



Is It Necessary to Use Digital Tools in the Flipped Classroom to Improve the Memorization Process?

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Memorization is a crucial factor in effective learning and achieving educational goals. Recent research has suggested that short video sequences viewed by students before class can aid in acquiring and retaining basic concepts, thereby improving memorization and positively impacting the learning process in the flipped classroom approach. However, frequent use of digital tools among adolescents has been found to negatively impact cognitive functions such as memorization. It is worth noting that the traditional use of paper-based materials has been found to have a positive impact on memorization, particularly among learners who are easily distracted by digital devices or experience eye strain from prolonged screen use. Printed materials can offer a more tactile experience, allowing learners to physically highlight and annotate text, which can aid in the encoding and retrieval of information. This study aimed to assess the role of digital tools in the flipped classroom approach and determine if they could be substituted by paper-based materials. To achieve this, a comparative study was conducted between 35 students using digital tools in their flipped classroom (FCDS) and 31 students using paper-based materials (FCPS). The study involved administering pre-tests and post-tests to both groups to evaluate their ability to retrieve basic concepts and assess the effectiveness of their learning in life and earth sciences. The results indicate that learners were able to retrieve knowledge effectively regardless of the medium used and that the positive effect of the FCDS on recall during learning is comparable to that of the FCPS.

Keywords: digital tools, flipped classroom, memorization, learning process, life, earth

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INTRODUCTION

The flipped classroom is an innovative pedagogy based on a hybrid mode of teaching that reverses traditional teaching methods by shifting the focus from the teacher to the student, lecturing outside the classroom, and conducting active learning activities inside the classroom (Cevikbas & Kaiser, 2022). With its hybrid nature, this approach seems to be the most suitable to integrate digital tools while preserving the qualities of direct contact with the teacher.

Before class meetings, the flipped classroom approach includes a kind of pre-class activities (e.g., watching videos)(Yu & Gao, 2022) and individual or whole activities during face-to-face lessons. (Abeysekera & Dawson, 2015; He et al., 2016). Similarly, Bishop and Verleger state that individual learning that occurs outside of the classroom must be guided by digital tool.

Naccarato and Karakok (2015) interviewed 19 mathematics instructors from 14 colleges and found that while all instructors shared video lectures before class, they applied different approaches to classroom activities, including a combination of short quizzes at the beginning of the course, video assessment of the course, small group and whole group instruction, discussions, student presentations, and application projects some mathematics instructors still set aside classroom time for traditional lecture-based instruction (Naccarato & Karakok, 2015).

According to the findings, many studies confirm that using digital tools, particularly video sequences, in the flipped classroom approach is beneficial to the learner, making this pedagogical practice one of the most affordable approaches for teachers at the secondary, college, and primary levels. After the COVID-19 pandemic, scientific research in this area has accelerated to verify its effectiveness and effects and to normalize these practices.

Following these definitions, we note that the use of digital tools, particularly instructional videos, during out-of-class learning sessions is a requirement in this approach (Bernard, 2015). However, such a requirement implies that in disadvantaged circumstances, such as those found in developing countries, teachers are unable to use this pedagogical approach due to a lack of technology among learners and, in some cases, among teachers. Also, He et al. objected to this requirement in 2016, declaring that it is not the support that defines the purpose of the out-of-class session. The central idea is that it should allow the learner to gain knowledge in advance. As a result, there is currently no standard way for the flipped classroom approach. (He et al., 2016)

According to (Porion et al., 2016), there is no significant difference in reading performance between paper-based and computer-based presentations if all presentation conditions are met (text structure, single-page presentation, screen size, and several types of questions measuring comprehension and memorization performance).

The flipped classroom appears to be a rational approach to overcoming several challenges encountered in the teaching of life and earth sciences, where insufficient time devoted to each session only allows the first two pedagogical objectives in the revised

BLOOM taxonomy to be achieved (Amer, 2006): memorizing and understanding, and thus the carrying out of experiments and production activities within the classroom to attain the high-level pedagogical objectives: applying, evaluating, and creating. In this view, providing learners with support in achieving the first two pedagogical objectives in advance will aid in targeting the others during a classroom session.

