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EFFECTIVENESS OF FLIPPED LEARNING ON ACADEMIC ACHIEVEMENT IN PHYSICAL SCIENCES

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Abstract- This study aimed to examine the effect of the flipped classroom strategy on academic achievement in physical sciences among third-year middle school students in Morocco. The study population consisted of all third-year students under the jurisdiction of the province of Sidi Slimane, a total of 5134 students during the second semester of the 2022-2023 academic year. The study sample consisted of 68 students deliberately selected from the study population and divided into two groups. The experimental group, which followed the flipped classroom strategy, comprised 34 students (20 boys, 14 girls), and the control group comprised 34 students (19 boys, 15 girls) who followed the traditional teaching method. To achieve the objectives of this study, a success test was developed, and its reliability was validated. To test the research hypotheses, the Mann-Whitney test was employed to clarify the differences between the control and experimental groups on the achievement test. The findings indicated that there were significant differences between the scores of the control and experimental group ranks in the academic achievement test, attributed to the method of teaching, these differences favored the experimental group students. Based on these results, the study recommended that teachers and educational decision-makers seriously consider integrating the flipped classroom into their educational practices. In addition, the study recommended that further research be undertaken to explore further the nuances of this strategy and its impact in various educational contexts.

Keywords: Flipped Classroom, Academic Achievement, Physical Sciences, The Teaching Method, Students.

1. INTRODUCTION

In recent times, the international education system has experienced swift and consecutive transformations, capturing the attention of both developed and developing nations, leading to the restructuring and adoption of innovative strategies in the learning and teaching processes [1]. The Moroccan national education sector has also seen significant evolution, attributed to various factors, such as the emergency plan 2009-2012, the strategic reform vision 2015-2030, the democratization and massification of access to education, and evolution of learning practices in connection with digital culture [2].

In response to these changes, modern teaching methods have emerged, emphasizing integrating information and communication technologies (ICT) into the learning process. Among these innovative methods, the "flipped classroom", also known as the "inverted classroom," has attracted the attention of researchers. This approach aims to motivate and empower students in their learning by, for example, offering them video vignettes to watch at home while class time is devoted to interactive activities and high-cognitive exercises guided by the teacher [3].

Several studies, including those by Gonzalez Gomez, et al. [4], Olakanmi [5], and Xiao Dong and Hong-Hui [6], have underscored the effectiveness and importance of the flipped classroom approach for the process of teaching and learning. Nevertheless, considering the unique features of the Moroccan education system, it becomes crucial to assess the impact of the flipped classroom on academic achievement in physical sciences among middle school students in Morocco. This study aims to conduct an in-depth examination of how the adoption of this pedagogical approach can positively or negatively influence students' academic performance in this subject.

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Through an analysis of prior research findings and a consideration of the specific context in Morocco, we seek to gain a better understanding of the advantages and challenges associated with the flipped classroom as a teaching strategy for enhancing academic achievement in physical sciences among middle school students in Morocco.

2. THEORETICAL FRAMEWORK

2.1. The Flipped Classroom

The flipped classroom is associated with a variety of generic names, including method, strategy, model, pedagogical approach, or pedagogical sequence [7]. It represents an approach that diversifies the methods offered to students [8]. Furthermore, the pedagogical model of the flipped classroom reorients the learning process by reversing traditional in-class and out-of-class activities [9]. Its fundamental principle lies in the fact that students engage in knowledge acquisition activities outside the classroom while knowledge application activities occur in the classroom [10]. The flipped classroom is an educational technique that comprises two essential elements: one that requires the use of computer technologies, such as lecture videos (the out-of-class activities), and the other that requires human interaction (the in-class activities) [11].

2.2. Types of Flipped Classrooms

Lecoq, et al. [12] have proposed a classification of three types of flipped classrooms. Type 1 corresponds to the classic model initially introduced by two American chemistry teachers, Bergman and Sams [13]. In this type, knowledge is externalized through digital tools, thereby liberating classroom space for other activities that facilitate learning. The emphasis is on externalizing knowledge [12]. Type 2 involves students actively seeking knowledge in various contexts. Upon returning to the classroom, they present the outcomes of their research or prepare activities for their peers. This type underscores the exchange of roles between teacher and learner [12].

