0.05) without obvious differences. After finishing the experiment, the post-test results of the control group have not improved significantly compared with the pre-test results (P=0.0938>0.05). However, the post-test results of the experimental group have improved significantly compared with the pre-test results ($P < 0.001$). The average scores of the experimental group are far higher than that of the control group, thus indicating the evident progress of the experimental group. Noticeable differences in the post-test results between the experimental group and the control group are observed ($P < 0.001$). The research results are of great significance to enriching the teaching mode of core application courses for engineering majors in university, as they provide evidence that the flipped classroom increases the learning interests and motivation of students and demonstrate the teaching effect of flipped classroom technology in universities.

Keywords—use of flipped classroom technology, road and bridge engineering technology, learning outcome, teaching experiment, independent sample T test, paired sample T test

1 Introduction

China has improved its scientific and technological level comprehensively, and it has launched the "Internet+" initiative in all sectors and industries. The combination of education and the Internet helps the education sector to conform better to the requirements of ubiquitous learning at any time and any place. Online teaching (e.g., MOOC) uses information and the Internet as its platform. It has been applied to various stages of different disciplines of education. Influenced by the COVID-19 pandemic, online courses have increased gradually. Universities in China have combined online-offline courses and applied hybrid teaching to the activities of various disciplines as a considerably important reform direction. In particular, smart devices, such as smart phones and tablet PCs, are popular tools in recent decades, as these technologies increase convenience in daily activities and enrich ways to communicate and learn. The transferring and sharing characteristics of the Internet are widely accepted. However, most universities in China have adopted the "transfer-acceptance" teaching mode for a long period, which hinders the creative thinking ability of students and is unfavorable for the improvement of students' learning outcomes. In the background that many universities have begun to pursue the modern classroom setup and advanced teaching levels in China, some teachers have changed the classroom into one that is free of blackboard writing. The whole lesson is taught using PPT. However, the prolonged use of PPT in class discussions easily causes low learning self-efficacy among university students. In particular, as science and engineering universities comprise a high proportion in China, the traditional single-classroom teaching approach used in engineering courses is disadvantageous for the internalization of knowledge. Communication between students and teachers cannot be replaced by merely presenting lessons on a screen. Teachers not only have to pursue information technological support to classroom teaching, but they should also pay more attention to improving teaching methods, adopting better teaching technologies that are appropriate for university students, and focusing on the improvement of the learning outcomes of learners.

In the background of hybrid teaching, the emerging teaching technology of flipped classrooms not only reflects the advantages of hybrid learning but also promotes the use of teaching resources. It reflects the concept of student-oriented teaching and conforms to the core idea of education informationalization in China. The flipped classroom is an innovative learning method and teaching mode. This technology is developed in such a background, and it is a teaching mode that can only be realized with the support of modern scientific and technological means. Different from the traditional teaching mode, the flipped classroom allows students to discuss and solve difficulties and problems that they encounter during independent learning in class. Meanwhile, homework tasks include watching videos independently, which will help to improve students' knowledge level. Hence, the support of modern scientific and technological means, as well as aid from various resources, are the key to the successful implementation of the flipped classroom. Hence, the use of this technology not only increases teacher-student interaction and student-student interaction in class but also helps students to solve problems that they encounter during independent study by allowing them to discuss with their classmates or teachers. This setup requires students to participate in learning,

which will help to maintain learning enthusiasm. Meanwhile, teachers need to think of a plan to stimulate the internal learning motivation of students so that they are willing to learn continuously. This link is highly important during the use of flipped classroom technology.

2 Theoretical basis and literature review

2.1 Theoretical basis

Attention, Relevance, Confidence, and Satisfaction (ARCS) model theory was proposed by Professor Keller, J. M [1] from Florida State University in the 1980s. The ARCS motivation design model is composed of the dimensions of attention, relevance, confidence, and satisfaction. These four basic elements are highly correlated and hierarchical rather than independent and irrelevant. First, attention refers to attracting the attention of learners by various teaching strategies. This aspect helps learners to be willing to learn and to stimulate their desire and interests in the learned contents. Only in this way can learners consciously pay attention to learning contents. Second, relevance refers to formulating more personalized learning objectives for learners according to their current cognitive structure and level as well as practical learning needs. This customization diversifies the range of learning contents and increases the degree of matching between the learner's knowledge needs and the teaching contents of teachers, thus facilitating the development of learners. Third, confidence means that learners have some psychological preparation and certain stock knowledge before the actual learning of the topic. Hence, they have the courage and confidence to tackle the topic, without any sense of aversion from and fear about the coming knowledge. Fourth, satisfaction means that learners are satisfied with their learning outcomes after studying for a particular period. Moreover, their expectations are met. Such satisfaction is highly important to learners, as it can maintain the learning motivation of learners. The ARCS motivation model is a relatively complete and systematic motivation model. Combining the ARCS motivation model and teaching can help educators to improve their teaching quality. Hence, this theory is the theoretical basis for the use of flipped classroom technology in the current study.

