# The Contribution of the Flipped Classroom to the Optimization of Alternating Teaching in Morocco

Mohammed Ben Mesaoud[1,2], Said Boubih[1,3,*], Khalid Najoui[1], Mohammed Rabih Raissouni[1,4], Essadiq Assimi[3], Hicham El Kazdouh[1,5] & Mohamed Radid[2,6]

[1]Research team Science Teaching and Issues of Multilingualism and Diversification of Learning Modalities in the Digital Era, Regional Center for Education and Training, Tangier, Morocco

[2]Laboratory of Physical Chemistry of Materials, Faculty of Sciences Ben M'Sik, Hassan II University of Casablanca, Morocco

[3]Research team in Pedagogical engineering and science didactics, Ecole Normale Supérieure, Abdelmalek Essaadi University, Tetouan, Morocco

[4]Laboratoire de Physique des Matériaux et Subatomique, Université Ibn Tofail, Kénitra, Morocco

[5]Laboratory of Epidemiology, Clinical Research and Community Health, Faculty of Medicine and Pharmacy, Sidi Mohamed Ben Abdellah University, Morocco

[6]Observatory of Research in Interdisciplinary Didactics and University Pedagogy, Faculty of Sciences Ben M'Sik, Hassan II University of Casablanca, Casablanca, Morocco

*Correspondence: Research team Science Teaching and Issues of Multilingualism and Diversification of Learning Modalities in the Digital Era, Regional Center for Education and Training, Tangier, Morocco & Research team in Pedagogical engineering and science didactics, Ecole Normale Supérieure, Abdelmalek Essaadi University, Tetouan, Morocco

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**Abstract**

This research aims to conduct an experimental study to apply a model of flipped classroom pedagogy (FCP) in selected Moroccan classrooms. This is to study its effectiveness in the local context, and to explore the possibility of investing the opportunities it offers to manage and optimize Alternating Teaching (AT), which was adopted during the Covid-19 pandemic to ensure educational continuity. This study adopted a semi-experimental design with a pre- and post-test, and utilized two groups (experimental and control) to evaluate the impact of FCP on AT performance. The study involved 67 students from two secondary school classes, 33 students in the Life and Earth Sciences (LES) class and 34 students in the Physics and Chemistry (PC) class. The results were analyzed using the t-test and learning gain as a function of cognitive abilities and confirmed the effectiveness of FCP in enhancing AT performance. These findings were further supported by classroom observations and semi-structured interviews with students in the experimental group, which showed the positive impact of FCP on both the didactic and relational aspects of AT.

**Keywords:** flipped classroom pedagogy (FCP), alternating teaching (AT), cognitive abilities, experimental sciences, learning gain

## 1. Introduction

When the COVID-19 pandemic hit Morocco in March 16, 2020, the government quickly decided to close schools and shift to distance learning. However, Morocco had already been working towards reducing the digital divide and catching up with the rest of the world in the digital arena. This effort started in 2008 and included initiatives such as the "Digital Morocco 2013" plan (Kabbaj et al., 2009), which aimed to equip schools with multimedia tools and train teachers to use them effectively. Despite the ambitious goals of the "GENIE" program, initiated in 2006 as part of this plan, it was not enough to meet the sudden demands of the Covid-19 pandemic (Naji, 2020). Furthermore, it faced criticism for its lack of effectiveness and efficiency (Naji, 2020). In response, the Ministry of Education turned to alternative methods such as creating resources for its official TelmidTICE platform or airing them on national

television to reach as many students as possible, especially those without access to the internet.

Multiple authors and the thematic report of the Higher Council of Education (HCETSR) report on education during the Covid-19 pandemic have noted major difficulties and limitations in distance education, as evaluated from the pandemic's impact (HCETSR, 2021; Berdi, 2021; Lbyad. 2022; Benkaraache, et al., 2020).

The Ministry of Education in Morocco has adopted alternating teaching (AT) as a new pedagogical model for the 2020-2021 school year due to the pandemic situation (as per Ministerial note 039x20 of 28 August 2020). This study examines the implementation of AT from the perspective of teachers, evaluating their experiences and perceptions of the Professional Competence Framework (PCF). It is part of a larger research study, with two additional studies underway. This study adds to the existing literature on flipped classrooms by exploring AT's contribution as a pedagogical alternative and contributes to research on teaching during emergency situations, including pandemics.