This research aims to investigate if non-digital resources, such as paper documents, can effectively replace digital materials in the flipped classroom model, with a potentially positive impact on memory retention.

Our hypothesis suggests that paper-based resources cannot replace digital tools in the flipped classroom approach, as their impact on memory retention during learning may be less significant compared to digital tools.

Throughout this study, we will consider definitions of the flipped classroom that emphasize the targeted pedagogical objectives rather than the nature of the digital tools used, such as that of Marcel Lebrun, who defines the approach as follows: "Flipped classrooms are based on a pedagogical method in which the transmissive portion of the teaching is done remotely as a precursor to an in-person session. Learning is based on face-to-face activities and interactions"(Lebrun et al., 2017) According to the Flipped Learning Network: " The flipped classroom is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students to apply concepts and engage creatively in the subject matter"(Flipped Learning Network, n.d.) We also consider digital tools to be any device that allows learners to access the internet and view video sequences prepared by the teacher and any support not included in this definition as a non-digital tool. (Brenner, 2022)

Literature Review

Effect of the flipped classroom on memorization and learning

Researchers examined the findings of 33 articles published between 2011 and 2020 in K-12 and higher education contexts and found that using the flipped classroom approach can increase aspects of behavioral engagement (interaction and attention/participation), emotional engagement (course satisfaction)(Mallik, 2023), and cognitive engagement (mathematical understanding) (Ismaniati et al., 2023; Lo & Hew, 2021).

Chei-Chang Chiou argues in 2020 that using a digital tool called SCACCM (structured computer-assisted collaborative concept mapping) in the flipped classroom will have a positive effect on motivation to learn (Eren et al., 2023), which leads to good memorization and, as a result, increased academic performance. (Chiou et al., 2020); Wang et al. claimed in 2020 that the flipped classroom improved knowledge mastery and retention, lending credence to the positive effect on long-term memory (Wang et al., 2020).

According to the findings of (Fernández-Martín et al., 2020), the implementation of the flipped classroom led to an improvement in students' knowledge and attitudes toward mathematics content and discipline in the majority of cases.

Furthermore, this method promoted aspects such as collaborative work, autonomy, self-regulation of learning, or academic achievement by linking these findings to the use of both face-to-face and virtual teaching via videos and online material, promoting more autonomous, flexible, and dynamic teaching for students. (Sopamena et al., 2023)

A meta-analysis of 21 comparative studies found that the flipped classroom outperformed the traditional classroom for mathematics teaching, with no evidence of publication bias. A larger research synthesis of 61 studies discovered that the flipped classroom approach improved student learning in three ways: increased time spent in class on tasks/practices, integration of new knowledge with existing beliefs, and real-time feedback. (Lo et al., 2017)

A study conducted in Morocco found that students in the flipped classroom had higher motivation than students in the traditional classroom, particularly in terms of self-efficacy for learning and positive beliefs about assessments, which could be attributed to the benefits and functionalities provided by digital tools (Naciri et al., 2022).

The flipped classroom also had a positive effect on the development of soft skills such as self-learning, critical thinking, curiosity, autonomy, and communication for 4th-year students at NSAS (National School of Applied Sciences) (Jamila, 2020; Zain et al., 2022).

A study in the field of vocational education found that incorporating the flipped classroom into a training situation for future life and earth science teachers has a positive effect on improving learning performance (Boubih et al., 2020).

Because of the importance of these digital tools in flipped classroom implementation (Huang et al., 2023), a study published in 2022 provides a clear illustration of the types of technologies that could be used both at home and in the classroom for effective flipped classroom implementation in primary education (Loizou, 2022).

We note that the literature review focuses on the impact of the flipped classroom in higher education, especially in mathematics courses which are one of the core STEM (Science, Technology, Engineering, and Mathematics) disciplines, by evaluating essentially learning efficiency or psychological factors such as learner motivation while ignoring how an important cognitive function such as memorization is influenced and that in the majority of the articles the experimentation of the flipped classroom makes use of digital tools by considering them as a default tool but if we do the same experiments without digital tools will we get the same findings ?

