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Research Article

Blended Learning: The Effect on Students' Self-Regulation and Academic Achievements

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Abstract: The study aims to determine the impact of blended learning on the performance of science students and their self-regulation and to identify effective recommendations to improve the effectiveness of blended learning. Third-year students of Kazan Federal University took part in the study. The measurement scale tools adopted in this study included pre-test, post-test and self-regulation questionnaires. Analyses showed that participants in the experimental group scored higher on the final test than students in the reference group. The experimental group scored significantly higher than the reference group on the self-regulation questionnaire. It can be concluded that the blended learning model can significantly improve students' self-regulation compared to the traditional approach to learning. Recommendations were made to improve blended learning.

Anahtar Sözcükler:
Harmanlanmış öğrenme,
bilim eğitimi,
öz-düzenleme,
akademik başarı

Harmanlanmış Öğrenmenin Öğrencilerin Öz-Düzenleme ve Akademik Başarılarına Etkisi

Özet: Bu çalışmanın amacı, harmanlanmış öğrenmenin fen bilimleri öğrencilerinin performansına ve öz düzenlemelerine etkisini belirlemek ve harmanlanmış öğrenmenin etkililiğini artırmaya yönelik önerilerde bulunmaktır. Araştırmaya Kazan Federal Üniversitesi üçüncü sınıf öğrencileri katılmıştır. Çalışmada uygulanan ölçüm ölçeği araçları ön test, son test ve öz düzenleme anketini içermektedir. Analizler, deney grubundaki katılımcıların son testte referans grubundaki öğrencilere göre daha yüksek puan aldığını gösterdi. Deney grubu, öz-düzenleme anketinde referans grubuna göre önemli ölçüde daha yüksek puan aldı. Kullanılan harmanlanmış öğrenme modelinin, geleneksel öğrenme yaklaşımına kıyasla öğrencilerin öz düzenlemelerini önemli ölçüde geliştirebileceği sonucuna varılabilir. Harmanlanmış öğrenmenin geliştirilmesine yönelik önerilerde bulunulmuştur.

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1. Introduction

The changes taking place in the education system are a good reason to explore new approaches and forms of teaching to prepare educators to deal with various emerging issues (Embacher & Primetshofer, 2008; Kilinc et al., 2023). Integrated online (usually distance learning courses) and traditional learning is one of the effective technologies of modern education (Adedokun & Oyetunde-Joshua, 2024; Fraser, 2017; Korableva et al., 2019). This technology is known as blended learning (Banados, 2006; Bonk & Graham, 2006; Chong & Quek, 2022; Dube et al., 2023; Gabidullina et al., 2023). In fact, there is no generally accepted classification of specific models for implementing blended learning (Burns, 2011). The most common are rotation models (station rotation, lab rotation, individual rotation, flipped classroom), Flex model, A La Carte model, and Enriched Virtual model (Kintu et al., 2017). Despite all the differences, existing blended learning models rely on traditional direct face-to-face interaction in the learning process, technologically mediated interaction, and self-learning (Moore, 2012).

Blended learning technology is said to combine formal and informal learning, face-to-face and online communication, guided activities and independent choice to achieve personal goals and objectives (Rosett & Frazee, 2003). Blended learning teaches students how to make decisions, plan and organize their own activities, handle the online learning platform, and search, select and analyse information (Moore et al., 2011). The e-learning component of blended learning can be put into practice using all kinds of tools (Gonen & Basaran, 2008; Kalimullina et al., 2021), including social media such as Facebook (Hensley & Waters, 2023; Meishar-Tal et al., 2012). However, in most cases, teachers tend to use different learning management systems (LMS). These systems represent a set of software-hardware, instructional methods and technical measures (Naveh et al., 2010) and are widely used in both academic and corporate learning (Shurygin et al., 2021). Currently, there are many such systems, for example, BlackBoard, WebCT, Top-Class, Claroline, ILIAS, Desire2Learn, Moodle, etc. (Green et al., 2012). They allow teachers to create interactive e-courses that contain all the necessary teaching, support and monitoring elements (Almarabeh, 2014). The availability of such courses makes it possible to use effectively a blended learning approach as a combination of traditional and distance learning (Cerezo et al., 2016).