2.2 Literature review

In foreign countries, especially in the USA, the study and implementation of flipped classroom technology was developed early. Flipped classrooms were first practiced in the USA. This approach allows students to discuss and solve difficulties and problems that they encounter during independent learning in class. Then, homework entails students independently watching micro-videos about the knowledge contents that teachers should have taught in class. As such, the influence of flipped classroom technology on the teaching quality of teachers and learning outcome of learners has been investigated. O'Flaherty, J et al. [2] pointed out that the flipped classroom teaching mode increases the academic performance of students as well as the satisfaction of both students and employees. McNally, B et al. [3] investigated 563 undergraduates and

postgraduates who participated in flipped classroom teaching mode and found that university students respond more positively to flipped classroom activities (pre-class and in-class) and show a strong sense of participation in the content. Meanwhile, Long, T et al. [4] conducted structured interviews with eight teachers who had used or were planning to use the flipped classroom teaching mode. According to survey results, the flipped classroom teaching mode could improve both teaching and learning effects. Then, Murillo-Zamorano, L. R et al. [5] developed a measurement scale to explore the existence degree of flipped classrooms in our learning experiences in higher education. According to empirical results, the flipped classroom has positive influences on the knowledge, skills, and engagement of students. Castedo, R et al. [6] demonstrated that the flipped classroom teaching mode has direct influences on the academic performance of students. In particular, the academic performance of students with higher engagement is about 1.5 points higher than those with lower engagement. In addition, McLaughlin, J. E et al. [7] discussed the implementation of flipped classrooms in two higher education institutions and emphasized several key methods for effective design and implementation. He also considered supporting such innovation by using supplementary technologies. Furthermore, Kay, R et al. [8] compared the learning experiences and performances of students from community colleges under the traditional teaching mode, active learning, and flipped classroom teaching. Their results showed that under active learning and flipped classroom teaching, students' evaluation on social presence is significantly higher than that under the traditional teaching mode. Fraga, L. M et al. [9] believed that the flipped classroom is a teaching mode that will gain increased popularity. He also investigated the opinions of pre-service teachers toward the flipped classroom teaching mode as well as its influences on the academic performance of students. Moreover, Sosa Díaz, M. J et al. [10] believed that among online teaching modes, the flipped classroom is a teaching mode that can substantially change the field of education. Results showed that students have a positive evaluation of the flipped classroom mode and proved its considerable potentials from academic, ability, individual, and social perspectives. Saglam, D et al. [11] discussed the influences of the flipped classroom on new grammatical pattern learning and attitudes of students toward English. He found that compared with traditional teaching, the flipped classroom has moderate influences on the academic performance and learning attitudes of students. Jdaitawi, M [12] analyzed the influences of the flipped classroom strategy on the self-adjustment ability and social connection ability of students in preparatory school. He found that the self-adjustment level and social connection level of students attending a flipped classroom are significantly higher than those of students attending traditional classroom. This observation proved that the flipped classroom strategy can facilitate self-adjustment learning and strengthen the social connections of students. Furthermore, Hsiao, C. C et al. [13] pointed out that although flipped classroom teaching technology has no significant influence on the short-term online learning outcome of students, it can influence long-term learning outcomes significantly. Zheng, B et al. [14] argued that a flipped classroom can evidently facilitate the learning outcomes of medical students. Moreover, Evseeva, A et al. [15] showed that flipped classroom technology refers to the educational process organization that flips classroom activities and homework and it can strengthen learning motivation and improve the academic performance of students. Kawinkoonlasate, P [16] reported that flipped classroom technology