*1.1 Alternating Teaching and Flipped Classroom Pedagogy*

1.1.1 Alternating Teaching

The alternating teaching model, as per the ministerial note (Note 039X20), involves two distinct periods: 50% face-to-face instruction and 50% self-learning. The proportion of each period may vary depending on the resources available at each institution, including human resources, capacity, infrastructure, and equipment.

1.1.2 Implementation of the Alternating Teaching

According to the same ministerial note (Note 039X20), the national reference framework for the implementation of alternating teaching (AT) includes the following operations:

• Division of classes into two groups to facilitate a return to normal operations when the health situation improves and to comply with physical distancing measures related to Covid-19.

• Development of schedules divided into two equal parts, with the first part dedicated to face-to-face instruction and the second part dedicated to self-learning. Some groups receive face-to-face instruction while others engage in self-learning activities at home.

• Assignment of regional inspection bodies with the responsibility of creating "guides" for AT implementation.

The main principles outlined in the guides for alternating teaching (AT) include:

a. Allocating the majority of face-to-face sessions for acquiring knowledge and skills and correcting synthesis exercises that require mathematical reasoning and modeling. A small portion (approximately 10 minutes) is reserved for providing instructions and guidance for self-learning activities.

b. Giving priority to the development of new concepts, laws…, determined by the official document of pedagogical guidelines and activities that require significant teacher involvement and have implications for higher-level certifications.

c. Utilizing self-learning sessions to foster learner autonomy based on the provided guidelines and instructions.

Some guides suggest incorporating the flipped classroom approach in certain lessons and activities by having learners watch course videos on the TelmidTICE platform prior to the in-person session.

1.1.3 Self-learning

Self-learning or self-directed learning, as defined by Knowles (1975) and cited by Moustadraf (2020), is when individuals take charge of their own learning, with or without assistance from others. This form of learning involves the learner actively creating their own learning experiences to reach their goals. Self-directed learning offers various benefits, as highlighted by Rothwell and Sensenig (1999) and Boubih (2022), such as: allowing the learners to tailor their learning style, study at their own pace, and assess their own performance; fostering curiosity and meeting individual learning needs; promoting life-long learning, developing skills in time management, self-assessment, and goal setting; enhancing problem-solving skills, and increasing motivation for deeper learning. However, for self-directed learning to be effective, the learner must possess the ability to learn how to learn (Smith, 1982) and specific skills (Tremblay, 2003). However, the implementation of self-learning in Morocco's AT context lacked a structured pedagogical and didactic framework and relevant evaluation model, leading to the use of only general guidelines. These guidelines included writing summaries in notebooks, identifying elements that may take longer during face-to-face teaching (such as summaries, demonstrations, experimental activities, reasoning, etc.), completing self-learning exercises with answer keys and feedback, researching and creating presentations, and viewing digital simulations of experiments that can't be done in the classroom. (Note 039x20 of 28 August 2020).

The lack of published scientific studies on the evaluation of the implementation of the AT in Morocco highlights the need for this study. Our goal is to shed light on this issue. The study provides general guidelines for self-learning, such as writing summaries, completing exercises with answers and feedback references, conducting research, and watching digital simulations of experiments that cannot be performed in person. (Note 039x20 of 28 August 2020).

1.1.4 Flipped Classroom Pedagogy

The Flipped Classroom approach reorders traditional in-class and at-home activities. Thus, the usual classroom activities become homework, while homework tasks are done in the classroom. Students first gain an understanding of the subject through self-directed learning using resources provided by their teacher, such as videos, texts, and handouts, before working on related tasks in a group setting during class time (Bergmann & Sams, 2012; Dufour, 2014; Faillet, 2014; Manon, 2016).

According to Lecoq and Lebrun (2016), the flipped classroom model is not simply about watching videos before class and doing exercises during class. Instead, they see it as a transformative approach to knowledge and the roles of both learners and teachers, as outlined in their guide "La classe à l'envers pour apprendre à l'endroit".

The traditional teaching approach focuses on lower-level cognitive activities, such as knowledge and comprehension, inside the classroom, while higher-level activities, such as application, analysis, evaluation, and creation, are left for outside of class. However, the flipped classroom model disrupts this traditional process by having learners complete lower-level activities at home and using classroom time for more advanced, higher-level thinking skills (Bristol, 2014; Guilbault & Viau-Guay, 2017). This approach, based on Bloom's taxonomy, promotes the development of higher-order thinking skills in learners (Zainuddin et al., 2019).