The online learning platform known as Modular Object-Oriented Dynamic Learning Environment (Moodle) is most common in Russia as well as in many other countries. LMS Moodle has been used effectively in education for over a decade (Cole & Foster, 2007). Both universities (Costa et al., 2012) and schools use and benefit from the platform (Psycharis et al., 2013). Over the years, the system has become widespread, particularly in teaching physics and other science disciplines at various educational levels (Benito et al., 2007; Ekici et al., 2012). Distance learning is becoming crucially popular, greatly expanding the learning space (Beese, 2014; Zwane & Mudau, 2023) and allowing students to immerse themselves in university programs at a deeper level (Aktaruzzaman & Plunkett, 2016; Bochkareva et al., 2017; Sujaya, 2023). Computer technology allows participants in the learning process to exchange information at any distance (Adedokun et al., 2023; So & Brush, 2008). In addition, this way of learning has a number of advantages over traditional learning, as it provides students with opportunities to learn at their own pace and in their own space (Thoms & Eryilmaz, 2014).

The improvement of distance learning is currently a problem because teachers are not ready for such an experience; they lack IT competence and the necessary skills to use computer-

based online learning systems (Leontyeva, 2018; Yelubay et al., 2022). In today's context, the success of distance learning is related to the way teachers relate to the process. Some often doubt the effectiveness of online education due to time factors and technical problems (Anderson & Dron, 2011). It is also important to investigate the impact of different blended learning models on students' academic performance and self-regulation, especially in the context of science subjects, which are the most difficult to learn on their own. The results of such studies will help to adjust the learning process if necessary.

With the development of the COVID-19 pandemic and the forced shift from face-to-face to online learning, self-regulated learning strategies have assumed a special role (Yeung & Yau, 2022). This further underlines the growing importance of research into different self-learning technologies. The document should be written in English and should adhere to the textual and/or graphic requirements outlined in this template. Authors are advised to copy and paste their content into the proper places in this template. All of the colored instructional material that appears in brackets throughout the manuscript should be removed.

1.1. Literature Review

There are many definitions of blended learning, but most of them have in common that they indicate a combination of virtual and real learning environments (Basitere & Ivala, 2017; Hung, 2016). Despite the plurality of definitions of blended learning, they all emphasize that it is a learning strategy combining different traditional and distance learning models and using different forms of interaction (Akbarov et al., 2018; Dwomoh et al., 2023). Blended learning combines the best of face-to-face classroom learning and online learning through its applications (Ramulumo & Mohapi, 2023; Volchenkova, 2016; Nureeva et al., 2019). Blended learning has also been defined as a program that utilizes more than one method to convey information to enhance learning outcomes through student-teacher interaction (Bednarova & Merickova, 2012; Hamakali & Josua, 2023; Nyika & Motalenyane, 2023). Blended learning is known as an integrated system designed to help students at every stage of learning by using a combination of traditional learning and e-learning in its various forms in the classroom (Alajmi, 2021; Garrison, 2009; Gqokonqana et al., 2022).

As defined by other authors, blended learning is a form of learning in which e-learning is integrated into traditional classroom learning, using a computer, the Internet or a smart classroom, where the instructor meets the student face to face, and student-teacher interaction is embedded in the e-course design (Akhmetshin, 2023; Al-Said et al., 2023; Baytiyeh, 2017; Kavitha & Jaisingh, 2018). It emerged as a natural evolution of programmed and e-learning (Martin-Blas & Serrano-Fernandez, 2009). Based on previous definitions of blended learning, researchers have defined it as a new learning strategy that aims to increase students' motivation and improve their academic performance (Dziuban et al., 2018). The main characteristics of blended learning are summarised as follows (Linn et al., 2013):

- combines different types of Internet technologies to achieve educational goals;
- is a hybrid of traditional learning methods with Internet technologies;
- combines different learning methods based on multiple theories, such as constructivism and behavioural theory.
- consists of face-to-face classroom sessions as well as individual online learning through e-learning and the Internet.