is being used to increase level of EFL and ESL learners and found that it can improve English learning skills. He also put forward some positive methods to help learners to improve the English language skills of students. Baytiyeh, H [17] used the qualitative case study design, and their results showed that flipped classroom technology can enrich the learning experiences of students and help them gain soft skills, which are needed for the success in all careers. Filiz, S et al. [18] pointed out that flipped classroom technology can improve attitudes toward foreign language courses, academic performance, cognition, and writing performance to varying extents. Lo, C. K [19] proposed the design framework of flipped classroom to improve education practice. Based on the ADDIE model, Suryawan, I. P. P et al. [20] found that the flipped classroom is effective for improving the learning independence and acquisition of math skills of students by combining the method with Google Classroom and video meetings. Wang, F. H [21] carried out a case study to 135 sophomores from two classes of a programming course and concluded that flipped classroom technology can improve learning outcomes significantly. Meanwhile, Zarinfard, S et al. [22] demonstrated that a flipped classroom can improve the learning outcomes of cross-cultural learners. In addition, Haqiyah, A [23] showed that a flipped classroom can strengthen the learning outcomes significantly by combining the method with an online learning platform ($P \leq 0.05$). Meanwhile, Sailer, M et al. [24] proposed a game-based flipped classroom teaching for non-game classroom activities and found that it has positive indirect effects on application knowledge, as well as positive effects on internal motivation and social connection. Nurhayati et al. [25] demonstrated that flipped classroom teaching technology can help develop a hybrid learning mode effectively and improve learning outcomes in the study of art culture. Cho, H. J et al. [26] analyzed applications of the flipped classroom teaching mode in mechanical engineering and found that this teaching mode has the potential to create an environment for independent learning and offer beneficial learning experiences. Zhao, L et al. [27] compared the influences of the flipped classroom teaching mode and modern education technology (MET) on pre-service students. Results showed that the academic performance of the experimental group, which used the flipped classroom teaching mode, were better than that of the control group. The experimental group was significantly superior to the control group in terms of learning satisfaction, self-efficacy, and learning motivation. The flipped classroom teaching model was applicable to MET teaching for pre-service students. According to the research results of Förster, M et al. [28], the video watching time of learners in the flipped classroom teaching mode has influences on academic performance and knowledge retention. Yang, C. C et al. [29] pointed out that compared with traditional classroom teaching, a flipped classroom has positive influences on the learning engagement and learning performance of students. He carried out a quasi-experiment in which the flipped classroom teaching mode was applied to the experimental group. The experimental group showed better performances than students who were not recommended with systematic learning in terms of learning outcomes and pre-class preparation engagement. Aguilar, R et al. [30] proved that the implementation of the flipped classroom teaching mode has significant influences on the internal motivation and exam performance of students in learning topics as well as the reduction of absence rates. Setyosari, P et al. [31] proved that the online flipped classroom learning scheme of Microsoft Teams can improve engagement and reading comprehension competence of

students better than WhatsApp. He suggested synchronizing flipped classroom teaching based on the compatibility of Internet technologies. In addition, Ruiz-Jiménez, M. C et al. [32] reported that the flipped classroom teaching mode can facilitate learners to learn more and better, thus improving their academic performance.

Based on the above literature review, abundant and comprehensive research contents concerning the origin, definition, and model of flipped classrooms have been published. During flipped classroom teaching, learning resources are essential tools that help students with their self-study. In addition, high-quality learning resources can help students to learn better to a very large extent. The application of the flipped classroom in different education fields and education levels have had varying conclusions due to the influences of the research object number, discipline and major, experiment time, variable selection, and so on. However, most studies support the conclusion that the flipped classroom can evidently improve learning outcomes. Most studies are from classroom practices and explore the personalized flipped classroom mode by combining this mode with practical teaching conditions. The flipped classroom is not only conducive to the increase of learning motivation and learning interests of learners, but it also facilitates the improvement of academic performance. Hence, a growing number of teachers and students have relatively high satisfaction to the flipped classroom teaching mode in engineering practice courses, thus providing relatively high evaluations.

3 Methodology

3.1 Research objects

A total of 80 freshmen majoring in Road and Bridge Engineering Technology from Yellow River Conservancy Technical Institute in Henan Province of China were chosen as research objects. They were selected from two classes, with 40 students in each class. Both classes were taught by the same teacher. The experimental group had never experienced the flipped classroom teaching mode before the study. Therefore, the whole experimental process was carried out under a very natural state, which assured the authenticity and effectiveness of the experiment.