Type 3 combines the two previous types by alternating different types of activities [12]. In this kind of classroom, the theoretical components of the course are made available outside of class, including videos for viewing, quizzes for completion, and preparations for presentations. However, in the classroom, for various reasons such as challenges in accessing online resources or uncompleted planned activities, more emphasis is placed on the theoretical aspects before progressing to practical exercises [14]. Finally, the study carried out by Lebrun et al [15] analyzing just over a hundred flipped classrooms, reveals that levels 1 and 3 are predominant and more widely practiced.

2.3. Problematic, Question, and Hypotheses of the Research

Student academic achievement in science, particularly in the field of physical sciences, is a paramount concern within the Moroccan education system today. The traditional teaching model, commonly employed, has its limitations, as it often fails to address individual differences among learners and struggles to incorporate active teaching methods such as problem-based learning, investigation, and the integration of information and communication technology (ICT) [16]. Considering these challenges, the flipped classroom strategy is emerging as a promising alternative.

This approach differs fundamentally from the traditional classroom by proposing a reversed process: students are introduced to course concepts before attending class, while complex tasks requiring additional support are carried out in collaboration with their peers and the guidance of their teacher. This method enables teachers to provide immediate support tailored to each student's specific needs [14]. However, the effective integration of ICT into a traditional classroom context goes beyond merely introducing new technological resources. It hinges on meaningful social interactions among peers and educators, offering students the opportunity to grasp and fully harness the advantages of a profound understanding of their learning processes [17].

From this perspective, it becomes imperative to assess to what extent the implementation of the flipped classroom strategy promotes such integration and its impact on the academic achievement of physical science students in Morocco.

Furthermore, the changing role of the teacher in guiding teaching and learning processes, with an emphasis on placing the learner at the focal point, necessitates the implementation of contemporary teaching methods and strategies that align with the swift transformations in the educational system [1]. Within this context, can the flipped classroom strategy be considered a relevant response to improve the academic achievement of middle school students in the physical sciences in Morocco while considering the challenges and opportunities associated with this pedagogical evolution?

In summary, the research issue can be framed as follows: To what extent does the implementation of the flipped classroom approach impact the academic performance of middle school students in the physical sciences at Sidi Slimane?

The purpose of this research is to examine the validity of the following hypotheses:

- Null hypothesis ($H0$): there is no significant difference, at the 0.05 significance level, in the rank scores between the control and experimental groups in the academic achievement test for third-year middle school students in physical science, attributed to the method of teaching.
- Alternative hypothesis ($H1$): there is a significant difference, at the 0.05 significance level, in the rank scores between the control and experimental groups in the academic achievement test for third-year middle school students in physical science, attributed to the method of teaching.

3. OBJECTIVE AND IMPORTANCE OF THE RESEARCH

The objective of this research is to investigate the influence of incorporating the flipped classroom approach on the academic achievement of third-year middle school students in the physical science course.

The significance of our study is underscored by the following aspects:

- Providing curriculum specialists with a modern approach to teaching science by integrating it into developing science programs.
- Addressing the gap in pedagogical research in physical science education, addressing similar problems, and exploring the potential benefits of the flipped classroom method.
- Developing teaching methods for physical science teachers using modern approaches, such as the flipped classroom, as alternatives to the traditional methods that still predominate in science education.
- Enhancing middle school students' understanding of scientific subjects by integrating technology into learning methods.
- Encouraging physical science teachers to adopt the flipped classroom method in the teaching process to improve teaching quality.

4. RESEARCH METHODOLOGY

In this research, we followed the quasi-experimental approach to assess the impact of the flipped classroom strategy (independent variable) on the dependent variable, which is student achievement in physical science.

4.1. Research Population and Sample

The study population encompassed all third-year middle school students (5134) in the province of Sidi Slimane, Morocco. For this study, the sample was deliberately selected from students at Zellaka Middle School during the 2022/2023 academic year. Two out of the four third-year classes were selected randomly, resulting in a purposive sample of 68 students distributed into two groups: the experimental group, which followed the flipped classroom strategy, consisted of 34 students (20 boys, 14 girls), whereas the control group, instructed through the traditional method, comprised 34 students (19 boys, 15 girls).