*1.2 Problematic, Research Questions, Hypotheses and Limitations of the Research*

In response to the challenges posed by pandemics like Covid-19, the Moroccan education system is seeking a new model that can maintain pedagogical continuity while ensuring the quality of learning. The goal of this study is to experiment with the flipped classroom approach as a potential solution for managing alternating modes of teaching. The main research question being explored is: to what extent can the flipped classroom approach contribute to the successful implementation of the AT and improve learning quality?

Based on this problematic, the following research questions are proposed:

i. How does the implementation of the flipped classroom pedagogy (FCP) impact the learning gain of students compared to traditional methods in the context of alternating teaching (AT)?

ii. Which cognitive abilities are enhanced by the use of FCP?

iii. What impact does FCP have on both the didactic and relational aspects of the teaching-learning process?

The current study aims to examine the validity of three hypotheses:

iv. There are significant differences, at the (0.05) level, in mean scores between experimental and control groups in Physics and Chemistry (PC) and Life and Earth Sciences (LES) due to the implementation of the flipped classroom approach.

v. There are significant differences, at the (0.05) level, in learning gains between experimental and control groups in PC and LES based on cognitive ability levels.

vi. The flipped classroom approach positively impacts the teaching-learning process at pedagogical, didactic, and relational levels and can improve the optimization of the implementation of AT.

The current research has the following limitations:

i. Subjective: The scope of the study is restricted to evaluating the impact of the FCP on the learning of students in Physical and Life Sciences in Moroccan secondary schools as part of the AT implementation.

ii. Human: The sample size is limited to pupils in the 2nd and 3rd year of the qualifying secondary education cycle.

iii. Spatial: The research was conducted in two secondary schools located in Tangiers, Morocco.

iv. Temporal: The study was conducted during the second semester of the 2021-2022 academic year.

## 2. Method

As mentioned above, the purpose of this study is to evaluate the efficacy of flipped classroom pedagogy as a means

of enhancing the implementation of Alternating Teaching (AT). The methodology employed is semi-experimental design with a pre-test and post-test, based on a quantitative approach. This design was selected as it enables random assignment of control and experimental groups without disrupting the existing classroom configuration (Cohen et al., 2007).

*2.1 Sample*

The study involved 67 students from two secondary school classes in the city of Tangier, Morocco (33 students in the LES class and 34 students in the PC class). The selection of these schools was based on the enthusiasm and cooperation of two teachers who participated in the research.

To comply with the AT implementation requirements, the participating teachers divided their classes into two sub-groups, following the established practical work grouping. One of these sub-groups was randomly assigned as the control group while the other served as the experimental group (as shown in Table 1).

**Table 1.** Distribution of Students between Control and Experimental Classes

| Subject taught | Total number of learners | Groups | Number of learners | Females | Males |
|---|---|---|---|---|---|
| PC | 34 | Control group | 17 | 11 | 6 |
| | | experimental group | 17 | 11 | 6 |
| LES | 33 | Control group | 16 | 9 | 7 |
| | | experimental group | 17 | 9 | 8 |

This table demonstrates an equal distribution of sample size among both groups and disciplines.

*2.2 Research Instruments*

The researchers from the prospective teacher training centers and two volunteer teachers developed two assessment tools for the subjects PC and LES. These tests were used for pre- and post-tests.

**Table 2.** Difficulty and Discrimination Indices of the Two Tests

| | LES Test | | PC Test | |
|---|---|---|---|---|
| Item | difficulty index | discrimination index | difficulty index | discrimination index |
| 1 | 0.15 | 0.31 | 0.41 | 0.47 |
| 2 | 0.33 | 0.47 | 0.38 | 0.41 |
| 3 | 0.42 | 0.29 | 0.06 | 0.12 |
| 4 | 0.18 | 0.29 | 0.18 | 0.24 |
| 7 | 0.79 | 0.06 | 0.35 | 0.47 |
| 8 | 0.79 | 0.06 | 0.56 | 0.41 |
| 9 | 0.85 | 0.18 | 0.41 | 0 |
| 10 | 0.30 | 0.29 | 0.41 | 0.59 |
| 11 | 0.33 | 0.59 | 0.59 | 0.35 |
| 12 | 0.21 | 0.47 | 0.53 | 0.35 |
| 13 | 0.67 | 0.53 | 0.59 | 0.12 |
| 14 | 0.39 | 0.47 | 0.56 | 0.06 |
| 15 | 0.42 | 0.76 | 0.41 | 0.47 |
| 16 | 0.55 | 0.41 | 0.44 | 0.41 |
| 17 | 0.39 | 0.35 | 0.76 | 0.24 |
| 18 | 0.39 | 0.71 | 0.65 | 0.12 |
| 19 | 0.36 | 0.65 | 0.38 | 0.41 |
| 20 | 0.21 | 0.24 | 0.41 | 0.41 |

The validity was confirmed by experts (teachers training centers in Chemistry and Geology and their didactics and secondary school teachers of PC and LES) and their suggestions were incorporated. The final tests included 20 MCQs divided into 4 levels of cognitive ability: Knowledge, Comprehension, Application, and Analysis and Synthesis.