3.2 Research methods

The experiment spanned half a semester. After a half-semester learning of *Road Survey Design and Lofting* in the spring of 2022, all students had a mid-term exam with completely consistent questions and time limit (100 scores). According to the test results, students of the two classes had generally the same learning ability, without evident differences. Hence, the experiment could be implemented. In the second half of the semester, Class 1 was set as the experimental group, which used the flipped classroom mode based on the ARCS model. Meanwhile, Class 2 was set as the control group, which used the traditional teaching mode. At the end of the semester, a final exam of *Road Survey Design and Lofting* was given to students from both classes, and data were analyzed. Next, a questionnaire survey and interview survey were conducted to students of the experimental group to verify whether their learning outcome improved.

4 Results analysis and discussions

4.1 Comparative analysis of pre-test results between experimental group and control group

Table 1. Independent samples T-test

	Test	Statistic	df	p	Location Parameter	SE Difference	95% CI for Location Parameter		Effect Size
							Lower	Upper	
Pre-Test Results	Student	–0.116	78.000	0.908	–0.225	1.944	–4.096	3.646	–0.026
	Welch	–0.116	77.732	0.908	–0.225	1.944	–4.096	3.646	–0.026
	Mann-Whitney	777.500	–	0.832	–1.000	–	–4.000	4.000	–0.028

Notes: For the Student T-test and Welch T-test, effect size is given by Cohen's d. For the Mann-Whitney test, effect size is given by the rank biserial correlation. For the Student T-test and Welch t T-test, location parameter is given by mean difference. For the Mann-Whitney test, location parameter is given by the Hodges-Lehmann estimate.

Table 1 shows that according to the independent samples T-test results of the pre-test result comparison between the experimental group and the control group, the significance (sig) corresponding to the T distribution value is 0.908 (>0.05), and it does not reach the significance level. In other words, no significant difference is observed between the pre-test results of the experimental group and the control group. This outcome indicates that students from these two classes mastered *Road Survey Design and Lofting* similarly at the mid-term exam, thus eliminating influences of objective factors in the follow-up experiment.

4.2 Comparative analysis between pre-test and post-test results of the control group

Table 2. Pre-test and post-test results of the control group

Control Group	Pre-Test Results	Post-Test Results
Arithmetic mean	59.63	60.43
95% CI mean	56.9271–62.3229	57.6635–63.1865
Variance	71.1635	74.5583
Standard deviation	8.4358	8.6347
Standard error of mean	1.3338	1.3653
Difference of means	0.8	
Standard deviation of mean deviation	2.9457	
Standard error of mean deviation	0.4658	
95% CI of difference	–1.8842	
Statistic T	1.718	
Degree of freedom (DF)	39	
Bilateral probability	P = 0.0938	

Table 2 shows that according to the paired samples T-test results between the pre-test and post-test results of the control group, the significance (sig) corresponding to the T distribution value is 0.0938 (>0.05) and it does not reach the significance level. In other words, no significant difference is observed between the pre-test results and the post-test results of the control group. This outcome indicates that the academic performance of students in *Road Survey Design and Lofting* do not improve substantially under the traditional teaching mode.

4.3 Comparative analysis between pre-test and post-test results of the experimental group

Table 3. Pre-test and post-test results of the experimental group

Experimental Group	Pre-Test Results	Post-Test Results
Arithmetic mean	59.40	71.35
95% CI mean	56.5387–62.2613	68.2658–74.4342
Variance	80.041	93.0026
Standard deviation	8.9466	9.6438
Standard error of mean	1.4146	1.5248
Difference of means	11.95	
Standard deviation of mean deviation	3.8361	
Standard error of mean deviation	0.6065	
95% CI of difference	10.7232–13.1768	
Statistic T	19.702	
Degree of freedom (DF)	39	
Bilateral probability	P < 0.0001	