The most significant advantages of blended learning are more efficient use of classroom time. Students are more active and better prepared, it is more interesting for them, and it provides an opportunity to offer them many educational resources (Susan et al., 2015). The best way to properly implement blended learning is to choose the right component or media package that provides maximum effectiveness at minimum cost (Ekici et al., 2012; Escobar-Rodriguez & Monge-Lozano, 2012; Ion et al., 2016). Mobile systems may be of great importance (Titova & Talmo, 2014; Volkova et al., 2020; Zulham et al., 2022).

There has been extensive research on blended learning and its impact on student achievement in educational settings such as schools and universities (Akhmetshin et al., 2023; Detyagin et al., 2019; Georgakopoulos et al., 2020; Kintu et al., 2017; Seage & Türegün, 2020; Tosun, 2015;). Although most studies related to blended learning have been conducted in universities, some studies have shown that this approach is also useful for school students (Seage & Türegün, 2020; Radzitskaya & Islamov, 2024). Implementing blended learning in teacher education has been noted to be particularly effective (Abdullah & Meral, 2018; Keengwe & Kang, 2013; Solovyeva et al., 2023).

A wide range of studies have shown that blended learning has a positive impact on student achievement, while other studies have shown that it achieves student success rates equivalent to traditional education (Chen & Jones, 2007; Krylova et al., 2020; Panova et al., 2021). The use of multimedia, such as videos, Encarta Encyclopedia, and simulation software, can provide advantages over textbooks, especially when learning complex science topics and difficult concepts that are unfamiliar to learners (Addam, 2022; Kagohara, 2010; Mashudi et al., 2020; Omodan &). Blended learning helps to improve learning and teaching, and students often prefer blended learning to traditional learning (Bowen et al., 2014; Saenko et al., 2019; Taylor, 2022; Shurygin et al., 2023).

There have been several studies investigating the use of blended learning in teaching instead of traditional teaching in institutions such as universities and schools, which have confirmed that blended learning is more effective than traditional learning in terms of outcomes (Akbarov et al., 2018; Bakeer, 2018; Maccoun, 2016; Otts et al., 2021). On the other hand, other studies found no significant effect of using blended learning, finding no statistically significant differences between groups that were trained using blended and traditional methods (Ofori-Kusi & Tachie, 2022; Tosun, 2015; Wei et al., 2017). Therefore, they concluded that blended learning has no significant positive effect on students' academic performance. Thus, the researchers consider it essential to study the impact of modern learning strategies directly related to digital technology on student performance, especially in science subjects.

1.2. Purpose

The study aims to determine the impact of blended learning on students' performance in physics as a science discipline and their self-regulation and to develop effective recommendations for improving the effectiveness of blended learning. The objectives of the study are the following:

- to assess the level of achievement of students in the reference and experimental groups by means of testing;

- to determine the level of self-regulation of students, to identify whether there is a significant difference in the level of self-regulation of students of the reference and experimental group by means of the questionnaire
- to offer recommendations to teachers on improvement of the effectiveness of blended learning.

2. Methods and Materials

A quasi-experimental study was conducted to study the impact of blended learning on students' performance in science subjects and their level of self-regulation. The quasi-experimental design is a scientific approach to research as it explores causal relationships between independent and dependent variables in a well-controlled context.

2.1. Participants of the study

Third-year students of Kazan Federal University took part in the study. One hundred forty participants were selected, 70 randomly selected as the experimental group and 70 as the reference group. The average age of the participants was 20 years old. Physics was chosen as the science discipline. Learning in the reference group took place traditionally – through lectures, practical and laboratory classes at the university, while the experimental group used a hybrid blended learning model (Krasnova & Shurygin, 2020). Distance learning was mostly asynchronous, with the help of the author's e-learning courses, which were developed in LMS Moodle. Elements of the "flipped classroom" model were utilized. Only control tests were conducted synchronously.