The tests' reliability was verified using two methods: internal consistency expressed by Cronbach's alpha coefficient with values of 0.714 for PC and 0.849 for LES, exceeding the minimum threshold of 0.70 (Nunnaly, 1978) and split-half reliability translated by Pearson correlation between odd and even items (Ozen et al., 2006), with values of 0.732 for PC and 0.742 for LES, indicating acceptable reliability.

To assess the difficulty levels of pre- and post-test items, the difficulty and discrimination indices were calculated (Worthen et al., 1999; Jarrah et al., 2022) and are presented in Table 2.

The results show that the difficulty index ranges from 0.07 to 0.85 and the discrimination index ranges from 0 to 0.76, indicating that these values meet the goals of this study.

*2.3 Research Design*

This study employed a pre-test-post-test experimental design with control and experimental groups, as depicted in Figure 1.

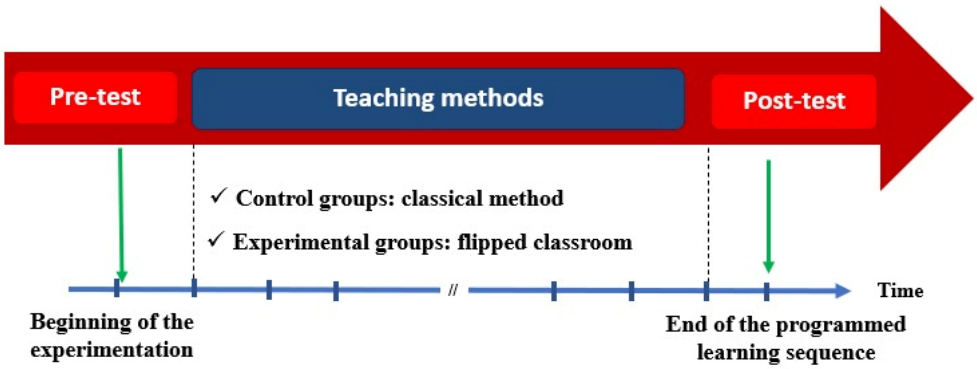


**Figure 1.** Research Design

Before conducting the experiment, pre-tests were administered to both the control and experimental groups to establish their equivalence. The two volunteer teachers then taught the selected lessons using two methods: the traditional method for the control group and the flipped classroom method for the experimental group.

The traditional method involved the same teaching approach the teachers had used during the Covid-19 pandemic, as described in the paragraph on the AT. At the end of each session, teachers simply suggested homework activities for students in the form of application exercises with answer elements. These were intended to summarize the lessons or allow students to view digital simulations of experiments that couldn't be done in person. Unfortunately, the lack of time resulted in these homework activities being barely or not used by the teachers in subsequent sessions. This resulted in the learning time being simply halved.

For the flipped classroom approach, pre-class exploration of essential course concepts is achieved through video clips selected or created by volunteer teachers on YouTube. These videos come with accompanying investment sheets that include links to the videos and questions to guide the viewing. During the in-class phase, pupils exchange and discuss their answers, fostering socio-cognitive interactions. At this point, the educator confirmed the students grasped the crucial ideas of the lesson and offered personalized feedback or extra clarification as needed. After completing formative evaluation exercises, the students reconvened in their groups for collaborative problem-solving tasks. The teacher ends the session by providing additional resources for self-learning and encouraging out-of-class activities for next session preparation.

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completing formative evaluation exercises, the students reconvened in their groups for collaborative problem-solving tasks. The teacher ends the session by providing additional resources for self-learning and encouraging out-of-class activities for next session preparation.

At the conclusion of the instructional program, as depicted in Figure 1, we administered a post-test to the study participants, which was identical to the pre-test.