Table 3 shows that according to the paired samples T-test results between the pre-test and post-test results of the experimental group, the T distribution value is 19.702 (>0.05), and the corresponding the significance (sig) is lower than 0.01, thus reaching the significance level. Hence, significant differences are observed between the pre-test results and post-test results of the experimental group. According to statistical results on classification means, the post-test result of the experimental group is 71.35 points, which is far higher than the pre-test result (59.40 scores). Therefore, after using the flipped classroom technology in teaching *Road Survey Design and Lofting* for one semester, the grammar performances of the experimental group are significantly improved. One possible circumstance is that *Road Survey Design and Lofting* is a core subject for students majoring in Road and Bridge Engineering Technology, and it is difficult to study to some extent. University students easily lose interest in it during learning. Moreover, the flipped classroom mode has high requirements on the independent study of students. Only students who have strong learning impetus can complete each learning task assigned by teachers well. As a result, teachers shall pique the interest of students through the teaching content, as well as stimulate and maintain their attention to assure good teaching equality. In this teaching experiment, the

teacher of the experimental group not only used the flipped classroom technology but also applied the ARCS motivation model and designed a relatively complete scientific teaching process with strong interaction. He introduced the basic principle knowledge of *Road Survey Design and Lofting* in teaching videos, which easily attracted the attention of students and strengthened their enthusiasm in the teaching content. Moreover, the inclusion of case studies of specific construction projects also helps students to perceive the practicability of knowledge related to the learning contents of *Road Survey Design and Lofting*. However, it can only assure strong learning motivation of students in class as long as they are interested in the subject matter.

4.4 Comparative analysis of post-test results between the experimental group and control group

Table 4. Comparison of post-test results between the experimental group and control group

Samples	Mean	Standard Deviation	Standard Error of Mean
Post-test results of the experimental group	71.35	9.64	1.5
Post-test results of the control group	60.42	8.63	1.4
Test			
T value	**DF**	**P value**	
5.34	77	0.000	

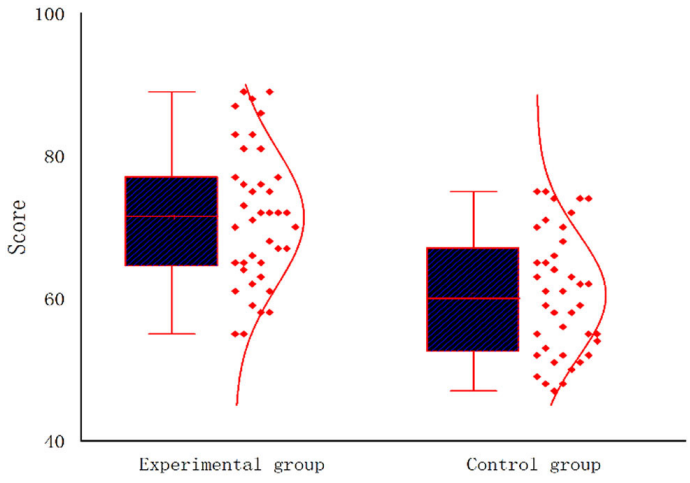

Fig. 1. Comparative analysis of post-test results between the experimental group and control group

The independent sample T-test results of the post-test result comparison between the experimental group and the control group are shown in Table 4 and Figure 1. The sig corresponding to T distribution value is smaller than 0.01 and reaches the 1% significance level. Significant differences are observed between the post-test results of the experimental group and the control group. Compared with the traditional classroom

teaching mode, the flipped classroom teaching mode improves the final-exam scores of students in *Road Survey Design and Lofting* greatly. This outcome is mainly because the teacher of the experimental group produced micro-videos in the form of a "PPT+lecture," which attracted the attention of students better. During the use of the flipped classroom teaching mode for the experimental group, the duration of micro-videos varied, and the most appropriate duration for middle school students was found to be about 5–8 min. Moreover, the video quality was very good, which further increased the learning interests of students. Teachers encourage students to watch videos carefully and use written tasks in some practice projects, thus making lectures boring. In a flipped classroom, teachers must seek teaching contents that are truly appropriate for the flipped classroom. Although this approach brings great teaching pressure on teachers, it produces positive stimuli to the learning behaviors of students. Trying new teaching modes occasionally in the traditional form can strengthen the learning interests of students. It allows the full development of students at all levels. Students can learn at their own pace before the class and solve problems they want to overcome in class. In other words, teachers can teach students according to his/her abilities. In a class, some students have strong abilities, and they hope to understand relevant knowledge more deeply to expand their scope of knowledge. Once the classroom content cannot meet their demands, it may influence their learning interests. Hence, teachers shall provide rich teaching contents.