2.2. Research Tools

The measurement scale tools adopted in this study included a pre-test, a post-test, and a self-regulation questionnaire (Appendix). The pre-test and post-test were developed in LMS Moodle by teachers who had been teaching physics for many years. The pre-test was aimed at assessing the students' prior knowledge. It consisted of ten multiple-choice and ten true/false questions, with a top score of 100. The post-test was designed to assess students' knowledge of the physics course being studied. The test also included ten multiple-choice computational questions and ten true/false questions with a top score of 100. The sections of physics covered were mechanics and molecular physics. Two physics assessors stated that the tests were adequate to assess the student's performance in this block.

Self-regulation questionnaire judgments were suggested to be assessed using a Likert psychometric scale. A numerical scale of 1 to 5 was used to indicate the degree of approval of a particular judgement instead of 'strongly agree' or 'strongly disagree'. A 24-item self-regulation questionnaire proposed by Barnard in 2009 was used (Barnard, 2009). It was divided into six dimensions: environmental structuring (4 items), goal setting (5 items), task strategies (4 items), time management (3 items), help-seeking (4 items), and self-esteem (4 items).

2.3. Statistical Analysis

The reliability of the tests was verified with Cronbach's alpha. The scale for interpreting Cronbach's alpha values, according to George and Mallery (2000), is as follows: > 0.9 excellent; > 0.8 good; 0.7 acceptable; 0.6 doubtful; and> 0.5 poor.

Cronbach's alpha pre-test and post-test values were 0.88 and 0.90, respectively, indicating acceptable internal consistency (Cortina, 1993). The overall Cronbach's alpha on the self-regulation questionnaire was 0.92, and the Cronbach's alpha values separately for the six dimensions were 0.95, 0.92, 0.93, 0.87, 0.96 and 0.94, respectively. An ANCOVA analysis was conducted to eliminate the difference between the pre-tests of the two groups and to research the effectiveness of the blended learning model used. The Shapiro-Wilk test was used to calculate the normality of the data obtained in the study.

Some limitations of the present study should be noted. Primarily, future research might consider a longer experiment. Moreover, it is worth considering increasing the sample size of the experiment in order to attract more students and increase the accuracy of the experimental results. Finally, factors such as different science disciplines, different learning styles, and different academic achievement characteristics can also be considered further to expand the scope and depth of the study.

3. Results

3.1. Analysis of Learning Achievements

The Shapiro-Wilk test was used to calculate the normality of the data obtained in the study. The result of this test was 0.97 ($p=0.23$), which indicates a normal distribution of the data. Moreover, Levene's test was performed to determine the homogeneity of variance ($F=3.11$, $p>0.05$), showing that the assumption was reasonable and that there were no significant differences in the variance of the two groups. The assumption of homogeneous regression slopes was confirmed, indicating that a one-way ANCOVA analysis could be performed ($F=0.26$, $p> 0.05$).

In order to examine the impact of blended learning on the performance of the physics students, ANCOVA analysis of covariance was used to exclude the difference between the prior knowledge of the two groups. ANCOVA treated the pre-test score as a predictor variable (or reference variable) of the post-test score and then determined whether the adjusted post-test score had inter-group differences after adjusting for the pre-test score. Table 1 shows the results of the ANCOVA analysis regarding student performance. The adjusted mean and standard error were 74.71 and 3.45 for the experimental group and 65.9 and 3.59 for the reference group. According to the results, there was a significant difference between the test results of the two groups ($F = 10.84$, $p < 0.05$).

Table 1.

Results of analysis of learning achievements (ANCOVA) of students

Groups	N	Value	SD	Adjusted mean value	SE	*F*	η^2
Reference group	70	65.44	19.75	65.90	3.59	10.84*	0.62
Experimental group	70	75.14	12.43	74.71	3.45		

** p<.05*

Students in the experimental group scored higher on the final test (74.71) than those in the reference group (65.9). This indicates that the hybrid blended learning model can contribute to the improvement of students' academic performance. Moreover, the effect value ($\eta 2$) of learning achievement was 0.62, corresponding to a small mean value (Cohen, 2013).

