Investigating Effectiveness of Flipped Classroom as an Approach to Recover Learning Loss

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Abstract

This study reports the impact of the flipped classroom model of instructions on mitigating learning loss that was experienced in Lebanese public high schools during the COVID-19 Pandemic. Specifically, it establishes the impact of this model on the academic achievement of Grade 11 Chemistry students. A mixed-methods quasi-experimental study with pre-test and post-test design was conducted. A field study comprising three experimental groups and three control groups was employed at three public high schools of West Bekaa that were chosen purposefully. Students of the flipped classroom group were provided with video lessons to be prepared at home before in-class sessions. Meanwhile, the traditional method was followed with the control group. A pre-test/post-test Chemistry achievement test was administered. Additionally, a semi-structured focus group interview was conducted with participants from the experimental group to enrich the quantitative data and get more insight about their experience. Findings from this study showed that the flipped classroom model significantly enhanced students' academic achievement in Chemistry. Also, other benefits were gained from the flipped classroom; students were able to interact and collaborate with peers, learn in a flexible environment, actively engage in the learning process, and become self-independent learners. Finally, the findings of this research call for reconsidering the teachers' training programs before integrating the flipped classroom in the learning process, and other recommendations were provided.

Keywords*:* Flipped classroom, Blended learning, students' achievement, and chemical calculations.

1. Introduction

Improving global education is a main goal of the United Nations 2030 Agenda for Sustainable Development (SDG4). SDG4 has been proposed as a stand-alone goal to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all (United Nations Educational, Scientific, and Cultural Organization [UNESCO], 2017). However, many unexpected events would interrupt the learning process and impede progress towards attaining SDG4 and would lead to sudden school closure. Some of these events include, but not limited to, natural disasters, wars, summer vacation, and weather conditions. The research on interruption of school education due to these unexpected events shows that being out of school is likely to have a negative impact on students' learning (Kuhfeld et al., 2020).

During the past two years, specifically since spring 2020, students' learning time at schools decreased due to unexpected school closure which occurred to reduce the health risks of COVID-19 pandemic. According to a report issued by UNESCO (2020), worldwide schools and university closures have impacted hundreds of millions of students. Indeed, the World Bank reported that learning would usually drop during COVID-19, with a loss of 0.3 –0.9 years of schooling when quality is considered. Moreover, these short-term learning losses will arise after the pandemic, causing accumulated learning losses since most children who fall behind will not catch up (Alsaleh, 2021).

As a response to the school closure due to COVID-19 pandemic, different attempts have been taken by schools and universities to adopt distance learning to assure learning continuity, leading to a sudden shift from in-person to online classes. These attempts have shown varied results, with differing degrees of progress and an increase in inequities in student learning depending on the modalities, characteristics, response, and implementation techniques of the various education programs as reported by the United Nations Educational, Scientific, and Cultural Organization (UNESCO, 2021).

Studies that address learning loss due to COVID-19 worldwide tend to mitigate its effects through remedial programs. For example, in England, as part of the National Tutoring Programme (NTP), students who require extensive academic assistance receive assistance to regain lost learning. In Cambodia, the Ministry of Education agreed to allow students to pass to the next grade level while also providing them with a remedial adaptive learning program (UNESCO, 2021).

Reviewing the existing literature in the Arab World has shown a growing interest to address the issue of learning loss through different approaches. A recent study in Kuwait emphasizes the role of school principals and head-teachers in reducing potential learning loss while emphasizing the significance of providing teachers with adequate training and highlighting the role of parents in such a process (Alsaleh, 2021). However, Palestine announced launching a one-month remedial program that combines in-person and online instruction. Oman followed the hybrid approach and invested in digital tools in addition to combining an altered curriculum and expanding teacher capacity for physical learning (UNESCO, 2021).

In Lebanon, the context of the study, during the scholar year 2020-2021, the Ministry of Education and Higher Education (MEHE) decided to adopt blended learning. Then, as the country went again for a lockdown, distance learning was adopted. However, there has been a partial failure to achieve the objectives and competencies during this period. Accordingly, the Center for Educational Research and Development (CERD) was forced to reduce a set of learning objectives in more than one subject At the beginning of the academic year 2021-2022, CERD issued a plan for recovery. This plan aims to motivate learners, actively engage them in the teaching-learning process, and stimulate the motivation to learn in addition to attaining other objectives at the

psychological and social level (Center for Educational Research and Development [CERD], 2021). Despite this, many obstacles affected this recovery such as the economic status that the country was passing through, the strikes that the educational sector has been subjected to, and the emergent school holidays and no action was taken to compensate for student learning loss.

There is also an emphasis that learning losses can be reversed using blended learning (e.g., UNESCO, 2021; UNICEF, 2021) which allows for the provision of a wide range of educational resources to learners and help students be more active and creative (Alsahli, 2019). Additionally, students would be more responsible for their learning as they can work at their own pace with self-directed learning along with other opportunities to communicate and collaborate either with each other or with their teacher (as cited in Dermirer & Sahin, 2013). In their study, El-Husseini and Taha (2017) argued that blended learning would be a solution to address certain problems faced in igher education, one of which is compensating for sudden closures of the Lebanese University. Additionally, few studies highlighted the effectiveness of online learning (e.g., Shaaban, 2021) in creating learning environments that help learners be active participants by exploring concepts and constructing knowledge. However, to the knowledge of the researcher, no studies in Lebanon have investigated the effect of using blended learning models as remedial programs to reverse learning loss at high schools. Thus, studies are needed to investigate whether a blended learning model would be an effective approach to reverse the learning loss in the Lebanese high school context or not.

