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Effectiveness of Flipped Learning Model (FLM) for Grade 11 Physics Classroom

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Abstract

This action research investigates the impact of the flipped classroom model (FLM) on grade 11 students' problem-solving competency in a physics classroom in a francophone school in Beirut during the winter of 2017. After interviewing the physics teacher and the school principal the issue of weakness in problem solving skill has been identified in one of grade 11 classrooms. As a second step, a flipped learning classroom has been designed and implemented as a remedy. Without comparing to a control group, the data has been collected using a pretest and posttest on the same classroom. After two weeks of intervention, results revealed an improvement in students' problem solving at all cognitive levels. Wilcoxon rank sum test was used to check for significance difference between pretest and posttest. This nonparametric test was used because of the small sample size of population. However, despite the promising findings, such interpretation should be interpreted with caution and not generalized because of limitations such as time constraints and the small-scale of intervention. For further engagement in the FLM, it is recommended to integrate gamification strategies.

Keywords

Flipped Learning Model, Problem Solving Skills

1. Introduction

The FLM has become increasingly popular due to the advancement of technology in education. A key milestone in this progress includes the rise of MIT open courseware and Khan academy platform that played a pivotal role spreading this teaching methodology. It is an approach associated with reversing the way regular class operates. FLM entails engaging students to prepare subject material before class time and then applying what they have learned through problem solving or projects at school (Yarbro et al., 2014). FLM provide a more flexible learning environment and may adapt to the school context. For instance, Zainuddin & Halili (2016) stated that flipped learning can integrate both face-to-face and distance learning. Indeed, FLM is an innovative educational strategy which revolutionize the regular roles of teachers and students by delivering the lesson contents in prior to class time (Shimamoto, 2012). This enables students to engage with new material at home, and then apply their knowledge during class activities. Parallel to that, Mason, Shuman and Cook (2013) claim that FLM is an opportunity for students to raise their motivation and cooperate in a problem-solving community. Similarly, recommended by Jamaludin and Osman (2014) to increase students' learning ownership of the content and outcomes.

Indeed, FLM has been proposed as a remedy for students' weakness in problem solving skills, which is an essential part in physics that empower students dealing with diverse and novel challenges (Reif & Heller, 1982). That skill particularly is the foundation of critical thinking and innovation (Kay & Honey, 2006). In that sense, five-step strategy has been developed to assist students in solving physics problems. First, visualize the problem, second, describe the problem in scientific terms, third, plan a solution (involve equations with known and unknown), fourth is initiate with the solution, and finally evaluate the solution. This problem-solving framework has been taught to students in prior of the study intervention. Briefly, this study is meant to address lower and higher order thinking skills (Bates & Galloway, 2012) through problem solving when FLM is applied.

Significance of the Study

This action research serves as an investigation on the effect of flipped learning in a single physics classroom. Equally important, this study serves in growing the body of literature in the school where the intervention occurred in order to deeply understand students' problem-solving skill development. Moreover, the small-scale action research can be scaled to wider context paving the way for other schools to extend the model. Indeed, a broader adoption of this model could influence teaching methods and curriculum design. The single research question of this study is formulated as, can flipped learning be an effective tool to enhance students' problem-solving skills in physics?

2. Literature Review

The FLM is defined as a pedagogical approach in which regular teacher instruction moves from classroom to individual learning space, whereas the group space is transformed to a more dynamic environment. It has been described as a way that assists in students' personalized learning (Bergmann & Sams, 2012) and frees up time for other engaging activities (Ernst, 2016). As a matter of fact, the FLM evolves teacher role from a source of knowledge to acting as facilitator. Additionally, Ahmed (2016) stated that flipped learning allows students to attain higher order thinking. This argument has been supported by Lankford (2013) who clarifies that student secure reaching the lower thinking level (remembering, understanding) at home while focusing on higher levels of thinking (applying, analyzing, evaluation) in class. Practically, this concept of engaging students with course materials outside class and leaving class time for dynamic interaction has gained momentum in the last decade. Equally important the FLM assists students in learning scaffolding (Van der Stuyf, 2002) by first gaining exposure to lesson content at home through a video or a reading and then by gradually increasing in complexity in class. However, a transition towards a flipped learning model is not straightforward but requires a change in student-teacher interaction (Shimamoto, 2012), adding to the lack of technical resources like access to the internet or electronic devices at home (Davies et al., 2013). That is why, Arnold-Garza (2014) claimed a flipped classroom requires a careful design by teachers on the first place to allocate tasks to students and efficiently manage time for maximum efficiency. Despite challenges, the FLM remains flexible to the class environment and is able to provide a personalized learning experience (Bormann, 2014). This has been supported when a positive impact has been reported by Leo and Puzio (2016) who examined the flipped model in high school biology class, and by Schultz et al. (2014) who investigated the model in a chemistry class with similar positive results. Generally, students' opinion of the FLM is rather positive than negative (Prasetyo et al., 2018)