3.2. Analysis of Self-regulation

The Shapiro-Wilk test was used to calculate the normality of the data obtained in the study. The result of this test was 0.96 ($p = 0.32$), indicating a normal distribution of the data. Moreover, Levene's test for homogeneity of variance was performed ($F = 0.71$, $p > 0.05$), which means that the assumption is reasonable and that no significant differences were found in the variance of the two groups. The assumption of homogeneity of regression slopes was also tested, showing that one-way ANCOVA analysis could be applied ($F = 0.56$, $p > 0.05$).

Table 2.

Results of analysis (ANCOVA) of students' self-regulation

Self-regulation	Group	N	Value	SD	Adjusted mean value	SE	*F*	η^2
Goal-setting	Experimental group	660	3.53	0.68	3.60	0.08	8.23**	0.76
	Reference group	660	3.05	0.70	3.06	0.08		
Environmental structuring	Experimental group	660	3.23	0.63	3.23	0.11	6.70*	0.10
	Reference group	60	3.06	0.59	3.00	0.10		
Task completion strategies	Experimental group	660	3.60	0.81	3.53	0.15	7.17*	0.10
	Reference group	660	2.91	0.92	2.97	0.14		
Time- management	Experimental group	660	4.25	0.68	4.20	0.13	8.40**	0.12
	Reference group	660	3.65	0.79	3.69	0.12		
Help-seeking	Experimental group	660	4.12	0.65	4.03	0.10	5.50*	0.08
	Reference group	660	3.67	0.64	3.73	0.10		
Self-assessment	Experimental group	660	3.89	0.68	3.89	0.11	9.41**	0.86
	Reference group	660	3.39	0.64	3.40	0.11		
Total	Experimental group	60	3.73	0.66	3.68	0.13	9.84**	0.15
	Reference group	660	3.06	0.71	3.10	0.12		

***p<0,01. * p < 0.05.*

Table 2 presents the ANCOVA results of students' self-regulation. The adjusted mean and standard error were 3.68 and 0.13 for the experimental group and 3.10 and 0.12 for the control group. The results showed a significant difference in scores between the two groups after the questionnaire ($F = 9.84$, $p < 0.05$). The current study included the analysis of six dimensions (goal setting, environmental structuring, task strategies, time management, help-seeking and self-assessment). The results showed that the experimental group achieved significantly higher scores than the reference group on goal-setting (AM = 3.60, SE = 0.08), environmental structuring (AM = 3.23, SE = 0.11), task completion strategies (AM = 3.53, SE = 0.15), time management (AM = 4.20, SE = 0.13), help-seeking (AM = 4.06, SE = 0.10) and self-assessment (AM = 3.89, SE = 0.11).

3.3. Recommendations for Improving Blended Learning

Blended learning provides an opportunity for both students and teachers to utilize modern digital technology to improve the learning process significantly. One of the main advantages of blended learning is that it makes possible for students to avoid overcrowded classrooms and to be largely self-directed in their learning activities. However, if not organized correctly, blended learning can be a hindrance rather than a solution. Therefore, to summarize the results of this study, the following effective recommendations for improving blended learning can be proposed.

1. Determine how interactive your course is. When optimizing or implementing blended learning, the first thing to do is to determine how interactive your course will be. Blended classrooms are designed to incorporate e-learning and the use of the Internet so that students can work independently wherever they are in the course. However, they are not designed to be fully interactive. Therefore, the first step is to determine what part of the course will be delivered in the classroom and what part will be delivered remotely via the Internet. Knowing this will help you plan the course efficiently and schedule it. Students will know when they need to be in the classroom physically and when they can study online.