*2.4 Procedure*

To carry out the experiment, we followed these key steps:

- Secured permission from local authorities to conduct the study in schools;
- Selected lessons for experimentation: organic chemistry for physics and chemistry, and metamorphism and its connection to plate tectonics for life and earth sciences;
- Conducted meetings with volunteer teachers to inform them about the study's goals and metrics;
- Assisted volunteer teachers in preparing their sessions;
- Administered pre-tests to students;
- Implemented two teaching methods;
- Conducted pos-test on students;
- Collected and analyzed data.

*2.5 Data Analysis*

The pre-test and post-test data was analyzed to determine if there was a significant difference between the experimental and control groups using both descriptive statistics (mean and standard deviation) and inferential statistics (t-test). SPSS version 20 was utilized for all data analysis. The magnitude of the effect of the teaching method on learners' learning was estimated by calculating the eta-square ($\eta^2$) using the formula (1) derived from the t-test results.

$$\eta^2 = t^2/(t^2+ddl) \quad (1)$$

Verifying the effectiveness of the flipped classroom method in comparison to the traditional method, we measured the learning progress of each student through the calculation of their learning gain (gi) in various cognitive abilities. The gain was determined using formula (2).

$$gi = \frac{Posttest\ score - Pretest\ score}{Ideal\ score - Pretest\ score} \quad (2)$$

The learning gain of groups of size N (N-Gain) is calculated using formula (3) :

$$N - gain = \frac{\sum gi}{N} \quad (3)$$

**3. Results**

The objective of this research was to assess the effect of the flipped classroom approach on student achievement in science subjects within the AT context and identify which student abilities are most impacted by this teaching method.

*3.1 Verification of the Equivalence of the Control and Experimental Groups*

To verify the equivalence of the control and experimental groups, we employed a t-test to compare the pre-test data. The results are shown in Table 3.

No significant difference was found between the average scores of students in the control and experimental groups for Bloom's skills and the test as a whole based on p-values greater than 0.05. This validates the equivalence of the groups for PC and LES and justifies the use of a pre-test and post-test experimental design.

**Table 3.** T-test Results for the Average Scores of the Experimental and Control Groups in the Pre-Test According to Cognitive Abilities for Both PC and LES

| Discipline | ability | Groups | N | $\bar{X}$ | sd | t | ddl | p |
|---|---|---|---|---|---|---|---|---|
| PC | Entire pre-test | Control | 17 | 5.47 | 1.84 | -0.58 | 32 | 0.56 |
| | | Experimental | 17 | 5.82 | 1.70 | | | |
| | Knowledge | Control | 17 | 1.53 | 0.80 | -1.30 | 32 | 0.20 |
| | | Experimental | 17 | 1.94 | 1.03 | | | |
| | Comprehension | Control | 17 | 1.12 | 0.70 | 0.00 | 32 | 1.00 |
| | | Experimental | 17 | 1.12 | 0.78 | | | |
| | Application | Control | 17 | 1.76 | 0.97 | 1.31 | 32 | 0.20 |
| | | Experimental | 17 | 1.35 | 0.86 | | | |
| | Analysis and synthesis | Control | 17 | 1.06 | 0.75 | -1.33 | 32 | 0.19 |
| | | Experimental | 17 | 1.41 | 0.80 | | | |
| LES | Entire pre-test | Control | 16 | 5.69 | 2.57 | -0.67 | 31 | 0.50 |
| | | Experimental | 17 | 6.35 | 3.08 | | | |
| | Knowledge | Control | 16 | 0.94 | 0.85 | -1.55 | 31 | 0.13 |
| | | Experimental | 17 | 1.59 | 1.46 | | | |
| | Comprehension | Control | 16 | 1.31 | 0.95 | -0.97 | 31 | 0.34 |
| | | Experimental | 17 | 1.65 | 1.06 | | | |
| | Application | Control | 16 | 1.75 | 1.53 | -0.14 | 31 | 0.89 |
| | | Experimental | 17 | 1.82 | 1.51 | | | |
| | Analysis and synthesis | Control | 16 | 1.69 | 1.82 | 0.69 | 31 | 0.49 |
| | | Experimental | 17 | 1.29 | 1.45 | | | |

$\bar{X}$: Mean; sd: standard deviation

*3.2 Effect of the Teaching Method Applied on Students' Results*

We calculated average scores and learning gains of students in the control and experimental groups, in pre- and post-test, for the classical teaching method and flipped classroom method to determine their effect on learning. Results are shown in Table 4.