3. Methodology

Roots of the flipped learning classroom are generated from the constructivism theory (Jantakoon & Piriyasurawong, 2018) where students are given support until perform tasks independently. This is witnessed when FLM gives students autonomy over their learning rather than passively receiving information. FLM facilitates this by allowing learners to access content at their own pace. In this action research, the problem identification stage was initiated by interviewing physics teacher and school principal who both insisted on lack of problem-solving skills in physics with grade 11 students, which is the main reason of their poor engagement as they claim in the interview. A number of open-ended questions used to dig deeper into the situation. Based on that conversation and researcher class observation, it was decided to apply the FLM as a remedy, then the learning tools students are required to prepare in prior to class time such as videos and physics simulations. Similarly, in order to increase the validity and accuracy of the tests that included both multiple choice questions and long-answer questions the pretest and posttest have been designed and developed in collaboration between the grade 11 physics teacher with another physics teacher from the same school and the science coordinator as well. Together, they verified that questions were accurate and free of bias (Appendix A). The classification of questions is based on taxonomy of Anderson & krathwohl (2001). **Table 1** clarifies the time management distribution and activities of flipped classroom model applied in this study to regular classrooms. Prior to class, the teacher assigns a 15-minute video that explains the basic components of the chapter. Students are required to watch the video at home and take notes. In the warm-up activity students review the chapter's key terms and complete few questions online using mentimeter.com In the Q&A discussion, the teacher opens the floor for questions about the video and address students' misconceptions. Next, in the guided group-work students are divided into small groups to create mind map or provide a detailed solution to a book question following the steps of problem-solving framework. Approaching the end of the session, teacher clarifies the remaining uncertainties. It is another opportunity for students to discuss mind maps or problem solution. This scenario has been repeated for two weeks.

Table 1. Comparison of class time in flipped classroom vs regular classroom.

Flipped classroom		Regular classroom	
Activity	Time	Activity	Time
Warm-up activity	8 minutes	Warm-up activity	5 minutes
Review previous material: Video discussion (Q&A)	10 minutes	Teacher reviews previous material	5 minutes
Guided group work	20 minutes	Teacher lecture new content	35 minutes
Q&A discussion	7 minutes		

4. Results

Students' answers have been collected and scored based on a mark scheme developed by the two physics teacher, science coordinator and the study researcher. A descriptive statistic for the problem-solving pretest and posttest scores has been conducted. Based on Table 2, it is noted that posttest mean scores were higher for all levels. While the standard deviation (SD) for the posttest is smaller indicating a more cluster around the mean of the posttest.

Table 2. Analysis of student scores based on Anderson & Krathwohl taxonomy.

Level*	Max. score	Test	Mean	Median	Mode	SD	Minimum	Maximum
1 (Remembering)	10 pts	pre	7.29	7.50	7.50	0.72	5.00	7.50
		post	7.33	8.00	8.00	0.98	6.00	8.00
2 (Understanding)	10 pts	pre	6.46	7.50	7.50	1.67	2.50	7.50
		post	6.67	7.50	7.50	1.23	5.00	7.50
3 (Applying)	10 pts	pre	5.00	7.50	7.50	3.69	0.00	7.50
		post	6.33	8.00	8.00	3.06	0.00	8.00
4 (Analyzing)	10 pts	pre	5.59	6.88	7.50	2.71	0.83	8.75
		post	6.66	8.33	8.33	3.26	0.00	8.33
5 (Evaluating)	10 pts	pre	1.81	0.00	0.00	2.41	0.00	5.00
		post	6.83	9.00	9.00	3.43	0.00	9.00
6 (Creating)	10 pts	pre	2.57	0.00	0.00	4.09	0.00	9.17
		post	5.08	8.00	9.00	4.52	0.00	9.00
Total	60 pts	pre	28.72	28.75	14.17	10.95	14.17	45.42
		post	38.91	38.83	35.50	8.71	15.50	47.83

This table presents a descriptive statistic for each cognitive level assessed before and after the FLM intervention. Each level is scored out of 10 points.