Effects of paper support on memorization and learning

In 2013, (Mangen et al., 2013) conducted a study that found that students who read print texts performed better on a reading comprehension test compared to students who read digital texts. However, in 2014, (Cheng et al., 2014) conducted a study that found that

students performed better on multiple-choice and summary reading tests when reading on a computer screen compared to a tablet computer. This suggests that familiarity with digital tools may impact reading performance. To determine whether using tablets would impair student performance when drawing and explaining ideas about the particle nature of matter, (Chang & Yu, 2015) asked students to complete the task on three different media: computers, tablets, and paper. The study found that the medium used did not have a significant effect on student performance.

(Aparicio et al., 2022) compared the effects of two media (interactive whiteboards and paper) on the comprehension of expository and narrative texts in grade 5 primary school children. Thus, they suggest that texts with a similar structure, with a single-page presentation, perform similarly on paper and on electronic devices. (Pucko & Pečjak, 2016) report similar findings, but they found significant differences in problem-solving performance. Students who worked with printed texts spent less time answering questions. The study also found that problem-solving speed, perceived self-efficacy, and interest were significant predictors of reading comprehension.

So, we note that there was a shift in results from studies that claim that print media are more beneficial to students' recall and comprehension than digital media to results that seem to be increasingly in favor of the digital tools as they continue to develop.

Effects of digital tools on memorization and learning.

According to one study, the ubiquity of information affects user attention and knowledge management rather than memorizing. In other words, cognitive misery is caused by the availability of online information and the efficient use of attentional resources, not by users' lack of cognitive ability. (Kang, 2022)

This is because people, particularly those with a high working memory capacity, are less likely to remember details but more likely to remember how to access information (a keyword for a search engine query). (Hamzi et al., 2021) But people who are not confident in their ability to remember tend to use external tools (Fisher & Oppenheimer, 2021) making the 2011 statement (Sparrow et al., 2011) increasingly valid. Because of its massive storage capacity, the Internet has become a primary form of external or transactive memory, where information is stored collectively outside of us.

(Ihara et al., 2021) conducted an experiment to determine the effect of digital handwriting on learning and discovered that, once individuals become accustomed to it, handwriting with a digital pen and tablet can increase learning ability compared to keyboarding. Their findings also indicate that the movements involved in handwriting aid in the recall of new words. The advantage of handwriting over typing could also be attributed to a more positive attitude while learning.

This debate about the effects of digital tools on cognitive abilities leads psychology researchers to answer the following question: How much of our cognitive success is due to our abilities, and how much is due to external support?

Offloading can lead to downstream effects such as forgetting reduced effort and altered memory strategies (Kelly and Risko 2022), according to a series of rigorous experiments

Fisher et al also discovered that, in the unaided condition, participants' actual memory performance closely matched their predictions. Furthermore, previous research has shown that when memory is entrusted to assistive devices, performance is overestimated.(Fisher & Oppenheimer, 2021).

We conclude that, under certain conditions, the use of digital tools can be harmful by impairing cognitive functions such as memorization.(Kang, 2022)

Given the limited number of studies that have examined the effects of flipped classrooms on the memorization of college students, especially in subjects such as life and earth sciences, the purpose of this study will be to examine this avenue by questioning the usefulness of digital tools in such a pedagogical approach based on the following hypothesis.

paper-based resources cannot replace digital tools in the flipped classroom approach, as their impact on memory retention during learning may be less significant compared to digital tools.

To verify this, we try to answer the following research questions:

- What is the effect of using digital tools in the flipped classroom on memorization?
- What is the effect of using non-digital tools such as paper supports in the flipped classroom on memorization?
- Is there a significant difference in favor of digital supports over paper supports on the effect of the flipped classroom on memorization?