The present study aimed to investigate the effectiveness of a blended learning model to reverse the learning loss that has occurred in Grade 10 Chemistry Class during the COVID-19 pandemic. It also aimed to add knowledge to the Lebanese context regarding the learning loss in Chemistry during COVID-19 pandemic and fill a gap in the literature concerning blended learning as an approach to address this issue in Grade 11 Chemistry Class.

2. Literature Review

2.1 Learning Loss

In literature, the notion "learning loss" is not new. It is frequently used to characterize losses in student knowledge and abilities (Donnelly & Patrinos, 2021). As mentioned earlier, the term "learning loss" refers to any particular or general loss of information and abilities, as well as reversals in academic progress, most typically caused by lengthy gaps or interruptions in the student's education. Learning loss can emerge in a variety of ways and from a multiplicity of factors which include, but are not limited to, summer break, interrupted formal education, and ineffective teaching (The Glossary of Education Reform, 2013). In this study, learning loss due to the interruption of formal education will be used.

Existing research found out that learning loss led to a decline in achievement and performance among students. Studies, in middle and high schools, on absenteeism found that school absence and missing classes lowered the academic achievement. For example, a study by Liu et al. (2021) found out that school absence led to a decrease in the final test scores of students by 3-4% of a standard deviation (SD) in Math and other subjects. School closure due to snow and bad weather decreased students' achievement in Math by about 0.013 to 0.039 SDs in Colorado per day (Hansen, 2011); in addition to this, Goodman (2014) found student scores in Math one-day absence due to snow reduced 0.05 SD. As for the summer vacation, students exhibit variable effects. Generally, more than 50 % of students suffer a learning loss.

Kuhfeld et al. (2020) noted that students who didn't receive online instructions would be mostly affected as they would start the new year with a loss in mathematics equivalent to one year. The shift to online learning would lead to "more variability" among students in terms of academic

achievement since not all of them have the same reaction to online learning (as cited in Cardinal, 2020, p.6). A systematic review by Donnelly and Patrinos (2021) about learning loss during COVID-19 pandemic revealed that learning losses were recorded in a variety of disciplines, grade levels, and geographic areas.

Kuhfeld et al. (2020) considered that a great and long-term efforts are needed for educational recovery. However, to address the impact of learning loss on students, researchers emphasize the effectiveness of pedagogical practices that focus on active learning and differentiating instructions. They recommended creating remedial programs through seeking community centers' support after school to assist students who are falling behind in addition to implementing interventions that extend learning especially for struggling students (Kuhfeld et al. 2020; Cardinal, 2020). Additionally, Sabates et al. (2021) claimed that to mitigate the losses and achieve gains, it is crucial to reconsider the learning process at home and in schools.

2.2 Blended Learning

Blended learning is a pedagogical approach through which a student learns partially through an online delivery of content but still receives face-to-face learning in class (Alsalhi et al., 2019; Hrastinski, 2019). Blended learning has been recognized as an essential alternative instruction method that combines the benefits of both face-to-face learning and online learning at various levels of education and subject areas (Huang, 2019). Research on blended learning reveals that it provides students with opportunities to work at their own pace and emphasizes a student-centered approach to enhance independent and active learning (El-Hussein & Taha, 2017).

Existing literature highlights the role of blended learning as an approach to develop students' achievement. In the context of UAE, a study was employed to investigate the impact of blended learning on Grade nine students' achievement in science and their attitudes towards it. This study revealed that there is a positive effect on students' academic achievement. Moreover, a statistically significant difference between the experimental and the control groups existed, in favor of the experimental group (Alsalhi et al., 2019). Alsalhi et al. (2019) recommended experts to design activities in science textbook that are suitable for blended learning in addition to training teachers and enhancing their abilities to adopt blended learning.

2.3 Flipped Classroom

Bergmann & Sams (2012) stated the concept of a flipped class as "that which is traditionally done in class is now done at home, and that which is traditionally done as homework is now completed in class". Ajmal and Hafeez (2021) defined the flipped classroom model as a model that integrates technology with the traditional method of teaching through which the traditional lecture method is flipped. In such a model, the initial learning starts at home while in-class time is devoted to cooperative learning and discussions. In other words, the internet takes over the traditional lectures, so that class time is entirely student-centered where the teacher is only a mediator during class discussion to help students make use of the content learned (Torkelson, 2012).

2.4 Flipped Classroom and Academic Achievement

In the literature, evidence exists regarding the impact of flipped classroom on academic achievement and students' performance. For example, a mixed method research design was conducted by Alamri (2019) to investigate the effectiveness of flipped classroom on academic performance and satisfaction; this study revealed that flipped classroom improves students' performance in computer applications used in education. Results from this study showed that the mean score of the experimental group students (M = 23.77, SD = 2.93) was greater than that of the

control group (*M* = 21.62, *SD* = 3.112) (Alamri, 2019). On the other hand, an experimental study was conducted in Saudi Arabia to measure the effectiveness of using flipped classroom strategy among university female students in enhancing academic achievement and self-efficacy. Results from this study showed that the mean score of the experimental group students (*M* = 21.41, *SD* = 3.846) was greater than that of the control group (*M* = 18.89, *SD* = 2.805). The results of this study were significant ($p = 0.018$) and showed that experimental group students outperformed the control group in the achievement test (AlJaser, 2017). Buskey (2019) reported similar findings. In his quantitative causal-comparative study to compare the means of students in Geometry classes using flipped and traditional classroom, Buskey (2019) found that students achieved a higher level of learning using the flipped classroom model than the traditional model.In addition to this, a study conducted by Mandina (2019) in the context of Zimbabwe, to investigate the effect of flipped pedagogical approach on the learning outcomes of students in Chemistry, concluded that this approach facilitated students' understanding of Chemistry concepts. Moreover, he emphasized the efficiency of integrating online courses with face-to-face classroom settings to enhance active learning strategies and recommended implementing flipped classroom models in schools as it improves students' academic performance.