This table shows the overall and particular improvement in mean score for each cognitive level. This improvement is notable most in Evaluating & Creating, while the lower standard deviation indicates a consistent improvement among students. This data demonstrates that the FLM had a positive impact on enhancing cognitive levels especially the higher orders. Consistently, Figure 1 shows the comparison between pretest and posttest that reveals an improvement in all scores at all levels.

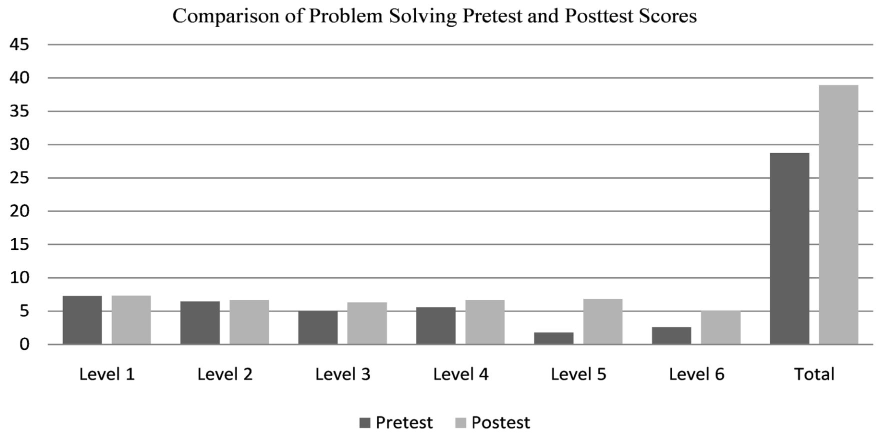

Figure 1. Graphical comparison between problem solving pretest and posttest mean scores.

The bar graph in Figure 1 illustrates the comparison between pretest and posttest scores across the six cognitive levels of problem solving. It could be found that all levels show an increase from pretest to posttest. However, this improvement varies from modest improvement (levels 1, 2, 3 and 4) to important improvement (levels 5, 6, and total). Meanwhile all levels show and upgrade in scores in the posttest, however, we are not sure whether this change is significant, reason why Wilcoxon rank test is selected. The justification behind this nonparametric test is the small sample size of students where the FLM is applied. This statistical test shown in Table 3 assesses significance between the pretest & posttest scores.

Table 3. The Wilcoxon rank sum test was used to check significant change in scores between the pretest and posttest at each level.

Levels	Sig*
Level 1	0.936
Level 2	0.763
Level 3	0.028
Level 4	0.264
Level 5	0.005
Level 6	0.573
Total	0.003

* Level of significance is set at $\alpha < 0.05$.

For levels 1 and 2, we can suggest that there is no significant difference in scores from pretest and posttest as *p*-value is much greater than 0.05. This is also applied to levels 4 and 6 suggesting that the difference is due to random variation. This lack of significance at levels 1, 2, 4, and 6 suggests no changes or the intervention did not show a notable impact. Meanwhile levels 3, 5 and total show a significant difference as *p*-value is less than 0.05. While this test shows a significant difference in few cognitive skills, it generally shows a positive effect on students' problem solving as a whole.

5. Conclusion

This study's findings seem to be aligned with the FLM literature, where a positive impact on all cognitive levels, but significant to only two levels (applying and evaluating). However, problem solving in physics is complex and requires expertise. Even after graduation, many students fail to understand basic concepts of physics problem solving skills (Henderson et al., 2002). Reason why changing the mode of instruction in this study is suggested, even though this process was not straightforward. Some students face challenges when FLM is applied as discussed by (Jenkins et al., 2017). One of these challenges is students building the habit of studying by themselves at home (Talbert & Bergmann, 2017). Similarly, instructors encounter problems applying the FLM because it is time consuming and requires a high level of expertise in preparing and designing the appropriate content to motivate students. As this action research involves relatively a small number of students, results should be interpreted with caution. Results could not be generalized as it is action research applied to a very narrow context.