**Table 4.** Pre- and Post-test Scores of Students in Control and Experimental Groups

| Discipline | Group | teaching method | N | Pre-test | | Post -test | | N-gain |
|---|---|---|---|---|---|---|---|---|
| | | | | $\bar{X}$ | sd | $\bar{X}$ | sd | |
| PC | Control | Traditional | 17 | 5.47 | 1.84 | 8.53 | 2.55 | 0.19 |
| | Experimental | Flipped classroom | 17 | 5.82 | 1.70 | 14.12 | 2.26 | 0.57 |
| LES | Control | Traditional | 16 | 5.69 | 2.57 | 10.06 | 4.28 | 0.31 |
| | Experimental | Flipped classroom | 17 | 6.35 | 3.08 | 13.24 | 4.53 | 0.51 |

$\bar{X}$: Mean; sd: standard deviation

The results show an improvement in post-test scores compared to pre-test scores for both teaching methods, with a higher learning gain for students in the flipped classroom. The flipped classroom method proved to be more effective than the traditional method, as evidenced by the statistically significant difference in mean scores from t-test analysis (presented in Table 5).

The results show that the differences between the control and experimental groups at post-test are statistically significant in favor of the experimental group, with p-values less than 0.05. This confirms the positive impact of the flipped classroom on student learning.

To measure the magnitude of the effect and ensure that it's not due to chance, we calculated the eta-squared value

($\eta^2$).

**Table 5.** Results of the T-Test for the Mean Scores Obtained by Students in the Control and Experimental Groups at the Post-Test

| Discipline | Group | Mean | N | t | ddl | p |
|---|---|---|---|---|---|---|
| PC | Control | 8.53 | 17 | -6.758 | 32 | 0.000 |
| | Experimental | 14.12 | 17 | | | |
| LES | Control | 10.06 | 16 | -2.064 | 31 | 0.048 |
| | Experimental | 13.24 | 17 | | | |

*3.3 Effect Size of the Teaching Method on Student Learning*

The calculation of eta-squared value ($\eta^2$), which measures the impact of the teaching method on students' learning, produced results of 0.588 for PC discipline and 0.121 for LES discipline.

To interpret the results, we utilized markers from Cohen (1988) (Table 6) and found that the flipped classroom in our experiment had a medium-sized impact on LES students and a large-sized impact on PC students.

**Table 6.** Interpretation of Eta-Squared Values

| Eta-squared values | effect size |
|---|---|
| 0.00 < 0.01 | Negligible |
| 0.01 < 0.06 | Small |
| 0.06 < 0.14 | Medium |
| 0.14 < 1.00 | Large |

*3.4 Abilities Developed by the Flipped Classroom*

To identify which abilities were improved by the flipped classroom method, we calculated the learning gain (N-Gain) for each group based on Bloom's cognitive abilities, which were grouped into four levels: knowledge, comprehension, application, and analysis/synthesis. We interpreted the N-gains using Table 7 by Hake (2002), as cited by Nasir et al. (2022). We then conducted a t-test to determine the statistical significance of the differences between the N-gains of the control and experimental groups, as presented in Table 8.

The comparison of students' performance in experimental and control classes in terms of learning gain based on their ability levels showed that:

- There were statistically significant differences in the comprehension and application abilities for PC and the application and analysis/synthesis abilities for LES.
- The flipped classroom method benefited the experimental group, as shown by their higher scores in knowledge and analysis/synthesis for PC and knowledge and comprehension for LES, but these differences were not statistically significant.

**Table 7.** Interpretation of N-gain Score

| N-gain score | Criteria |
|---|---|
| 0.0≤N-gain<0.3 | Low |
| 0.3≤N-gain<0.7 | Medium |
| N-gain>0.7 | High |