In the context of Nigeria, Olakanmi (2017) conducted a mixed-method study about the effect of flipped classroom model of instruction on students' performance and attitudes towards Chemistry; results showed that students who were taught using the flipped classroom model outperformed those who were taught using the traditional method. Findings from this study revealed that the mean of students' scores in rates of reactions knowledge test for the control group shifted from (*M* = 5.73, *SD* = 2.75) to (*M* = 7.14, *SD* = 2.54); however, the mean of the students' scores for the experimental group shifted from (*M* = 5.12, *SD* = 2.53) to (*M* = 10.82, *SD* = 2.44). Moreover, the results of the independent-samples *t* -test (t (64) = 4.9, $p < 0.05$) assured that there was a statistically significant difference between the two groups. Additionally, the interviews he conducted with students revealed the benefits of the flipped classroom in terms of independent learning and peer collaboration. He concluded that the flipped classroom model improves students' performance and instills a positive outlook for learning by moving lectures out of the classroom through technology and inside the classroom through learning activities.

On the other hand, some studies have found different results. For example, Overmyer (2014) conducted a quasi-experimental study entitled as "The Flipped Classroom Model for College Algebra: Effects on Student Achievement". This study aimed to investigate the effect of flipped classroom method on students' achievement in Math versus the traditional method of teaching. The results obtained from this study showed that the mean of mathematics achievement scores of the students taught by the traditional method (*M* = 20.14, *SD* = 5.101) was slightly lower than the mean of the students of the flipped classroom sections (*M* = 21.27, *SD* = 5.130); additionally for a mean difference of 1.133, t (299) = 1.912, $p = 0.057$, this result showed that there was no statistically significant difference between the groups. Overmyer (2014) claimed that this result could be attributed to the insufficient experience of teachers about the flipped classroom model in addition to the absence of the training programs for those teachers. Moreover, the absence of collaboration group work, inquiry based learning and active methods of teaching are one of the reasons that led to this result (Overmyer, 2014). It was noted that flipping the class wouldn't be enough to enhance the students' achievement. However, for this achievement to be greater, teachers have to prepare convenient activities for the in-class sessions (Overmyer, 2014). Additionally, Overmyer (2014) recommended teachers to prepare assignments and make short quizzes to check if the students have watched and prepared the videos at home; meanwhile, class time will be devoted for cooperative learning and inquiry-based learning.

In the context of Korea, Lee et al. (2021) conducted a sequential mixed-method design study to compare the effect of different instruction methods including cooperative flipped learning, simple flipped learning and traditional lecture on students' achievement in Chemistry and motivation to learn. Quantitative results obtained from this study reported a noticeable decrease in students' post-test scores as compared to pre-test scores. However, motivation to learn was different among the groups. Students of cooperative flipped learning and traditional lecture groups showed higher motivation to learn, whereas students of simple flipped learning group reported a decrease in learning motivation (Lee et al., 2021).

In the context of Lebanon, Hamad (2021) conducted a quasi-experimental study to assess the impact of flipped classroom on students' performance and their learning outcomes in Math. It was noted that flipped classroom model of teaching enhanced the understanding level of low achieving students only. The mean score of the flipped class was (M = 10), while that of the traditional class was (M = 4.29), the Mann Whitney U test showed a significant difference for low achievers (U = 7.5, p = .047). Additionally, it was reported that flipped classroom had no impact on low or high achieving students regarding the levels of Bloom's Taxonomy (remember, apply, and analyse) (Hamad, 2021).

2.5 Further Benefits of Flipped Classroom

The implementation of flipped classroom as a model for teaching could allow the realization of several benefits in education: (a) Personalized education; (b) Flexible environment; (c) Interaction and collaboration. According to Bergman & Sams (2012), in a flipped classroom a framework that considers students' needs and enables personalized education is created.

According to Olakanmi (2017), students reported that the flipped classroom model allowed them to be more engaged in the learning process as they can interact and participate more. Moreover, students preferred the flipped classroom model due to its flexible nature, as they can watch the videos at any time and without any stress (Olakanmi, 2017). On the other hand, qualitative findings from the study conducted by Alamri (2019) showed that the online phase of the flipped classroom model allowed students to learn at their own pace in terms of time and place. In addition to that, students were able to interact and collaborate with each other leading to effective peer discussions. Other qualitative findings from the study of Warren et al. (2020) revealed that the interactivity among students allowed them to learn from their mistakes and this allowed students to enhance their skills in Math. Furthermore, other benefits were reported, such as students were able to prepare the delivered lesson content at home and become ready for in-class discussions (Alamri, 2019). Additionally, AlJaser (2017) noted that the flipped classroom model renders the teaching and learning process more engaging and exciting, and students become more confident and responsive for their learning.