METHOD

In this experimentation, we employed "Solomon's group design" according to the following design:

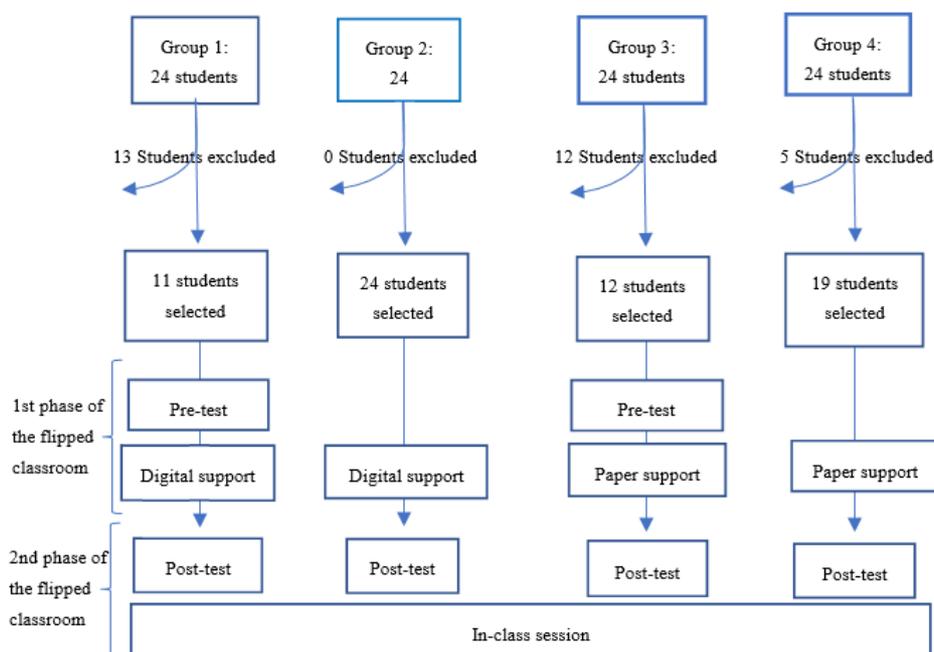


Figure 1
Design of the experimentation (Johnston & Warkentin, 2010)

Group 1 and group 3 will take the pre-test shortly before receiving the resources used to learn about microorganisms. All groups will take the post-test three days after benefiting from the content, just before beginning the second phase of the flipped classroom, which will take place in class and aims at pedagogical objectives other than remembering or understanding.

Students who did not review the supports provided before class because they were absent during delivery, as well as those who chose not to take the pre-test for personal reasons, are excluded from the study. This presents a challenge to implementing the approach, as not having access to the content beforehand prevents the teacher from targeting specific learning objectives during the class session. To ensure ethical considerations and a high-quality sample, only students who meet the required standards are included in the experiment, resulting in a different number of participants.

Materials

- Digital support

To be used during the preparation phase of the flipped classroom, a 6:30-minute video sequence targeting memorization and comprehension objectives related to microorganisms was created and validated by 5 specialists in life science teaching and then shared with the students of the flipped classroom via digital tools (USB, social networks, YouTube).

- Paper support

the POWER POINT (PPT) presentation that was used in the video sequence was printed without modification and delivered in paper format for the flipped classroom students.

- test of memorization

The pre-test and post-test for our experiment are identical in content and thus in purpose, and because the experiment's interest is aimed at memorization, we have developed a specific memory test for the course in question, namely "microorganisms," so that the student only has to restate his or her knowledge to pass the test; by answering this test in 10 minutes, the student will receive a score out of 20.

The test has four educational goals:

- Define microorganisms
- Determine the conditions in which microorganisms live.
- Understand the various kinds of microorganisms.
- Understand the pathogenic properties of microorganisms.

These four objectives do not go beyond the first two levels of Bloom's revised taxonomy (Remember and Understand) because these are the two lowest cognitive cost levels that the student can achieve alone by using the delivered supports.

Before starting the experiment, this memory test was previously tested on a sample of 17 students (47% male, 53% female) with the same characteristics as the study sample to approve its validity and reliability.