4.5 Discussions

During online self-study, most students can watch the teaching video and take notes independently; then, they can complete self-study tasks independently as self-exam and consolidation (Jensen, S. A [33]). Many students ask for help from teachers and classmates in an e-community (e.g., WeChat Group) when they encounter problems. Hence, they are able to comprehend the lessons before classes. In this way, their learning independence improves significantly. In class, students assimilate knowledge by communicating and discussing with teachers and classmates positively rather than receiving knowledge passively (Le Cornu, A [34]). Learners solve problems they encounter during learning through reflection and exploration. The sense of achievement they gain improves their confidence on tackling difficult professional courses, such as *Road Survey Design and Lofting* in the current study. After experiencing enjoyment from having a sense of success, students' enthusiasm and initiative in learning professional courses are improved gradually (Troy Frensley, B et al. [35]). In a flipped classroom, students assimilate knowledge through six links, including exam, homework, discussion, and exhibition (Deng, F [36]). Students make self-exams and discover problems timely by completing their homework. When discussing with classmates in the same group, students are not only able to explore answers for their homework but also given the opportunity to learn different ways of understanding the topic and the unique thinking or memory methods of others (Hargis, J et al. [37]). The flipped classroom mode does not make students mere containers that receive knowledge passively, but it trains them

to be individuals who can develop independent thinking and dare to explore and think critically. Through a series of learning activities, students can master knowledge of professional core courses (Egbert, J et al. [38]). Through the analysis of pre-test results, students of the experimental group and the control group were found to have equivalent learning outcome levels before the experiment. This similarity eliminated other disturbance factors of the experiment. According to the comparison of the post-test results of two classes, the learning outcome of the experimental group using flipped classroom technology is improved more greatly than that of the control group. According to the analysis of the pre-test and post-test results of the control group, although the learning outcomes of students under the traditional teaching mode is improved, such improvement is not noticeable. According to analysis of the pre-test and post-test results of the experimental group, the learning outcome is improved significantly by using the flipped classroom technology. This outcome proves that the flipped classroom teaching mode based on the ARCS model can improve the learning outcome levels of students to some extent.

5 Conclusions

In this study, 80 freshmen majoring in Road and Bridge Engineering Technology at Yellow River Conservancy Technical Institute in Henan Province of China were selected as research objects. *Road Survey Design and Lofting* was chosen as the teaching course to be examined in this research. A teaching experiment comparison was designed. The experimental group used the flipped classroom mode based on ARCS motivation model theory, while the control group used the traditional teaching mode. Some major conclusions are drawn. (1) The learning outcomes of two groups in *Road Survey Design and Lofting* are basically consistent before the experiment ($P=0.908>0.05$), without remarkable differences. (2) The pre-test results of the control group are not improved significantly compared with the pre-test results ($P=0.0938>0.05$). However, the post-test results of the experimental group are improved significantly compared with the pre-test results ($P < 0.001$). (3) Obvious differences of the post-test results between the experimental group and the control group are observed ($P < 0.001$). Further studies on the teaching time of the flipped classroom and the expansion of research objects from the perspective of improving the independent learning ability of students and expanding the ARCS model shall be carried out in future.

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7 References

[1] Keller, J. M. (1987). Development and use of the ARCS model of instructional design. Journal of Instructional Development, 10(3), 2–10. https://doi.org/10.1007/BF02905780

[2] O'Flaherty, J., & Phillips, C. (2015). The use of flipped classrooms in higher education: A scoping review. The Internet and Higher Education, 25, 85–95. https://doi.org/10.1016/j.iheduc.2015.02.002

[3] McNally, B., Chipperfield, J., Dorsett, P., Del Fabbro, L., Frommolt, V., Goetz, S., … & Rung, A. (2017). Flipped classroom experiences: Student preferences and flip strategy in a higher education context. Higher Education, 73(2), 281–298. https://doi.org/10.1007/s10734-016-0014-z

[4] Long, T., Cummins, J., & Waugh, M. (2017). Use of the flipped classroom instructional model in higher education: Instructors' perspectives. Journal of Computing in Higher Education, 29(2), 179–200. https://doi.org/10.1007/s12528-016-9119-8

[5] Murillo-Zamorano, L. R., Sánchez, J. Á. L., & Godoy-Caballero, A. L. (2019). How the flipped classroom affects knowledge, skills, and engagement in higher education: Effects on students' satisfaction. Computers & Education, 141, 103608. https://doi.org/10.1016/j.compedu.2019.103608

[6] Castedo, R., López, L. M., Chiquito, M., Navarro, J., Cabrera, J. D., & Ortega, M. F. (2019). Flipped classroom—comparative case study in engineering higher education. Computer Applications in Engineering Education, 27(1), 206–216. https://doi.org/10.1002/cae.22069