2. Try a flipped classroom. If you are going to introduce blended learning, it is also useful to try different models of how to organize it. The flipped classroom model involves taking traditional classroom roles and changing them. In a traditional classroom, the teacher lectures during class time, and students can use their time to study and check the course material. In a flipped classroom, students can review pre-recorded lectures at their leisure and use class time for discussion and assignments. This is a particularly good model if your aim is to get students actively working with the course material in their own time. A flipped system also means that they will be much more active in the physical classroom than in a traditional setting.

3. Use videos as teaching aids. One of the best ways to make your blended class more successful is to use video lessons. They can play an important role in creating the flipped classroom we have used, but their benefits go far beyond pre-recorded lectures. Video tutorials can be a great way of explaining the most difficult points for students to understand. We recommend using DemoCreator Video Recorder, a professional tool for recording tutorial and demonstration videos. Students are much more likely to engage with videos and learn much faster and more effectively than with a multi-page document. One of the best ways to use video for learning purposes is to ask students to make a video presentation of their understanding of some element of the course as an assignment. You can then play back the videos they have sent in class and assess their work.

4. Group cooperation and interaction. In order for blended learning to be effective, it is not sufficient for the student and teacher to interact, it is necessary for the learners to interact with each other. While it is very easy to do this in the classroom, it is not so easy in the online classroom. For effective group cooperation on the Internet, many multimedia tools and software have to be combined. Once this is achieved, learners can easily communicate and collaborate outside the classroom. Fortunately, as already mentioned, many learning management systems are designed for this purpose. Choosing an off-the-shelf platform, rather than trying to create one by combining several tools, is more beneficial for the effective organization of blended learning. For example, our LMS Moodle contains chat rooms, forums, and a private messaging function that allows students to communicate with each other and the teacher.

5. Use distance technology for different types of classes. Experience shows that distance technology can have a significant positive impact on all types of science classes. This includes the study of theoretical material and practical sessions on problem-solving, as well as the organization of a laboratory workshop. Elements of different blended learning models should be combined.

4. Discussion

Compared to the traditional teaching approach, the blended learning model may result in better student achievement in the context of physics learning. It can be assumed that students were more interested in working with interactive learning materials and receiving active feedback from teachers. The results convincingly show that, compared to the traditional teaching approach, the blended learning model can be effective in improving students' self-regulation.

When using this learning system, significant differences were observed in the six dimensions of the self-regulation questionnaire between the two groups: goal-setting, environmental structuring, task completion strategies, time-management, help-seeking and self-assessment. Moreover, it shows that learning through a blended learning model has improved learners' abilities in these six dimensions. The approach helps learners to be more conscious of their learning process, improve learning behaviour, and self-monitoring, and realize their learning goals more effectively.

Regarding the learning environment, some students noted that learning through the blended learning model would increase their determination to find an effective learning environment, but some students said that there was no particular difference. These results merit further investigation and analysis to improve the accuracy of the data. The results of one study on the impact of blended learning on student performance showed that there were statistically significant differences between the experimental and control groups in favour of the experimental group, and the attitude of the experimental group towards using blended learning was more positive (Alsalhi et al., 2019). In our case, the average post-test score for students in the experimental group is 16.11 compared to 14.12 for the reference group, consistent with the results obtained in the mentioned study. Other researchers have come to a similar conclusion (Akbarov et al., 2018; Bakeer, 2018; Maccoun, 2016). However, the results of our study are inconsistent with those of others, which have shown that the use of blended learning had no significant effect (Tosun, 2015; Wei et al., 2017). There are probably a number of other factors affecting student performance that we did not consider.

The authors of another experiment stated that students who study with blended learning feel more engaged in the learning process; they do not get bored as easily during classes. Blended learning is able to improve student engagement, concept understanding and learning outcomes (Fitri & Zahari, 2019). Students in one study were able to achieve certain learning outcomes, and the authors believe that their model supports previous findings on the effectiveness of blended learning in higher education: 'blended learning is consistent with the values of traditional higher education institutions and has a proven potential to improve both the effectiveness and efficiency of meaningful learning' (Bralić & Divjak, 2018). Based on the results of the following study, it was also concluded that blended learning technology is quite effective in improving student performance and developing scientific cognition skills in a science course (botany) compared to a traditional teaching strategy (Harahap, 2019).