**Table 8.** N-gain of Experimental and Control Groups According to Cognitive Abilities

| Discipline | abilities | Group | pre-test | post-test | N gain | Criteria | t | P |
|---|---|---|---|---|---|---|---|---|
| PC | Knowledge | CG | 1.53 | 3.18 | 0.428 | Medium | -0.26 | 0.796 |
| | | EG | 1.94 | 3.65 | 0.463 | Medium | | |
| | Comprehension | CG | 1.12 | 1.24 | 0.001 | Low | -10.35 | 0.000 |
| | | EG | 1.12 | 4.41 | 0.826 | High | | |
| | Application | CG | 1.76 | 1.82 | -0.022 | Low | -5.79 | 0.000 |
| | | EG | 1.35 | 3.29 | 0.512 | Medium | | |
| | Analysis and synthesis | CG | 1.06 | 2.12 | 0.253 | Low | -0.39 | 0.698 |
| | | EG | 1.41 | 2.76 | 0.307 | Medium | | |
| LES | Knowledge | CG | 0.94 | 3.69 | 0.673 | Medium | -0.32 | 0.745 |
| | | EG | 1.59 | 3.88 | 0.718 | High | | |
| | Comprehension | CG | 1.31 | 1.69 | 0.084 | Low | -1.12 | 0.270 |
| | | EG | 1.65 | 2.65 | 0.227 | Low | | |
| | Application | CG | 1.75 | 2.56 | 0.235 | Low | -3.22 | 0.003 |
| | | EG | 1.82 | 3.82 | 0.702 | High | | |
| | Analysis and synthesis | CG | 1.69 | 2.13 | 0.152 | Low | -2.02 | 0.042 |
| | | EG | 1.29 | 2.88 | 0.365 | Medium | | |

CG: Control Group; EG: Experimental group

## 4. Discussion

Under the AT teaching mode, with a 50% - 50% split between in-person classroom lessons and self-directed learning, we evaluated two teaching methods (flipped classroom and classical) on 67 students from two secondary school classes and two scientific disciplines (PC and LES). The results were assessed using a 20-question test based on Bloom's cognitive abilities, administered before and after the teaching intervention. The findings will be analyzed to address three research questions.

**Research question 1**: How does the flipped classroom pedagogy (FCP) impact the learning gain of students in our sample compared to the classical method?

The pre-test results revealed no significant disparities in the performance of both the experimental and control groups regarding total test scores and scores on each ability level. This confirms that the two groups were comparable in terms of their understanding of the test objectives before the experiment began. Thus, the semi-experimental design with pre-test and post-test is justified (Cohen et al., 2007).

The post-test results showed that students taught in the flipped classroom had a higher average score and greater learning gain in both PC and LES disciplines compared to those in the control group. A significant difference in results was found through independent sample t-test analysis at a 0.05 level, indicating that the flipped classroom pedagogy improved the performance of PC and LES students.

Eta-squared coefficient calculation revealed that the students' improved performance in the flipped classroom was due to the teaching method, not chance, with medium to high effect sizes in LES and PC respectively. The flipped classroom method has a significant impact on improving student learning, as demonstrated in our experiment with the AT implementation. Multiple studies (Boubih et al. 2020a, Boubih et al. 2020b, Zainuddin et al., 2019; Akçayir & Akçayir, 2018; Fulton, 2012) have shown that flipped classrooms lead to higher test scores compared to traditional classrooms, supporting our finding of the positive impact of flipped classroom pedagogy. The success of flipped classroom pedagogy can be attributed to its numerous benefits, such as enabling students to complete tasks at home, freeing up classroom time for interactive activities like pair exchange, group work, and problem solving, and ultimately saving time overall. The improvement in learning performance through flipped pedagogy can be attributed to active learning strategies, as stated by Leo and Puzio (2016). Our research confirms Eric Mazur's (1997) discovery that learners achieve better results in an environment where they take an active role in their learning.

The flipped classroom approach positively impacts learning, partly due to its use of instructional videos. These videos allow learners to control the pace of their education by pausing, rewinding, and revisiting content as needed,

thereby enabling them to absorb information at their own desired speed, as highlighted by Lee and Martin (2019).

The use of videos incorporating images, graphics, video clips, and sound effects has been shown to effectively stimulate multiple senses in learners, leading to improved memorization, comprehension, assimilation, and elevates the learning experience with enjoyable engagement (AbuZaherah, 2020).

**Research question 2.** Which cognitive abilities are most enhanced by flipped classroom pedagogy?

Our experiment revealed that students in the experimental classes who were taught using the flipped classroom pedagogy showed statistically significant improvements in their cognitive abilities, particularly in the areas of comprehension, application, and analysis/synthesis. On the other hand, the recorded improvement in knowledge retrieval questions was not statistically significant. The results of our study align with the research conducted by Guilbault & Viau-Guay (2017), who found that the implementation of the flipped classroom approach led to enhanced results for open-ended questions and problem-solving skills, but the learning of conceptual and declarative content did not change. The flipped classroom approach allows for more class time to be spent addressing areas where students have a lack of understanding and assisting them in making connections between their acquired knowledge (Graziano, 2016). This extra time, made possible by the students' prior preparation outside of class, can then be utilized for learner-centered teaching (LCT), such as group discussions, collaborative work and hands-on exercises that help enhance advanced skills like analysis and synthesis.