6. Discussion & Recommendations

Despite the promising findings of this action research on students' engagement and outcomes, we cannot build on this action research findings particularly because of the small size population and the short-term intervention. For future studies, suggesting a similar study with a larger and more diverse population is necessary to validate the findings. In parallel, to further enhance students' engagement in self-learning, incorporating gamification could be an effective strategy. Assigning point-based system could mitigate students' motivation challenges. Additionally, artificial intelligence (AI) in education offers unprecedented opportunities to personalize learning that may assist teachers in differentiating and selecting the right learning materials for students. AI as a modern tech advancement has the potential to elevate the FLM experience to the next level where teachers could create a more dynamic learning environment (Azzam & Charles, 2024).

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

Ahmed, H. O. K. (2016). Flipped Learning as a New Educational Paradigm: An Analytical

Critical Study. *European Scientific Journal, 12,* 417-444.
https://doi.org/10.19044/esj.2016.v12n10p417

Anderson, L. W., & Krathwohl, D. R. (2001). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives: Complete Edition*. Addison Wesley Longman, Inc.

Arnold-Garza, S. (2014). The Flipped Classroom: Assessing an Innovative Teaching Model for Effective and Engaging Library Instruction. *College & Research Libraries News, 75,* 10-13. https://doi.org/10.5860/crln.75.1.9051

Azzam, A., & Charles, T. (2024). A Review of Artificial Intelligence in K-12 Education. *Open Journal of Applied Sciences, 14,* 2088-2100.
https://doi.org/10.4236/ojapps.2024.148137

Bates, S., & Galloway, R. (2012). The Inverted Classroom in a Large Enrolment Introductory Physics Course: A Case Study. In *Proceedings of the HEA STEM Learning and Teaching Conference* (Vol. 1).

Bergmann, J., & Sams, A. (2012). *Flip Your Classroom: Reach Every Student in Every Class Every Day.* International Society for Technology in Education.

Bormann, J. (2014). *Affordances of Flipped Learning and Its Effects on Student Engagement and Achievement.*

Davies, R. S., Dean, D. L., & Ball, N. (2013). Flipping the Classroom and Instructional Technology Integration in a College-Level Information Systems Spreadsheet Course. *Educational Technology Research and Development, 61,* 563-580.
https://doi.org/10.1007/s11423-013-9305-6

Ernst, D. C. (2016). *An Inquiry-Based Approach to Abstract Algebra.*

Henderson, C., Heller, K., Heller, P., Kuo, V. H., & Yerushalmi, E. (2002). Students Learning Problem Solving in Introductory Physics—Forming an Initial Hypothesis of Instructors' Beliefs. In *Physics Education Research Conference 2002.*
https://doi.org/10.1119/perc.2002.pr.005

Jamaludin, R., & Osman, S. Z. M. (2014). The Use of a Flipped Classroom to Enhance Engagement and Promote Active Learning. *Journal of Education and Practice, 5,* 124-131.

Jantakoon, T., & Piriyasurawong, P. (2018). Flipped Classroom Instructional Model with Mobile Learning Based on Constructivist Learning Theory to Enhance Critical Thinking (FCMOC Model). *Journal of Theoretical and Applied Information Technology, 96,* 5607-5614.

Jenkins, M., Bokosmaty, R., Brown, M., Browne, C., Gao, Q., Hanson, J., & Kupatadze, K. (2017). Enhancing the Design and Analysis of Flipped Learning Strategies. *Teaching and Learning Inquiry, 5,* 65-77. https://doi.org/10.20343/teachlearninqu.5.1.7

Kay, K., & Honey, M. (2006). Establishing the R&D Agenda for Twenty-First Century Learning. *New Directions for Youth Development, 2006,* 63-80.
https://doi.org/10.1002/yd.168

Lankford, L. (2013). *Isn't the Flipped Classroom Just Blended Learning.* Training Pros: Leighanne's Learning Notes.
http://ileighanne.wordpress.com/2013/01/24/isnt-the-flipped-classroom-just-blended-learning

Leo, J., & Puzio, K. (2016). Flipped Instruction in a High School Science Classroom. *Journal of Science Education and Technology, 25,* 775-781.
https://doi.org/10.1007/s10956-016-9634-4

Mason, G. S., Shuman, T. R., & Cook, K. E. (2013). Comparing the Effectiveness of an Inverted Classroom to a Traditional Classroom in an Upper-Division Engineering Course.