Even though flipped classroom could benefit students at different levels, qualitative results from the study of Lee et al. (2021) noted different findings. Some students considered that flipped learning allowed them to gain more confidence in Chemistry while watching videos and preparing for class. Meanwhile, others were dissatisfied with this strategy and preferred traditional learning. In addition, it was noted that students who can be self-dependent learners have benefited from the simple flipped learning strategy, while other students considered it as a distracting strategy and they still need the support of their teacher (Lee et al., 2021).

3. Methodology

This section of the article describes the methodology used in carrying out this part of the original study.

3.1 Research Design

The researcher adopted a mixed-methods (QUAN + qual) quasi-experimental design. A field study comprising three experimental groups and three control groups was conducted at three public high schools where students were present in intact classrooms, "random assignment of intact groups to treatments, not a random assignment of individuals" was followed (Gay et al., 2012, p. 270). The quantitative part is the quasi-experimental pre/post-test design with the non-equivalent control group (Gay et al., 2012). For further support to the quantitative data, the researcher collected qualitative data by exploring the perceptions of students in the experimental group using semi-structured focus group interviews to elicit more data regarding the effectiveness of the blended learning model through the eyes of the participants (Creswell & Plano Clark, 2018).

3.2 Research Questions

1- How do lessons designed on a flipped classroom model to mitigate the learning loss in Grade 11 Chemistry class affect students' performance on Chemistry Achievement Test?

2- How do Grade 11 students perceive learning Chemistry using the flipped classroom model?

3.3 Sampling

The present study was implemented in three public high schools located in three villages in the West Bekaa district. These high schools were purposefully chosen since each of them has at least two Grade 11 Sciences sections. Each school was given a pseudonym to maintain confidentiality: (School A, B, and C). The study was carried out with 110 Grade 11 students (Sciences section). The control group involved 53 participants and the experimental group involved 57 participants.

3.4 Instrumentation

The data of this study were collected using these instruments: (a) The Chemistry Achievement Test (CAT) and (b) Semi-structured focus group interview.

3.4.1 Chemistry Achievement Test (CAT)

The researcher developed a Chemistry achievement test to measure students' achievement and gain competencies related to Grade 10 chemistry subjects (stoichiometry and chemical calculation; preparation of solution), which have not been totally attained during COVID-19 pandemic. These competencies are considered the basics that the student needs along the secondary cycle; in addition, such competencies are required in the Official Lebanese Exams.

The researcher prepared two equivalent versions of this test as pre-test and post-test to avoid the effects of repeating the same tests for students, which might cause a threat to internal validity (Gay et al., 2012)

3.4.2 Semi-structured Focus Group Interview

A semi-structured focus group interview was conducted with 13 participants of the experimental group to collect the qualitative data. Some of those participants were chosen by their teacher due to her prior knowledge of their abilities to participate and answer the questions, while other participants expressed their desire to participate in the focus group interview once they were told about that. The interview was held online using Microsoft Teams. A sample of questions asked during the interview are: What did you like about the flipped classroom environment? What do you

think about using the flipped classroom model to teach you Chemistry? To what extent were peer discussions beneficial to you? What did not you like about the flipped classroom environment?

3.5 Procedure

The researcher began conducting the study. The beginning was with a pilot test; then, the researcher with the aid of the teachers at the participating high schools implemented the intervention.

3.5.1 Teacher's Training

The participating teachers have good experience in using educational technology tools, using platforms for online teaching and teaching from a distance. Also, they are familiar with using the Google Classroom Application. However, the researcher created a WhatsApp group for communication with the teachers and for explanation of the phases of the study, training the teachers in the experimental group on using materials prepared by the researcher in addition to clarifying any point related to the study.

3.5.2 Testing Sessions

Students in the experimental and control groups completed a pre-test one week before the flipped classroom intervention and a post-test directly after the end of the intervention. The researcher received the collected sheets immediately at the end of the testing sessions. Then each teacher started the intervention lesson. The CAT post-test was immediately completed after the intervention. The test occurred in the classroom and its allocated time was 45 minutes.

3.5.3 Intervention lessons

The competencies and objectives addressed by the intervention are of paramount importance in the Chemistry of the secondary cycle. Accordingly, the researcher designed PowerPoint slides and recorded videos related to these competencies. These videos were uploaded to YouTube. Students of the experimental group were provided with the links of those videos through the Google Classroom Application. Along with this procedure, each teacher delivered the intervention lesson for the experimental group supported by the materials provided by the researcher and following the flipped classroom model. Students of this group were enrolled in a virtual class using Google Classroom, so that any Chemistry content related to the competencies of Grade 10, resources, assignments, feedback, or discussion were provided through this application. Students, their Chemistry teacher, and the researcher were together in this virtual class. Each teacher devoted one session for in-class activities over a four-week period. During this time, the researcher followed up the sessions with the teachers and compiled qualitative data to ensure treatment fidelity and gain more understanding (Graham & Harris, 2014).

3.5.4 Control Group Instructions

In the control groups, students were taught the same lessons using regular teaching strategies. They revised with their teachers the competencies and the concepts related to stoichiometry, chemical calculations, and preparation of solutions in class. Moreover, they solved exercises and assigned homework on these concepts. Additionally, they received the same testing materials as those of the experimental group. They did the Chemistry achievement test under the supervision of their teachers and remote follow-up by the researcher.