The memory test's validity was assessed using three methods. Firstly, content validity was ensured by adhering to the official national guidelines for the specific knowledge targeted in each lesson and the methods used by teachers to evaluate them. Secondly, the construct validity was confirmed through the opinions of five specialists, including two educational inspectors of SVT (life and earth sciences) and three colleagues who teach SVT in the same college laboratory. They all agreed that the memory test measures the intended knowledge. Finally, criterion validity was established by comparing the scores of a sample of 17 students' pre-tests with the scores given by three teachers, using the score provided as a reference evaluation.

Table 1
Descriptive statistics of result of criterion validity

	N	Minimum	Maximum	Mean	SD	Variance
Baseline score	17	0.50	9.50	5.0294	2.40098	5.765
Score_given_teacher_1	17	0.50	9.50	4.9706	2.32157	5.390
Score_given_teacher_2	17	0.00	10.00	5.0882	2.52633	6.382
Score_given_teacher_3	17	0.00	10.00	5.0588	2.53033	6.403
Valid N (listwise)	17					

The descriptive results show that the memory test has criterion validity since the corrections of the 3 teachers are almost the same as the baseline score.

To measure the reliability of the memory test, the sample of 17 students was tested twice using an internal consistency test (Cronbach's alpha).

Table 2
Descriptive statistics of reliability result of the memory test

	N	Minimum	Maximum	Mean	SD	Variance
Tested_1st_time	17	0.50	9.50	5.0294	2.40098	5.765
Tested_2nd_time	17	1.00	9.00	5.1765	2.12824	4.529
Valid N (listwise)	17					

Table 3
Reliability result of the memory test

Cronbach's alpha	N of items
0.953	2

The Cronbach's alpha test yielded a score of 0.953, exceeding the 0.8 thresholds, indicating that the memory test is highly reliable.

- IBM SPSS version 20 software

By applying appropriate statistical tests, particularly the student's t-test with IBM SPSS version 20 software we compare the average score of the group doing the flipped classroom by using paper support (FCPS) to the average score of the group doing the flipped classroom by using digital support (FCDS) (video sequences watched via smartphone or computer).

- MICROSOFT EXCEL version 20

We also use MICROSOFT EXCEL version 20 to present descriptive data in tables and graphs.

The sample of experimentation

The third year of secondary school in the Moroccan education system is one of the decisive years for the orientation of the students since they will either go into the literary or scientific branches because of that the study focuses on two classes of 66 third-year students at the "JABER IBN HAYYAN" secondary school in Fez, Morocco, which is run by the regional academy of education and formation of Fez-Meknes. This sample was divided into four groups based on the characteristics listed in the table below:

Table 4
Descriptive statistics of the groups in the experiment

Class type	Flipped Classroom Digital Support (FCDS)		Flipped Classroom Paper Support (FCPS)	
	Group 1	Group 2	Group 3	Group 4
Number of students per group	11	24	12	19
% Of males in each group	45.45	50	45.00	40.00
% Of females in each group	54.55	50	55.00	60.00

Socio-cultural characteristics of the study

"JABER IBN HAYYAN" is a college with a limited structure that does not respond to current demographic changes caused by rural exodus. Students at "JABER IBN

HAYYAN" college come from a disadvantaged social group where poverty, aggression, divorce, and addiction are more prevalent than in other parts of the city. As a result, less than 10% of students participate in after-school tutoring programs; 20% of them can acquire essential high school skills, particularly in science subjects (statistics provided by the administration of the college in question for the first semester of 2022). Furthermore, the majority of students have no positive emotional connection to their institution.

Choice of study topic

The study focuses on the "microorganisms" lesson for pedagogical reasons (quality of available materials, limited and clear objectives, etc.), organizational reasons (availability of classrooms and students, the permission of the school, etc.) and contextual reasons (novelty of the subject for the students in the sample, awareness especially after covid 19, interesting to start the lesson on the immune system afterwards ...etc.).