4.2. Procedures and Educational Material

To answer the main questions and objectives of the study, we executed the following procedures:

- Develop lessons to be taught using the flipped classroom strategy, including outlining specific learning objectives. These lessons pertained to the field of mechanics.
- Create a WhatsApp group for the students who would participate in the flipped classroom experiment.
- Distribute the lessons to the students through this WhatsApp group, providing content in various formats such as videos and documents, three days before the in-class discussion.
- Hold face-to-face sessions with the students two times per week, with each session spanning one hour.
- Ensure the equivalence of the two groups before starting the teaching process.
- The control group adheres to the traditional teaching approach, involving three stages for each lesson: lesson initiation, knowledge building, and assessment.
- The experimental group follows the flipped classroom teaching method, which combines distance learning (activities carried out at home) and face-to-face learning (activities carried out in the classroom).

➢ At home, for example, students can watch a YouTube video sent to them by their teacher via a WhatsApp link. Following this, students complete a questionnaire based on the video's content, allowing the teacher to ensure that the students have viewed the video.

➢ In the classroom, the teacher begins by recalling previous knowledge related to the digital lesson's content. Students work individually or in groups on practical assignments, exercises, and problem-solving activities to apply the concepts covered in the video.

- Develop the academic achievement test and administer it to both study groups immediately after completing the teaching experience using the flipped classroom strategy (post-application).

4.3. Preparing the Academic Achievement Test

We prepared an academic achievement test following these steps:

4.3.1. Determining the Objective and the Specification Table of the Achievement Test

The primary objective of the test is to assess the academic performance of third-year middle school students in the field of physical sciences, specifically within the "mechanics" domain. The objectives of each lesson (knowledge and practical skills) were identified, along with the allotted time for their completion. The achievement test is designed to evaluate a range of competencies that can be classified into three distinct levels: Knowledge Recall, Resource Utilization, and Problem-solving in a contextual situation as Table 1.

Table 1. Specification of the achievement test

Domain	Sub-domains (lessons)	Number of hours	Percentage of relative importance to skill levels		
			Knowledge Recall	Resource Utilization	Problem-Solving
The mechanics	Mechanical actions - Forces	2H	40%	40%	20%
	Notion of force	3H			
	The equilibrium of a body subjected to two forces	2H			
	Weight and mass	2H			

4.3.2. Application of the Achievement Test to an Exploratory Sample

In the initial phase, we developed a set of 38 items for the Physical Science Achievement Test. This test was administered to an exploratory sample comprising 25 third-grade students who were not included in the study's intended target sample and population. Furthermore, we calculated the difficulty indices (DifI) and discrimination indices (DisI) for all the items on the achievement test using SPSS Version 21 software. Table 3 was used to analyze the difficulty and discrimination indices for each item.

Table 2. Evaluation of difficulty index (DifI) and discrimination index (DisI) according to Sharma [18]

Difficulty Index (DifI)	Interpretation	Recommendation	Discrimination Index (DisI)	Interpretation	Recommendation
< 0.20	Most difficult	Remove	Negative	Worst/defective item	Definitely Discard
0.20-0.39	Difficult	Keep	< 0.20	Not discriminating item	Revise / Discard
0.40-0.59	Moderately difficult	Keep	0.20-0.29	Moderately discriminating	Keep
0.60-0.79	Moderately Easy	Keep	0.30-0.39	Discriminating item	Keep
0.80-0.89	Easy	Keep	≥ 0.40	Very discriminating	Keep
> 0.90	Easiest	Remove	-	-	-

The results of the exploratory experiment showed that the achievement test is adapted to the level of the students and that the appropriate time to apply the test is one hour. Moreover, the findings provided in Table 3 reveal that the difficulty indices (DifI) for all items are deemed acceptable, ranging between 0.2-0.88, and the discrimination indices (DisI) are acceptable for most of the items in the achievement test, except for two items (16 and 17) which are not discriminating, as they have discrimination index (DisI) values strictly below 0.2. Therefore, according to the recommendations indicated in Table 2, items 16 and 17 were not retained. Finally, we retained 36 items in the final version of the achievement test.