4. Results

4.1 Quantitative Findings

Independent-samples *t*-tests were conducted to examine initial differences in CAT scores. Levene's test showed that equal variances were assumed (p = .665; p > .05) for the CAT pre-test scores. Results of the independent samples *t*-test with 95% confidence interval (CI) indicated no statistically significant difference in the CAT mean scores for the experimental (M = 3.54, SD = 2.01, N= 57) and control group (M= 4.00, SD = 1.99, N= 53); t (108) = 1.206, p = .231, 95% CI: [-.297 - 1.219].

In short, the result of the independent-samples *t*-test showed that both groups, the experimental and the control, demonstrated the same level of performance on the Chemistry achievement test before the study.

To this end, after the intervention, students did the CAT test posttest. Independent-samples *t*-test was conducted to examine whether significant difference between the mean scores of the experimental and the control group exist due to the flipped classroom model. Additionally, a paired-samples *t*-test procedure was conducted to examine the difference and gains on the mean scores of Chemistry achievement test (CAT) from pre-test to post-test within the experimental and control group (Pallant, 2011).

Results of the independent samples t-tests show no statistically significant difference between the experimental and control group on mean scores of the post Chemistry achievement test.

Table 1

Results of Independent-Samples t-test of Post-test Mean Scores of (CAT)

	Experimental Group		Control Group				
Post-test Mean Scores	*M*	*SD*	*M*	*SD*	Levene's test	*t*(*df*)	*P*
CAT	6.81	2.91	6.66	2.57	1.014	-.278(108)	0.782

Note. t = *t*-test value, df = degrees of freedom, p value > .05 significance level (no significant difference between groups).

A paired-samples *t*-test was conducted to evaluate the impact of the traditional teaching on students' scores on the Chemistry Achievement Test (CAT). There was statistically significant increase in CAT scores from pre-test (M = 4.00, SD = 1.99) to post-test (M = 6.66, SD = 2.57), t (52) = 7.96, p < .025 (one tailed). The mean increase in CAT scores was -2.65 with a 95% confidence interval [-3.32 to -1.98].

As for the experimental group, a paired-samples *t*-test was conducted to evaluate the impact of the intervention on students' scores on the Chemistry Achievement Test (CAT). There was statistically significant increase in CAT scores from pre-test (M = 3.54, SD = 2.01) to post-test (M = 6.81, SD = 2.91), t (56) = 10.73, p < .025 (one-tailed). The mean increase in CAT scores was – 3.26 with a 95% confidence interval [-3.87 to -2.65].

In this study, the effect size Cohen's d, is reported and interpreted using the guidelines of Cohen's (1988); Cohen d is interpreted as follows: (a) d = .2 (small), d = .5 (medium), and d = .8

(big) is interpreted as big (Cohen 1988, as cited in Cohen et al., 2018). The obtained values were 1.33 for the control group and 1.62 for the experimental group.

Table 2
Descriptive Statistics and Results of Paired-Samples t-tests of (CAT) Pre-test and Post-test in the Experimental (N = 57) and Control Group (N = 53)

	Pre-test		Post-test				
Source	*M*	*SD*	*M*	*SD*	*t*	*P*	Cohen's *d*
Experimental group	*3.54*	*2.01*	*6.81*	*2.91*	*10.73*	*.000*	1.62
Control group	*4.00*	*1.99*	*6.66*	*2.57*	*7.96*	*.000*	1.33

Note. M = mean scores, SD = standard deviation, t = t-test value, significance level p> .025, d indicates effect size and is compared to Cohen's (1988) guidelines (.2 = small effect, .5 = moderated effect, .8 = large effect).

These results revealed that there is an improvement in the scores of the experimental group from pre-test to post-test indicating that flipped classroom could have affected the students' scores in the CAT more than the traditional teaching. Additionally, the significant value of the paired *t*-test supported by the larger value of Cohen's *d* for the experimental group allowed the researcher to say that the hypothesis related to the first research question was supported. However, due to the non-significant difference yielded by the independent samples t-test, the researcher conducted further analysis in terms of comparing the mean score of the experimental and the control group per school.

The researcher attempted to dig deeper into the results to explore more the impact of the intervention on each of the participating schools independently, though it is neither hypothesized in the present study nor addressed by the research questions. This was done to inspect the factors that could have affected the impact of the flipped classroom model and lead to significant results and open a new horizon for researchers for new and further studies.

Accordingly, one-way between groups analysis of covariance (ANCOVA) was used to compare the effectiveness of the intervention designed and the differences between the groups of each school on CAT. The independent variable was the type of intervention, and the dependent variable consisted of scores of students on CAT administered after the intervention. Participants' scores on the pre-intervention administration of the CAT were used as the covariates in this analysis. Preliminary checks were conducted to ensure that there was no violation of the assumptions of normality, linearity, homogeneity of variances, homogeneity of regression slopes, and reliable measurement of the covariate.

After adjusting for pre-test scores, results indicated there was statistically significant difference between the experimental and control groups on post-test scores of (CAT) for school (A) F (1, 41) = 5.909, ρ = .02, partial eta squared (ηp2 = .132). The value of partial eta squared is close to large effect size according to Cohen's (1988) guidelines, and the effect of the intervention on the experimental group of school (A) was statistically significant (ρ < .05). Thus, the flipped classroom intervention accounted for 13.2 % of the variance in the CAT post-test for this group. Meanwhile, the covariate Pre-CAT accounted for 55.5 % of the variance in the CAT post-test. On the other hand, having a look at the results of the three high schools (table 3), the mean difference between the pre-test and post-test of the experimental group of school (B) is greater than the two other schools (A) and (C). Besides that, while examining the descriptive and inferential statistics of the experimental group of school (B), it is obvious that performance of the students of this group had improved after the intervention. Although there was no statistically significant difference between the experimental and control groups on post-test scores of (CAT) for school (B) F (1, 35) = 1.229, ρ = .276, partial eta squared (ηp2 = .037).