FINDINGS

Prior to conducting the t-test, we assessed the normality using the SHAPIRO-WILK test. The results indicated that the data from all four samples followed a normal distribution. Additionally, we considered the results of Levene's test to assess the equality of variances when interpreting the outcomes of the t-test.

Table 5
Normality test results

		Shapiro-Wilk statistic		
			df	sig.
Pre-test	Group1	0.906	11	0.174
	Group3	0.898	12	0.219
Post-test (FCDS)	Group 1	0.933	11	0.446
	Group 2	0.956	24	0.369
Post-test (FCPS)	Group 3	0.913	12	0.232
	Group 4	0.967	19	0.714

Difference between groups before the experiment

Table 6
Comparison of mean pre-test scores between pretested groups using independent samples t-test

	Group	N	Mean	SD	Levene's test for equality of variances		df	T	sig
					f	sig			
Pre-test score	Group 1	11	3.5000	2.39792	0.023	0.881	21	0.358	0.724
	Group 3	12	3.1250	2.60354					

There is no significant difference between the mean pre-test scores of the two classes, as evidenced by the results of the student's t-test. The p-value for the test of equality of means is 0.724, which is greater than the significance level of 0.05. This indicates that the difference in pre-test means between group 1 and group 3 students is not statistically significant. Thus, the initial scores of both classes were similar before the experiment, and this difference is unlikely to impact the outcomes of the experiment.

Effect of the flipped classroom on the memorization process

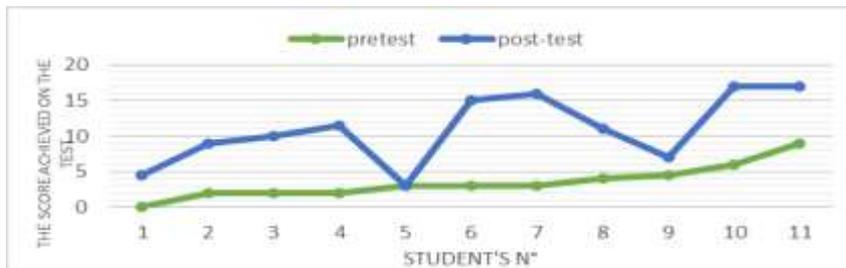


Figure 2
Comparing the results of the pretest and post-test for students in the flipped classroom with digital support (group 1)

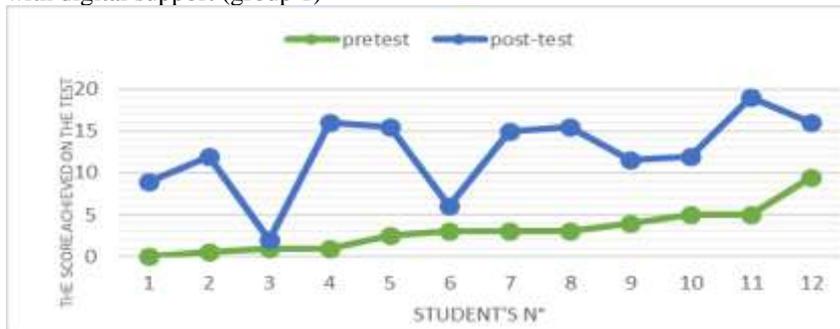


Figure 3
Comparing the results of the pre-test and post-test for students in the flipped classroom with paper support (group 3)

95.65% of the 23 students (groups 1 and 3) who took the pre-test and post-test made progress because the post-test score was higher than the pre-test score, while 4.34% made no progress because the pre-test and post-test scores were identical.

During the pre-test, all students in the two classes scored lower than the average (10/20), but during the post-test, 72.72% of group 1 students and 75% of group 2 students scored higher than the average.

- *The impact of the pre-test on the post-test score*

the post-test scores for those who took the pre-test and those who did not are examined by comparing their means to see whether the improvement shown is attributable to the pre-test distribution.