IEEE Transactions on Education, 56, 430-435. https://doi.org/10.1109/TE.2013.2249066

Prasetyo, B. D., Suprapto, N., & Pudyastomo, R. N. (2018). The Effectiveness of Flipped Classroom Learning Model in Secondary Physics Classroom Setting. *Journal of Physics: Conference Series, 997,* Article ID: 012037. https://doi.org/10.1088/1742-6596/997/1/012037

Reif, F., & Heller, J. I. (1982). Knowledge Structure and Problem Solving in Physics. *Educational Psychologist, 17,* 102-127. https://doi.org/10.1080/00461528209529248

Schultz, D., Duffield, S., Rasmussen, S. C., & Wageman, J. (2014). Effects of the Flipped Classroom Model on Student Performance for Advanced Placement High School Chemistry Students. *Journal of Chemical Education, 91,* 1334-1339. https://doi.org/10.1021/ed400868x

Shimamoto, D. (2012). Implementing a Flipped Classroom: An Instructional Module. In *TCC Conference*.

Talbert, R., & Bergmann, J. (2017). *Flipped Learning: A Guide for Higher Education Faculty*. Routledge.

Van Der Stuyf, R. R. (2002). Scaffolding as a Teaching Strategy. *Adolescent Learning and Development, 52,* 5-18.

Yarbro, J., McKnight, P., Arfstrom, K. M., Director, P. D. E., & Network, F. L. (2014). *Flipped Learning*.

Zainuddin, Z., & Halili, S. H. (2016). Flipped Classroom Research and Trends from Different Fields of Study. *International Review of Research in Open and Distributed Learning, 17,* 313-340. https://doi.org/10.19173/irrodl.v17i3.2274

Appendix A. (Problem Solving Pretest & Posttest)

I. Pretest - Chapter "Moment of Inertia"

Nom: Date:

Question 1) Rappel des connaissances

Vrai (V) ou faux (F)

a) Dans un mouvement de translation, les vitesses de tous les points d'un solide sont les même à chaque instant.

b) Le moment d'une force non nulle peut être nul.

c) Le moment d'une force $\vec{F}$ par rapport à un axe (Δ) est indépendant de la distance qui sépare (Δ) de la ligne d'action de $\vec{F}$.

d) Quand le moment résultant par rapport à l'axe de rotation des forces extérieures appliquées à un solide est nul, ce solide est nécessairement en équilibre.

Question 2) QCM Choisir la bonne réponse

a) La valeur algébrique du moment d'une force par rapport à un axe est:

1) toujours positive

2) toujours négative

3) positive ou négative.

b) Un solide S est soumis à un couple de forces. On double la valeur de chacune des deux composantes du couple de l'axe de rotation. La valeur du moment du couple:

1) ne change pas

2) est multipliée par 4

3) est multipliée par 2

c) Un solide S tourne à vitesse constante autour d'un axe fixe (Δ). Si M est le moment résultant des forces extérieures par rapport à l'axe de rotation, alors:

1) M = 0

2) M ≤ 0

3) M ≥ 0

d) Un solide S peut tourner autour d'un axe fixe (Δ). A partir du repos on soumet S à un ensemble de forces dont le moment M par rapport à (Δ) est −2 mN. Le mouvement de rotation de S est alors:

1) uniformément retardé

2) uniformément accéléré

3) uniforme

Question 3) Appliquez vos connaissances

Utilise la formule du moment du couple pour calculer le moment du couple exercé par

deux doigts sur un robinet tournant sachant que la force exercée par un doigt sur le robinet a une intensité de 0.20 N, et que la distance entre les deux extrêmes est 5 cm.

Question 4) Analyse des données

Freinage d'un disque.