Table 3

Pre-test and Unadjusted Post-test Mean Scores (M) and Standard Deviation (SD) for CAT of Each School

		Pre-test		Post-test	
School	Source	*M*	*SD*	*M*	*SD*
A	Experimental group	4.32	2.11	7.06	3.46
	Control group	4.80	2.22	5.91	2.75
B	Experimental group	2.75	0.98	7.15	2.75
	Control group	2.77	1.80	6.42	2.41
C	Experimental group	3.72	1.79	6.04	2.15
	Control group	4.28	1.93	7.98	2.10

Note. Unadjusted post-test means refer to means without controlling for the pre-test scores of HCSS and pre-test scores of CAT as a covariate.

4.2 Qualitative Findings

It was noted that students revealed positive impacts of Flipped classroom in the Chemistry class in terms of effects of instructional practices or procedures, these were categorized as follows:

4.2.1 Flexibility of Learning

The analysis of the students' responses to the interview questions showed how the implemented flipped classroom model created a flexible environment for learning as they work at their own pace. They watched the videos for several times and at any time they want till they acquire the concept. One of the participants mentioned that "they can watch the videos at any time, they can repeat and rewatch it". This, also, was ascertained by more than one participant, like what was mentioned by participant 5 "I can repeat them if I if I have misunderstandings in anything or any concept".

4.2.2 Quality of Instruction

Participants considered it as an effective way that helped them to understand the concepts in a short time and a simple way. They commented positively on the pre-instructional phase where they were supported with the videos. They highlighted the significance of using videos and the duration of these videos as a pre-class activity. For example, one of the participants said that he "liked the short duration of the videos". Additionally, these videos allowed them to understand the concept and become ready for the during phase (in-class). Participant 2 commented "I liked the explanation; it was very clear and simple, and I had no hard time in understanding the concepts". On the other hand, participant 3 said that she "liked the examples given in these videos". This was also emphasized by participant 6 who said "…for me it was an effective method especially that the explanation was clear, and also, I liked the details that you added to the videos…". On the other hand, preparing the lesson at home and coming to class to practice will provide more time for group work and collaboration. In this regard, participant 10 mentioned "it lets us come to class with to interact with our classmates and teacher, it can clean up any misconception".

4.2.3 Active Engagement in Learning

Participants prefer to learn Chemistry using this strategy as they considered it as "efficient way". The flipped classroom model promotes student-centered strategies. In this regard, participant 11 noted that "it gives opportunity to everyone to try solving", while participant 4 considered that the discussions that were held in-class allowed them to gain more information "we would have more information while discussing the lesson in class". Additionally, it was clearly noted that the flipped classroom model had a positive effect on the participating students. Their academic performance was enhanced, and their acquisition of the discussed concepts has been achieved in addition to the improvement in their laboratory skills. Participant 11, for example, reported that "It raises up our grades in schools such as in exams, and it helps us to understand more about Chemistry". While participant 3 commented that "I mostly gained aaa a deep understanding of the objectives and concepts".

4.2.4 Collaborative Learning with Peers

Participants reported that the interaction among students was very effective, allowed them to gain information and look at the same topic from different points of views. As was mentioned by one of the participants, students were able to communicate, help each other and share information. Hence, they considered that they were able to correct their mistakes and learn from each other. Participant 11 mentioned that "It helps us to correct our mistakes in calculations and aa to correct

our misunderstandings of some concepts". Further, participant 6 talked about the discussions held using the application and in class, as she said, "these discussions between me and my friends have benefit me by learning from the mistakes of my colleagues". In general, it can be noted that the flipped classroom model allowed students to collaborate and interact together. Hence, this would have a positive effect on their academic performance and enhance their self-efficacy in Chemistry.

4.2.5 Self-Independent Learners

Another gain due to this intervention was recorded. This gain was that they learnt independently and became self-independent learners. This experience has made students more self-reliant. Furthermore, participant 7 added "…I really like that I could watch the videos at any time, especially when I'm solving my homework and need help, this helped me depend on myself more". Regarding this concept, it can be stated that flipping the class contributes to the dependence of the students on themselves, becoming more responsible for acquiring concepts and promotes self-regulated learning.

4.2.6 Challenges and Preferred Experience

In this regard, other students faced some challenges and others have certain preferences related to the teaching method.

Participants mentioned that they did not like the timing of this intervention, the stress that they were subjected to and the lack of enough time. In addition to that, participant 5 commented that "we can't depend hundred percent in learning on a Google classroom, because we still need the help of the teacher and communicating face-to-face". Moreover, it was noted that some participants preferred to learn in-class with their teachers especially during laboratory sessions**.**

5. Discussion

5.1 Impact of the Flipped Classroom Model on Students' Performance on CAT

Results of paired-samples t-test indicated that there was statistically significant increase in CAT scores from pre-test to post-test for both groups, the experimental and the control one. Additionally, the mean of the post-test scores of the students of the experimental group (M = 6.81, SD = 2.91) was higher than the mean of the students' post-test scores of the control group (M = 6.66, SD = 2.57). As revealed by Cohen's d, the magnitude of the difference from pre to post-test was significantly higher, (p = .000) and d = 1.62 for the experimental group, whereas (p = .000) and d = 1.33 for the control group. These results ascertained that experimental group participants showed significantly developed performance based on scores of the achievement tests compared to the control group participants who received traditional teaching. This development could be attributed to the flipped classroom model being entirely student centered, engaging and flexible (Olakanmi ,2017). Specifically, the instructional practices provided during the pre-class stage where students of the experimental group received video lessons and other instructional materials to be prepared at home. These materials allowed students to be ready for the in-class sessions at which group work, collaboration, discussions, inquiry-based learning activities and other practices were held.