[7] McLaughlin, J. E., White, P. J., Khanova, J., & Yuriev, E. (2016). Flipped classroom implementation: A case report of two higher education institutions in the United States and Australia. Computers in the Schools, 33(1), 24–37. https://doi.org/10.1080/07380569.2016.1137734

[8] Kay, R., MacDonald, T., & DiGiuseppe, M. (2019). A comparison of lecture-based, active, and flipped classroom teaching approaches in higher education. Journal of Computing in Higher Education, 31(3), 449–471. Retrieved January 2014 from https://www.researchgate.net/publication/264117139; https://doi.org/10.1007/s12528-018-9197-x

[9] Fraga, L. M., & Harmon, J. (2014). The flipped classroom model of learning in higher education: An investigation of preservice teachers' perspectives and achievement. Journal of Digital Learning in Teacher Education, 31(1), 18–27. https://doi.org/10.1080/21532974.2014.967420

[10] Sosa Díaz, M. J., Guerra Antequera, J., & Cerezo Pizarro, M. (2021). Flipped classroom in the context of higher education: Learning, satisfaction and interaction. Education Sciences, 11(8), 416. https://doi.org/10.3390/educsci11080416

[11] Saglam, D., & Arslan, A. (2018). The effect of flipped classroom on the academic achievement and attitude of higher education students. World Journal of Education, 8(4), 170–176. https://doi.org/10.5430/wje.v8n4p170

[12] Jdaitawi, M. (2019). The effect of flipped classroom strategy on students learning outcomes. International Journal of Instruction, 12(3), 665–680. https://doi.org/10.29333/iji.2019.12340a

[13] Hsiao, C. C., Huang, J. C., Huang, A. Y., Lu, O. H., Yin, C. J., & Yang, S. J. (2019). Exploring the effects of online learning behaviors on short-term and long-term learning outcomes in flipped classrooms. Interactive Learning Environments, 27(8), 1160–1177. https://doi.org/10.1080/10494820.2018.1522651

[14] Zheng, B., & Zhang, Y. (2020). Self-regulated learning: The effect on medical student learning outcomes in a flipped classroom environment. BMC Medical Education, 20(1), 1–7. https://doi.org/10.1186/s12909-020-02023-6

[15] Evseeva, A., & Solozhenko, A. (2015). Use of flipped classroom technology in language learning. Procedia-Social and Behavioral Sciences, 206, 205–209. https://doi.org/10.1016/j.sbspro.2015.10.006

[16] Kawinkoonlasate, P. (2019). Integration in flipped classroom technology approach to develop English language skills of Thai EFL learners. English Language Teaching, 12(11), 23–34. https://doi.org/10.5539/elt.v12n11p23

[17] Baytiyeh, H. (2017). The flipped classroom model: When technology enhances professional skills. The International Journal of Information and Learning Technology, 34(1), 51–62. https://doi.org/10.1108/IJILT-07-2016-0025

[18] Filiz, S., & Benzet, A. (2018). A content analysis of the studies on the use of flipped classrooms in foreign language education. World Journal of Education, 8(4), 72–86. https://doi.org/10.5430/wje.v8n4p72

[19] Lo, C. K. (2018). Grounding the flipped classroom approach in the foundations of educational technology. Educational Technology Research and Development, 66(3), 793–811. https://doi.org/10.1007/s11423-018-9578-x

[20] Suryawan, I. P. P., Pratiwi, K. A. M., & Suharta, I. G. P. (2021). Development of flipped classroom learning combined with Google Classroom and video conference to improve students' learning independent and mathematics learning outcomes. Journal of Education Technology, 5(3). https://doi.org/10.23887/jet.v5i3.34466

[21] Wang, F. H. (2021). Interpreting log data through the lens of learning design: Second-order predictors and their relations with learning outcomes in flipped classrooms. Computers & Education, 168, 104209. https://doi.org/10.1016/j.compedu.2021.104209

[22] Zarinfard, S., Rahimi, M., & Mohseni, A. (2021). The impact of flipped classroom on learning outcome in a general English course: Grammar and vocabulary gains in focus. International Journal of Foreign Language Teaching and Research, 9(38), 65–80. https://doi.org/10.52547/JFL.9.38.65