Table 7

Comparison of mean post-test scores of FCDS students between pretested and non-pretested groups using independent samples t-test

Post-test score	Group	N	Mean	SD	Levene's test for equality of variances		df	T	sig
					f	sig			
					Group 1 (pretested)	11			
Group 2 (not pretested)	24	9.4375	2.659						

Table 8

Comparison of mean post-test scores of FCPS students between pretested and non-pretested groups using independent samples t-test

Post-test score	Group	N	Mean	SD	Levene's test for equality of variances		df	T	sig
					f	sig			
					Group 3 (pretested)	12			
Group 4 (not pretested)	19	10.947	2.204						

The results obtained from the student's t-test indicate that there is no statistically significant difference between the mean post-test scores of students who took the pre-test and those who did not. This is evident from the p-values obtained for the tests of equality of the FCDS and FCPS means, which are 0.228 and 0.244, respectively. Both of these p-values are greater than the significance level of 0.05, indicating that the pre-test distribution had no significant impact on the results.

Comparison of the effect of flipped classroom with digital support versus the effect of flipped classroom without digital tools on the memorization process

Table 9

Comparison of mean pre-test and post-test scores between FCDS and FCPS student groups using paired samples t-test

Group	Score	Mean	N	SD	Mean difference	df	T	sig
Pair 1: Group 1	Pre-test score	3.50	11	2.39	7.5	10	-6.258	0.000
	Post-test score	11.00	11	4.90				
Pair 2: Group 3	Pre-test score	3.12	12	2.60	9.3	11	-7.302	0.000
	Post-test score	12.45	12	4.83				

The results of the student's t-test show that the post-test mean scores for both group 1 and group 3 are significantly higher than their respective pre-test means, with p-values well below the accepted threshold of 0.05. This suggests that the flipped classroom approach has a positive effect on memorization for both paper-based and digital versions.

Moreover, the mean difference between group 1 and group 3 indicates that the use of paper-based materials (FCPS) has a more substantial positive effect (mean difference of 9.3) compared to the digital version (FCDS) (mean difference of 7.5). These findings suggest that using paper-based materials might be more advantageous than digital support in a flipped classroom setting for improving memorization skills.

Is this difference statistically significant?

To evaluate the effects of different supports in the flipped classroom approach, we combined group 1 with group 2 (FCDS) and group 3 with group 4 (FCPS), as the results of the pre-test did not influence the outcomes of the post-test.

Table 9

Comparison of mean post-test scores between FCDS and FCPS student groups using independent samples t-test

	Group	N	Mean	SD	levene's test for equality of variances		df	T	sig
					f	sig			
Post-test score	FCDS	35	9.9286	3.52124	0.037	0.849	64	-1.859	0.068
	FCPS	31	11.5323	3.47116					

While the FCPS mean score is slightly higher than FCDS, a student's t-test reveals a P-value of 0.68, which is greater than the significance threshold of 0.05. These findings suggest that the observed difference in means is not statistically significant. Consequently, the type of support used in the implementation of the flipped classroom approach does not have a significant impact on the positive effect it has on improving memorization skills.

DISCUSSION

The findings of this study corroborate previous research on the efficacy of the flipped classroom approach in teaching science subject (Fernández-Martín et al., 2020; Ji et al., 2022; Sopamena et al., 2023), specifically life and earth sciences at the college level, as reported by (Boubih et al., 2020). The results suggest that both digital and paper-based supports are effective in facilitating students' recall of knowledge before classroom sessions, indicating a positive impact on the memorization process (Porion et al., 2016; Pucko & Pečjak, 2016).

Despite initial differences observed during the pre-test, the majority of students demonstrated progress, indicating that the flipped classroom approach can help to level the playing field by supporting struggling students to catch up and improve, as long as

appropriate supports are available and accessible at a pace that aligns with their individual learning needs, as discussed by (Izadpanah, 2022).

The results of this study show that the use of paper-based materials has allowed students to acquire essential knowledge related to microorganisms and effectively recall it during the test. This observation can be explained by the fact that paper-based materials are easily accessible, portable, and affordable, making them particularly suitable for students in our sample who are accustomed to using such materials due to the unavailability of digital resources in their disadvantaged context (Florit et al., 2023).