The findings of the present study concerning the performance and the achievement of students aligns with several earlier studies that proved the impact of the flipped classroom on students' academic achievement in Chemistry and other subjects (Alsalhi et al., 2019; Alamri, 2019; AlJaser, 2017; Buskey, 2019; Mandina, 2019; Olakanmi, 2017). Additionally, the results of the present study are consistent to a great extent with the study of Overmyer (2014) who found that the mean of the mathematics achievement scores of the students taught by the flipped classroom model

was slightly greater than those taught by the traditional method. Besides that, qualitative findings from this study supported the quantitative results regarding the achievement and performance of the students. This was noted from the responses of the students to interview question "What do you think you have gained?", the students considered that "It raises up our grades in schools such as in exams, and it helps us to understand more about Chemistry".

However, the finding of the present study is not aligned with the results of other studies (e.g., Lee et al., 2021) who reported a decrease in the post-test scores in Chemistry as compared to the pre-test scores. Also, this study is not aligned with Hamad's (2021) study which noted that there was no statistically significant difference between the scores of the students in the flipped classroom and the traditional one.

As a result, the stated hypothesis "Grade 11 Chemistry students who receive lessons using flipped classroom model to mitigate Chemistry-learning loss, will significantly demonstrate higher scores on Chemistry achievement test from pre to post-test than do other students who receive traditional teaching" was supported.

5.2 Students Performance Per School

The descriptive statistics related to the CAT post-test scores revealed an improvement in the academic performance of students of the experimental and control group in the three high schools. This could be attributed to the fact that these sections were given remedial sessions at the beginning of the scholar year 2021-2022 in response to the recommendations of the Center for Educational Research and Development (CERD). Besides these remedial sessions, the experimental groups at the three high schools were taught using the flipped classroom model during the present study. This would explain the improvement of the experimental group students, at high schools (A) and (B), more than those of the control group. Meanwhile, in high school (C) the control group outperformed the experimental group on the Chemistry achievement test. It was noted that some students of the experimental group did not show their responsibility towards the implemented study, and others were not able to participate. This would be attributed to different reasons, one of these could be the frequent lack of internet access and the necessary devices as was noticed by the researcher and emphasized by their teacher. This prevented students from watching or receiving feedback through the Google Classroom Application, a requirement in the Flipped Classroom design in the present study.

5.3 Effect of the Intervention Per School

Analysis of covariance of CAT post-test scores as a function of flipped classroom lessons, with pre-test HCSS and pre-test CAT as covariates revealed that there was statistically significant difference between the experimental and control groups on students' post-test scores of (CAT) for school (A). The partial eta squared value (η_p^2 = .132) showed a large effect size for the intervention though remedial sessions were held previously. This result supported the quantitative findings of the present study and is in alignment with other earlier studies regarding the effect of flipped classroom on students' academic performance and achievement (Alsalhi et al., 2019; Alamri, 2019; AlJaser, 2017; Buskey, 2019; Mandina, 2019; Olakanmi, 2017). Additionally, it was found that the covariate (CAT pre-test) significantly accounted for 55.5 % of the variance (η_p^2 = .555, p = .000). As mentioned before, this finding would be attributed to the revisions conducted by the teachers at the beginning of the school year.

On the other hand, the effect of the intervention in school (B) was not statistically significant, and the partial eta squared η_p^2 = .037 indicating a small effect size. However, it was noted that there was an increase in CAT scores from pre-test (M = 2.75, SD = 0.98) to post-test (M

= 7.15, *SD* = 2.75), this increase was the greatest among the three high schools. Students of the experimental group in high school (B) were the lowest achievers among the three schools. This finding would be attributed to both students' level of performance and self-efficacy and teacher's instructional self-efficacy. The students made an effort and benefited from the videos and the explanations provided whether in class or at home. Such interpretation is supported by Hamad (2021) who noted that the flipped classroom model improved the understanding level of low achieving students only. Also, the teacher had a prominent role in the classroom while explaining, practicing, solving activities, and providing personal instructions and assistance. This finding is aligned with other studies (Hamad, 2021; Overmyer, 2014). Overmyer (2014) considered that convenient activities prepared by the teacher for the in-class sessions are necessary to increase the achievement of the students, while Hamad (2021) noted that flipped classroom improved the classroom communication and increased the class time which allowed the teacher to provide more personal instructions.

Despite the fact that these three high schools shared similar characteristics, yet different results were obtained. Additionally, this finding would be attributed to the teachers' performance at these high schools. This performance was different even though teachers have same qualifications and usually subjected to same training they usually received from training authorities such as the Center for Educational Research and Development (CERD). However, it seems that this training was insufficient in terms of using active methods of teaching, collaborative group work, inquiry based learning and other methods suitable for the flipped classroom model. This agrees with Overmyer (2014) who claimed that absence of training programs, insufficient teachers' experience about the flipped classroom model, absence of active teaching methods and inquiry-based learning could negatively affect the implementation of the flipped classroom and students' achievement. This would also indicate that teacher's role and efficacy are significant for a successful implementation of any evidence-based practice such as the flipped classroom model as was emphasized by Bandura (Shunk, 2012).