Table 3. Values of the difficulty indices (DifI) and discrimination indices (DisI) for the achievement test items

Items	DifI	DisI	Items	DifI	DisI
1	0.760	0.206	20	0.520	0.708
2	0.840	0.356	21	0.440	0.758
3	0.800	0.309	22	0.320	0.738
4	0.680	0.479	23	0.280	0.722
5	0.760	0.392	24	0.280	0.829
6	0.840	0.413	25	0.520	0.254
7	0.560	0.427	26	0.520	0.788
8	0.480	0.279	27	0.360	0.597
9	0.720	0.558	28	0.400	0.833
10	0.880	0.398	29	0.320	0.645
11	0.840	0.402	30	0.240	0.582
12	0.760	0.532	31	0.400	0.824
13	0.600	0.442	32	0.280	0.859
14	0.480	0.647	33	0.400	0.824
15	0.800	0.499	34	0.200	0.638
16	0.800	0.123	35	0.200	0.638
17	0.720	0.118	36	0.360	0.733
18	0.640	0.208	37	0.240	0.652
19	0.520	0.535	38	0.240	0.602

4.4. Reliability of Achievement Test

After administering the Academic Achievement Test to an exploratory sample of 25 students, we assessed the internal consistency reliability through the calculation of Cronbach's alpha [19]. According to Nunnally and Bernstein [20], a Cronbach's alpha coefficient exceeding 0.7 is deemed satisfactory. The academic achievement test demonstrated a Cronbach's alpha value of 0.945, suggesting strong internal consistency for this test.

4.5. Statistical Analysis

We used SPSS V. 21 software to check the normality of the distribution of the academic achievement test variables using the Kolmogorov-Smirnov test. Moreover, we assessed the internal consistency of the academic achievement test through the calculation of Cronbach's alpha coefficient. Additionally, to compare the rank scores of the two study groups on the academic achievement test variables after the application, we utilized the Mann-Whitney test. Using Excel, we calculated the effect size, according to Fritz, et al. [21] using the following formula: $r = \sqrt{\frac{Z^2}{N}}$

where, r is the effect size index, Z is the Z statistic of the Mann-Whitney test, and N is total size of the two samples combined

The effect size can be interpreted according to the value of the index (r) as a small (r = 0.10), moderate (r = 0.30), or large (r = 0.50) effect [22].

5. RESULTS AND DISCUSSION

5.1. Checking the Equality of the Study Groups

Before implementing the experiment, we conducted an assessment to verify the equivalence of the two study groups, i.e., the control and experimental groups. This initial assessment involved evaluating the normality of the distributions within both groups, using the Kolmogorov-Smirnov normality test, which is suitable for sample sizes exceeding 50 individuals [23]. This test's results (refer to Table 4) revealed that the variables did not follow a normal distribution.

Consequently, we employed the Mann-Whitney test, a non-parametric test, to investigate differences between two independent samples. This test allowed us to compare the control and experimental groups before the administration of the academic achievement test in the field of physical sciences. The results of the pre-application of the academic achievement test are presented in Table 5. Table 5 shows that there was no significant difference in the mean rank of the "Knowledge Recall" skill level between the control and experimental groups (p = 0.480 > 0.05).

Table 4. Results of Kolmogorov-Smirnov normality test of achievement test variables

Skill levels of the achievement test	Groups	Kolmogorov-Smirnov		
		Statistic	*ddl*	Significance
Knowledge Recall	Experimental group	0.201	34	0.001
	Control group	0.149	34	0.055
Resource Utilization	Experimental group	0.119	34	0.200*
	Control group	0.172	34	0.013
Problem-solving in a contextual situation	Experimental group	0.216	34	0.000
	Control group	0.241	34	0.000

Table 5. Mann-Whitney test results for the difference between the scores of the two study groups during the pre-application of the achievement test

Skill levels of the achievement test	Groups	Group size	Mean rank	Sum of ranks	*U*	*p*-value
Knowledge Recall	Experimental group	34	32.82	1116.00	521.00	0.480
	Control group	34	36.18	1230.00		
Resource Utilization	Experimental group	34	33.96	1191.50	559.50	0.820
	Control group	34	35.04	1154.50		
Problem-solving in a contextual situation	Experimental group	34	36.41	1238.00	513.00	0.408
	Control group	34	32.59	1108.00		

Similarly, no significant difference was found in the mean rank of the "Resource Utilization" skill level between the two groups ($p = 0.820 > 0.05$). Furthermore, there was no significant difference in the mean rank of the "Problem-solving in a contextual situation" skill level between the control and experimental groups ($p = 0.408 > 0.05$). In summary, these findings demonstrate the absence of statistically significant differences between the rank scores of the two study groups in the pre-application of the academic achievement test at all levels of skills assessed in this test. This suggests that the experimental and control groups exhibited equivalence in their performance on the Physical Science Achievement Test before the commencement of the experiment.