Un disque homogène, de masse M = 1 kg, de diamètre AB = 40 cm, tourne sans frottement à raison de 5 rad/s autour d'un axe horizontal (Δ) perpendiculaire au disque en son centre. On applique tangentiellement au disque à l'instant $t_0 = 0$ un couple de freinage de moment **M.** Le disque s'arrête à la date t_1 après avoir accompli 10 tours.

a) Faire le bilan des forces extérieures appliquées au disque.

b) Calculer l'accélération angulaire du disque.

c) Déterminer **M.**

d) Déterminer t_1.

Question 5) Evaluation et assemblement des données

Bras d'une force.

Une tige rigide AB de masse négligeable, a pour longueur AB = L = 1.2 m. Elle peut tourner sans frottement autour d'un axe horizontal (Δ) perpendiculaire à la tige et passant par son milieu O.

On lui applique au point A une force verticale F_1, dirigée vers las bas et d'intensité $F_1 = 10$ N.

Pour maintenir l'équilibre de la tige on lui applique au point C situe à la distance "d" de O une force verticale descendante F_2.

a) Faire le bilan des forces extérieures appliquées à la tige AB.

b) Exprimer F_2 en fonction de "d".

c) Compléter le tableau:

d (m)	0.10	0.15	0.20	0.25	0.30	0.40	0.60
F_2 (N)							

d) Tracer le graphe $F_2 = f(d)$

Echelle en abscisses: 1 cm ↔ 0.10 m.

Echelle en ordonnées: 1 cm ↔ 10 N.

II. Posttest - Chapter "Champ Electrique"

Nom: Date:

Question 1) Rappel des connaissances

Vrai (V) ou faux (F)

a) On peut isoler un pôle d'aimant

b) deux pôles de même nom peuvent s'attirer.

c) Une aiguille aimantée s'oriente dans un champ magnétique.

d) Une ligne de champ est toujours perpendiculaire au champ.

e) Le champ magnétique s'exprime en V/m.

Question 2) choisir la bonne réponse

Question à choix multiple

a) Dans un champ magnétique uniforme, les lignes de champs sont:

1) des droites perpendiculaires,

2) des droites parallèles,

3) des cercles.

b) La valeur du champ magnétique est de l'ordre de:

1) 1 T,

2) 10^5 T,

3) 10^{-5} T.

c) La valeur du champ magnétique est mesure avec un:

1) voltmètre,

2) ampèremètre,

3) tesla mètre.

d) Au centre d'une bobine plate, de Rayon R comportant N spires, la valeur du champ magnétique crée par un courant d'intensité I vaut:

1) B = 2 II·10^{-7}·$N \cdot I \cdot R$,

2) B = 2 II·10^{-7}·$\frac{N \cdot I}{R}$,

3) B = 2 II·10^{-7}·$\frac{N \cdot I}{R}$,

Question 3) Appliquez vos connaissances

En un lieu donne, le champ magnétique terrestre a pour valeur $B_T = 40$ µT et sa composante horizontale a pour valeur $B_H = 20$ µT.

a) Calculer l'inclinaison magnétique du lieu.

b) Calculer la valeur de la composante verticale du champ magnétique terrestre en ce lieu.

Question 4) Analyse des données

Un fil rectiligne long est traversé par un courant de 100 mA. Calculer la valeur du champ magnétique crée à 10 cm du fil.

En écartant de 10 cm de plus, comparé B_1 et B_2.

Question 5) Evaluation et assemblement des données

Une bobine circulaire pate est formée de 20 spires de rayon 50 cm chacune. Elle est parcourue par un courant d'intensité 50 Ma. Calculer la valeur du champ magnétique crée en son centre.

Sans faire de calcule, estimer la valeur de ce champ pour N = 200 spires de rayon 5 cm.

Question 6) Solénoïde théorique

Un solénoïde théorique, de longueur L = 50 cm, comporte 100 spires. Ils est traverse par un courant d'intensité I = 1 A. Déterminer la valeur du champ magnétique à l'intérieure du solénoïde.

Imaginer une distance de 10 cm séparant les centres de ces 2 solénoïdes identique, qu'elle doit être la valeur du champ magnétique à mi-distance de ces 2 solénoïdes.