5.4 Benefits and Gains of Flipped Classroom Group as Demonstrated by the Qualitative Findings

To begin with, meaningful information was obtained from students' responses to the interview questions which allowed the researcher to come out with several categories that belong to the following two concepts:(a) Effects of instructional practices and procedures and (b) Challenges and preferred experience.

It can be noted that the flipped classroom model highlighted several additional benefits from the perspectives of students. These benefits are related to: (a) Flexibility of learning; (b) Quality of instruction; (c) Active engagement in learning; (d) Collaborative learning with peers; (e) Self-independent learners.

Firstly, 6.1 % of students' responses revealed that the flipped classroom model allowed them to work at their own pace. This is due to the availability of the videos that students can watch and rewatch at any time at home till they acquire the concept. This result agrees with what Hamad, (2021) reported in her study that flipped classroom created a flexible environment to learn. Also, this finding is consistent with Olakanmi's finding about the flexible nature of the flipped classroom that allows students to watch the videos at any time and without any stress (Olakanmi, 2017; El-Hussein and Taha, 2017; Alamri, 2019).

The second category is the quality of instruction. As was mentioned earlier, 30.53 % of students' responses revealed awareness in terms of the quality of instructional practices employed in the flipped classroom. It allowed them to prepare at home before coming to class. Thus, the pre-

class activities were suitable for them and allowed students to become ready for the in-class session. Moreover, preparing the lesson at home provided more time for practicing, group work and collaboration during the in-class sessions. Similar results were reported by Alamri (2019) and is in alignment with the result of the present study.

Additionally, 32.06 % of students' responses revealed the active engagement of students in the learning process. In this regard, as was mentioned by one of the participants, the flipped classroom gives the opportunity for every student to try solving whether at home or during the in-class sessions. Hence, this model promotes student-centered strategies; the teacher can provide personal instructions for learners, and thus renders the learning process more engaging and exciting. This result is in alignment with other studies (AlJaser, 2017; Hamad, 2021).

In addition to what was mentioned, the present study provided students with the opportunity for collaborative learning with peers. As revealed in their responses (10.6 %), students were able to communicate, collaborate, help each other, and share information. Also, students were able to learn from each other and correct their mistakes. Additionally, the feedback provided to the students through the Google Classroom Application helped students to correct their mistakes and any misunderstanding. These findings are in alignment with other studies (Alamri, 2021; Ma & Lee, 2021; Warren et al., 2020). Additionally, these findings are supported by the social cognitive theory of Bandura that emphasizes the role of social interaction in learning (Shunk, 2012) and by Vygotsky's sociocultural theory which considers that learning is co-constructed when people interact and collaborate. These are aligned with Vygotsky's theory which emphasizes the role of peer collaboration, support, and constructive feedback in learning science (Vygotsky, 1978 as cited in Shunk, 2012). Along with these findings, 6.87 % of students' responses revealed that students experienced a kind of self-independent learning. This experience was provided by the flipped classroom model that allowed students become more reliable on themselves and responsible for their learning. In this regard, students were able to be self-dependent while watching the videos and revising the questions and the answers provided to them through the Google Classroom Application. This result is in alignment with that of other studies (e.g., Olkanmi, 2017; Dermirer & Sahin, 2013).). Students were also asked about the challenges and preferred experience, their responses demonstrated that some of them were stressed and lacked enough time to actively participate in this study. While others argued that they cannot depend totally on this method and still need the help of their teacher and the direct communication with their colleagues. Additionally, other students preferred the in-class sessions especially the laboratory sessions. This result is in alignment with that of Lee et al.'s (2021). These qualitative findings revealed that flipped classroom model enhanced the performance of students. Hence, these results support the quantitative findings regarding the impact of flipped classroom on the academic performance of students that was discussed earlier.

6. Conclusion

The present study reports the effect of lessons designed on a flipped classroom model on eleventh Grade students' achievement in Chemistry. It revealed that students who received Chemistry lessons using flipped classroom model significantly demonstrated that there was an improvement in the mean scores of the experimental group from pre-test to post-test indicating that flipped classroom could have affected the students' scores in the CAT more than the traditional teaching. Along with these results, it can be noted that flipped classroom would be an effective model to be used by teachers and educators to recover learning and mitigate learning loss. Moreover, qualitative findings revealed that fruitful gains were experienced by students. At home a flexible environment for learning was created for students who learned using the flipped classroom

model and become self-independent learners. Additionally, students were actively engaged in the learning process, able to collaborate and interact with their peers during the in-class sessions and student-centered strategies were promoted.

In the present study, several limitations were encountered. These limitations are related to time, teachers' training, and the follow-up of the progress of the in-class sessions during the intervention in addition the perceptions of teachers about the flipped classroom were not captured.

This Study called for certain recommendations whether during the implementation of the Flipped Classroom in schools or during the conduction of other further research: (a) Train teachers on collaborative learning and inquiry-based learning; (b) extend the duration of the study to include more than one chapter; (c) conduct teachers' interview to investigate and elicit more about their perspective regarding the flipped classroom and its effectiveness.

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