5.2. Impact of the Flipped Classroom on Post-Application Student Achievement

To evaluate the hypotheses of our research, we employed the Mann-Whitney test to compare the rank scores of the two study groups in the post-application of academic achievement test in physical science.

Table 6. Mann-Whitney test results for the difference between the scores of the two study groups during the post-application of the achievement test

Skill levels of the achievement test	Groups	Group size	Mean rank	Sum of ranks	*U*	*p*-value	*Z*	Effect size *r*
Knowledge Recall	Experimental group	34	39.34	1337.50	413.50	0.042	-2.035	0.246
	Control group	34	29.66	1008.50				
Resource Utilization	Experimental group	34	42.47	1444.00	307.00	0.001	-3.330	0.403
	Control group	34	26.53	902.00				
Problem-solving in a contextual situation	Experimental group	34	39.96	1358.50	392.50	0.014	-2.446	0.303
	Control group	34	29.04	987.50				

The findings provided in Table 6 indicate a statistically significant difference in the mean rank of the "Knowledge Recall" skill level between the control and experimental groups ($p = 0.042 < 0.05$). Likewise, a significant difference was observed in the mean rank of the "Resource Utilization" skill level ($p = 0.001 < 0.05$), along with a significant difference in the mean rank of the "Problem-solving in a contextual situation" skill level between the two groups ($p = 0.014 < 0.05$). In summary, these findings reveal statistically significant differences between the scores of the two groups' ranks across all skill levels in the post-application of the Physical Science Achievement Test.

Notably, these differences favor the experimental group. Therefore, in light of these findings, the alternative hypothesis was accepted, and the null hypothesis was rejected. This indicates that teaching using the flipped classroom strategy had a positive impact on improving students' academic achievement in physical science. Our results were in line with previous studies conducted in other countries, which have confirmed the positive impact of employing flipped classroom pedagogy on students' academic achievement in physical science [24-27].

Nevertheless, a study conducted by Faillet [28] revealed contrasting results, indicating that students with a high level of proficiency in physical science within the traditional classroom context performed less effectively when exposed to the flipped classroom strategy. Conversely, students with lower proficiency levels in the traditional classroom exhibited improved performance with the flipped classroom approach. In Morocco, a study conducted by Ben Mesaoud, et al [29] suggests that flipped classroom pedagogy has a positive impact on student's academic achievement in physical sciences. Moreover, the integration of this pedagogical approach, using the (SRPCM) pedagogical model, has a beneficial effect on the learning of electricity for middle school students in the physical science classroom [30].

Looking at the findings presented in Table 6, it seems that the effect size of implementing the flipped classroom strategy on the academic achievement of students in the experimental group is moderate, with an effect size (r) between 0.24 and 0.40. These values indicate moderate effectiveness, with an effect size ($r = 0.403$) for the skill level (Resource utilization), and an effect size ($r = 0.303$) for the skill level (Problem-solving in a contextual

situation) of the Academic Achievement Test, except for the skill level (Knowledge recall) which has a small effect size (r = 0.246). These findings suggest moderate effectiveness of the flipped classroom approach in enhancing academic achievement in physical science for third-year middle school students.

The flipped classroom strategy offers students the opportunity to acquire physical science knowledge and skills through the use of information and communication technologies and facilitates the understanding of physics-related concepts. Furthermore, its implementation has clearly shown that it not only enhances the autonomous learning process but also contributes to increasing learner motivation [27]. Adopting the flipped classroom pedagogical model encourages collaboration within the workgroup and promotes active learner engagement.

6. CONCLUSION AND RECOMMENDATIONS

Our research sought to evaluate the impact of the flipped classroom strategy on academic achievement in physical science among third-year middle school students. The findings indicated that students who were taught using the flipped classroom strategy achieved higher scores in all skill levels of the academic achievement test compared to their peers instructed through traditional teaching methods. In light of these results, it is recommended that teachers and educational decision-makers seriously consider integrating the flipped classroom into their educational practices.

By fostering student autonomy, motivation, and deep understanding, the flipped classroom presents itself as a powerful lever for improving the quality of teaching in the physical sciences. However, it should be noted that the success of the flipped classroom also depends on how it is implemented. It is advisable to put adequate supervision, quality digital resources, and personalized follow-up in place to optimize the benefits of this approach. Moreover, further research could be undertaken to explore further the nuances of this strategy and its impact across diverse educational contexts.

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