5. Conclusions

The most obvious contribution of this study is the impact of blended learning on students' performance in physics as a science discipline. Data analysis showed that students in the experimental group scored higher on the final test (74.71) than those in the reference group (65.9). Thus, the implementation of blended learning had a positive impact on students' performance. There was a statistically significant difference between the experimental and reference groups in favour of the experimental group taught using blended learning.

The results of the study assessed the level of students' self-regulation in the hybrid model of blended learning and also revealed whether there were significant differences in the students' self-regulation levels in the reference and experimental groups. The experimental group scored significantly higher (3.68) than the reference group (3.10), indicating that this model can significantly improve students' self-regulation compared to the traditional learning approach. The results of the study once again show that blended learning is an effective form of education, especially in higher education. This means that learning can be more effective when the benefits of the web-based environment are intelligently combined with face-to-face interaction. Furthermore, the study provides recommendations for enhancing the effectiveness of blended learning. In particular, it is recommended that the degree of interactivity of the respective course be controlled carefully to try to use elements of different blended learning models, e.g., the flipped classroom. A wider use of videos as teaching and learning aids as well as group cooperation and interaction, seems to be effective. In the process of teaching science disciplines, e-learning elements should be used more extensively when organizing different types of classes: studying theoretical material, problem-solving, and laboratory practice. This can be done by applying similar research that reflects the views and experiences of practitioners who combine research work with teaching science disciplines.

The findings can contribute to developing a set of interventions that will help optimize the learning process in blended learning to improve student performance and self-regulation. Future research could investigate the positive and negative aspects of different blended learning models, expand the sample, conduct longer experiments, and explore the impact of this type of learning on students' performance in other disciplines.

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Note on Ethical Issues

The authors confirm that the study does not need ethics committee approval according to the research integrity rules in their country (Date of Confirmation: 16/04/2024).

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Appendix.

Self-regulation Assessment Questionnaire

Give the following statements a score from 1 to 5, depending on how much you agree with them (1 – strongly agree, 5 – maximum disagree):

Goal-setting

1. In a physics course, I set standards to be met in completing learning objectives.
2. I set not only long-term goals (one month or one semester) but also short-term goals (one day or one week).
3. I hold myself to a high standard when taking a physics course.
4. In a physics course, I set goals that will help me in my time management.
5. I do not lower my expectations of the quality of my learning just because it is a physics course.

Environmental structuring

1. I will choose a place to study so that I am not interrupted too often.
2. I will find an environment in which I feel comfortable doing my learning activities.
3. I know where my learning will be most effective.
4. I choose the times that interfere with my studies the least.

Task completion strategies

1. In this physics course, I will complete tasks more carefully, because this is more important in an e-learning course than in traditional learning.
2. I will study physics course tutorials more regularly so as not to interrupt the learning process.
3. I will prepare questions to ask before entering a chat room or discussion room.
4. I will try to study questions different from those in the physics course so that I can grasp the content of the course in more depth.

Time-management

1. I will use time for learning activities in the physics course beyond the assigned time because I know that this course requires time.
2. I will try to schedule the same study periods each day or week and follow this schedule carefully.
3. Although I do not need to go to university every day as I used to, I still try to spread my study time evenly each day.

Help-seeking

1. If I find someone who is familiar with the content of a physics course, I will ask for help if necessary.
2. I will share problems with my classmates so that I know what problems they are having and how to solve them.
3. I will discuss one-on-one with my classmates if necessary.
4. I will continue to receive help from the teacher via e-mail or personal messages in the e-course.

Self-assessment

1. I will summarize what I have learned in the physics course to see how well I understand what I have learned.
2. While studying, I ask myself many questions about the content of the physics course.
3. I discuss with my classmates how well I am doing in the course.
4. I will discuss with my classmates to see how my learning differs from theirs.