**Research question 3.** How does the use of flipped classroom pedagogy impact the teaching and learning process at both the didactic and relational levels?

In addition to the improved performance of the students in the flipped classroom, our findings from semi-structured interviews and direct observations in the classroom indicate that this experience is superior to the traditional method in several ways. These improvements were reflected not only in the enhanced performance of the students, but also in the following aspects:

i. The exceptional participation of students in self-directed learning is evident in their proactive preparation, leading to a boost in self-assurance and more impactful engagement in sharing their home learning with others. This is in stark contrast to the observed reluctance of students who prefer traditional learning methods (Elmaadaway, 2018; Green & Schlairet, 2017; Nel, 2017).

ii. The enhancement of communication skills among students is crucial for the success of the learning process. This can be achieved through effective bilateral and group work, fostering collaboration and teamwork. In a flipped classroom setting, the teacher plays a crucial role in guiding and supporting the students, while still allowing for their autonomy and active participation. In contrast, traditional classroom environments often prioritize the acquisition of basic knowledge, leaving limited room for the development of important transversal skills such as communication and collaboration.

iii. By utilizing the flipped classroom approach, the investment of learning time becomes more effective and efficient, as it frees up additional time while still considering the limitations imposed by the use of technology.

iv. The teacher in the flipped classroom is able to monitor and assess student progress more effectively through the scheduling of formative assessments at the start of each session. This helps ensure that students have a sufficient level of comprehension before moving on to more in-depth learning activities and allows the teacher to address any individual difficulties or needs. (Fulton, 2012).

v. The students in the experimental groups have expressed high levels of satisfaction with their experience in the flipped classroom, demonstrating the success of this pedagogical approach.

## 5. Conclusions and Recommendations

The results of this research present some noteworthy conclusions; however, they should be approached with caution due to the limited sample size, the particular context, the strong association with a particular disciplinary specialization, and the delicate subject matter being addressed. In general, the data yielded demonstrated that the mean scores and learning growth of students instructed through the flipped classroom approach exceeded those of their peers instructed through traditional methods for both PC and LES. These differences were established to be statistically significant at a 0.05 level, leading to the conclusion that the flipped classroom methodology has the potential to play a crucial role in optimizing and enhancing the delivery of alternating teaching (AT). Among the numerous pedagogical and educational benefits of the FCP, we see the streamlining of in-class learning time management, the enhancement of out-of-class self-learning efforts, the integration of digital technologies into the

education process and the inspiration of students to actively participate in their own learning journey. These results highlight that the flipped classroom approach has been instrumental in addressing the ongoing challenges facing the work-study experience in Morocco, by providing practical solutions.

In the same context, this research demonstrates that the flipped classroom approach enhances cognitive abilities, particularly in terms of comprehension and application for PC and application and analysis/synthesis for LES. These skills showed statistically significant improvement compared to other disciplines. However, it should be noted that the level of improvement varied among the different abilities. Additionally, the research revealed that there was no notable difference in the level of knowledge type.

Based on the results of our research, it can be concluded that the Flipped Classroom Pedagogy (FCP) can significantly improve medium and high-level skills such as application and analysis/synthesis. This helps overcome the obstacles to students' learning and the development of cross-curricular skills and autonomy. The FCP approach optimizes self-learning and strengthens the relational aspect in the flipped classroom, as evidenced by our direct observations and the positive feedback from the experimental groups. The use of FCP has the potential to greatly enhance students' learning experiences.

Based on fore-mentioned conclusions, which confirmed our initial hypotheses, the following recommendations can be made to further the use of flipped classroom pedagogy:

1. Broaden the scope of research on the efficacy of flipped classroom teaching in various subjects and grade levels.
2. Embrace the flipped classroom as a valuable pedagogical tool for alternating instruction.
3. Incorporate flipped classroom teaching into both pre-service and in-service teacher training programs.
4. Develop curricula, teaching materials, and school textbooks that incorporate innovative teaching methods, including flipped classroom teaching.
5. Encourage teachers to utilize the resources of the official TelmideTice platform and create additional educational platforms to promote self-directed learning and the adoption of flipped classroom methods.
6. Upgrade the infrastructure of schools to provide internet access and the means to create digital resources.
7. Urge teachers to continuously renew their professional practices both in and outside the classroom.

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