[23] Haqiyah, A. (2021). Flipped classroom model integrated with the online learning platform and video biomechanic analysis to enhance learning outcome of Pencak silat during the Covid-19 pandemic. Turkish Journal of Computer and Mathematics Education (TURCOMAT), 12(11), 2267–2272. https://doi.org/10.17762/turcomat.v12i11.6064

[24] Sailer, M., & Sailer, M. (2021). Gamification of in-class activities in flipped classroom lectures. British Journal of Educational Technology, 52(1), 75–90. https://doi.org/10.1111/bjet.12948

[25] Nurhayati., Ampera. D., Chalid. S., Farihah., & Baharuddin. (2021). Development of blended learning type and flipped classroom-based cultural arts subjects. International Journal of Education in Mathematics, Science and Technology, 9(4), 655–667. https://doi.org/10.46328/ijemst.1975

[26] Cho, H. J., Zhao, K., Lee, C. R., Runshe, D., & Krousgrill, C. (2021). Active learning through flipped classroom in mechanical engineering: Improving students' perception of learning and performance. International Journal of STEM Education, 8(1), 1–13. https://doi.org/10.1186/s40594-021-00302-2

[27] Zhao, L., Liu, X., & Su, Y. S. (2021). The differentiate effect of self-efficacy, motivation, and satisfaction on pre-service teacher students' learning achievement in a flipped classroom: A case of a modern educational technology course. Sustainability, 13(5), 2888. https://doi.org/10.3390/su13052888

[28] Förster, M., Maur, A., Weiser, C., & Winkel, K. (2022). Pre-class video watching fosters achievement and knowledge retention in a flipped classroom. Computers & Education, 179, 104399. https://doi.org/10.1016/j.compedu.2021.104399

[29] Yang, C. C., Chen, I. Y., Akçapınar, G., Flanagan, B., & Ogata, H. (2021). Using a summarized lecture material recommendation system to enhance students' preclass preparation in a flipped classroom. Educational Technology & Society, 24(2), 1–13.
[30] Aguilar, R., Santana, M., Larrañeta, B., & Cuevas, G. (2021). Flipping the strategic management classroom: Undergraduate students' learning outcomes. Scandinavian Journal of Educational Research, 65(6), 1081–1096. https://doi.org/10.1080/00313831.2020.1825524
[31] Setyosari, P., Kuswandi, D., & Widiati, U. (2021). Reading comprehension skills: The effect of online flipped classroom learning and student engagement during the COVID-19 pandemic. European Journal of Educational Research, 10(4), 1613–1624. https://doi.org/10.12973/eu-jer.10.4.1613
[32] Ruiz-Jiménez, M. C., Martínez-Jiménez, R., Licerán-Gutiérrez, A., & García-Martí, E. (2022). Students' attitude: Key to understanding the improvement of their academic RESULTS in a flipped classroom environment. The International Journal of Management Education, 20(2), 100635. https://doi.org/10.1016/j.ijme.2022.100635
[33] Jensen, S. A. (2011). In-class versus online video lectures: Similar learning outcomes, but a preference for in-class. Teaching of Psychology, 38(4), 298–302. https://doi.org/10.1177/0098628311421336
[34] Le Cornu, A. (2009). Meaning, internalization, and externalization: Toward a fuller understanding of the process of reflection and its role in the construction of the self. Adult Education Quarterly, 59(4), 279–297. https://doi.org/10.1177/0741713609331478
[35] Troy Frensley, B., Stern, M. J., & Powell, R. B. (2020). Does student enthusiasm equal learning? The mismatch between observed and self-reported student engagement and environmental literacy outcomes in a residential setting. The Journal of Environmental Education, 51(6), 449–461. https://doi.org/10.1080/00958964.2020.1727404
[36] Deng, F. (2020). Research on the flipped college English class based on "Knowledge internalization". Journal of Language Teaching and Research, 11(3), 467–472. https://doi.org/10.17507/jltr.1103.15
[37] Hargis, J., & Marotta, S. M. (2011). Using flip camcorders for active classroom metacognitive reflection. Active Learning in Higher Education, 12(1), 35–44. https://doi.org/10.1177/1469787410387816
[38] Egbert, J., Herman, D., & Chang, A. (2014). To flip or not to flip? That's not the question: Exploring flipped instruction in technology supported language learning environments. International Journal of Computer-Assisted Language Learning and Teaching (IJCALLT), 4(2), 1–10. https://doi.org/10.4018/978-1-4666-8246-7.ch082

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