Furthermore, some previous studies have also suggested that paper-based materials can offer unique advantages. (Kazazoğlu, 2020) For example, they can promote active reading, which involves more attentive and thoughtful reading, as well as the development of note-taking skills. Additionally, the use of paper-based materials can also encourage deeper engagement with the content, as students can annotate, highlight, and physically interact with the information presented (Talbert, 2017)

It is worth emphasizing that incorporating paper-based materials in the flipped classroom approach can offer significant advantages, especially in settings where digital resources are not easily available. Our study involved students from a disadvantaged context with limited access to digital resources. Through the use of paper-based materials, students were able to access the required information for class preparation in a practical and cost-effective manner. This finding highlights the importance of including paper-based materials in the implementation of the flipped classroom approach, particularly in contexts where access to digital technologies is restricted.

Furthermore, the use of paper-based materials can also contribute to equity in education. In many contexts, access to digital resources can be unequal, leading to disparities in learning opportunities. The use of affordable and easily accessible paper-based materials can help reduce these inequalities by providing all students with the opportunity to effectively prepare for flipped classroom classes, regardless of their socio-economic level, this challenges the assumption that digital tools are indispensable in the flipped classroom, as paper-based supports can be equally effective (Aparicio et al., 2022). It emphasizes the need to question the mandatory use of digital tools in this approach, as discussed by (He et al., 2016), and calls for a reevaluation of definitions that impose the use of digital tools in the flipped classroom, as argued by (Baillie et al., 2022).

The results of this study highlight that the use of digital materials in the flipped classroom approach can also be effective for acquiring knowledge (Wang et al., 2020) about microorganisms and their retrieval during tests. These findings may differ from previous studies (Fisher & Oppenheimer, 2021) that claim that digital materials are detrimental to learners' cognitive functions often rely on excessive and uncontrolled use of digital devices, particularly in entertainment or leisure contexts (Shakoor et al., 2021). However, in the context of the flipped classroom approach, where digital materials are used intentionally and structured to support learning, the results can be different and beneficial for students (Cecutti et al., 2021).

It is important to recognize that the effect of digital materials on learning can vary depending on their mode of use. Reasonable and balanced use of digital materials in the flipped classroom approach can be beneficial for students' learning process (Medved et al., 2023), as demonstrated in this study. Digital materials can offer advantages such as interactivity, access to content-rich resources, and the ability to personalize learning based on individual student needs (Förster et al., 2022).

It is also important to consider that learners' needs and preferences may vary depending on their socio-economic level, cultural context, and learning habits. Some students may prefer the use of digital materials due to their familiarity with these tools (Huang et al., 2023), while others may prefer paper-based materials due to their preference for physical interactions with information. Therefore, it is essential to consider learners' needs and preferences when choosing materials to use in the flipped classroom approach.

CONCLUSION

In conclusion the results of this study did not support the initial hypothesis that digital materials cannot be replaced by paper-based materials in the flipped classroom approach, as the results demonstrate that both digital and paper-based supports are equally effective in helping students recall and retain knowledge before classroom sessions.

The findings of this study indicate that paper-based supports can serve as a viable alternative to digital supports in the flipped classroom approach, especially in unfavorable conditions where digital resources may be limited. However, it is important to note that such substitution is recommended only in specific circumstances. In favorable conditions, digital supports are better aligned with the current and future needs of education in the digital era. It is crucial to recognize that the effectiveness of digital supports depends on their mode of use, and a thoughtful and intentional use of digital tools in the flipped classroom can positively impact the memorization process. Therefore, when choosing between paper-based and digital supports in implementing the flipped classroom approach, contextual and pedagogical factors must be carefully considered, while taking into account the unique needs and demands of learners in today's digital world.

Overall, the results of this study contribute to the growing body of literature supporting the flexibility and adaptability of the flipped classroom approach, and suggest that it can be effectively implemented without solely relying on digital supports. Further exploration of diverse ways of implementing the flipped classroom, including non-digital approaches, can provide valuable insights for educators seeking innovative pedagogical strategies to enhance student learning outcomes in various educational contexts.

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