Journal of Education, Society and Behavioural Science

Volume 37, Issue 6, Page 132-142, 2024; Article no.JESBS.121365
ISSN: 2456-981X
(Past name: British Journal of Education, Society & Behavioural Science,
Past ISSN: 2278-0998)

Investigating the Impacts of Flipped Classroom Approach on Class Nine Students Learning of Thermal Energy

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jesbs/2024/v37i61334

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/121365

Original Research Article

Received: 16/07/2024
Accepted: 19/08/2024
Published: 21/09/2024

ABSTRACT

The flipped classroom is an emerging pedagogical model characterized by shifting teacher-oriented to student-oriented learning. This study aimed to investigate the impacts of flipped classroom approach on academic success of class nine students learning thermal energy in one of the Middle Secondary Schools in Bhutan. A quantitative method that is true-experimental design, specifically, pretest-posttest control group design and survey design were employed in this study. The data were collected from the physics learning achievement test and survey questionnaire. A total of 50 students participated in the true-experiment with 25 each in the control group and experimental group. The experimental group participated in a survey questionnaire to find their opinions on the impact of flipped classroom approach on learning thermal energy. The Statistical Package for Social Sciences version 22 was used to analyze the quantitative data. The results of the study indicated a

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Cite as: *Zangpo, Tashi, Ugyen Pem, and Tandin Penjor. 2024. "Investigating the Impacts of Flipped Classroom Approach on Class Nine Students Learning of Thermal Energy". Journal of Education, Society and Behavioural Science 37 (6):132-42. https://doi.org/10.9734/jesbs/2024/v37i61334.*

statistically significant difference (t (48) = 2.53, p = .05) in physics learning achievement test between control and experimental groups with a medium effect size (d = 0.68), signifying implementation of flipped classroom has positive effect on learning thermal energy. Moreover, flipped classroom approach brought positive impacts toward students' learning such as accessibility with supports from teacher and friends, motivation to learn at their own space and time, active engagement in the class, and achieve higher order thinking skills. There is a strong positive correlation (r =0.828) between flipped classroom approach and higher order thinking skills. This study was limited to short duration and small sample size. Further studies are recommended for longer duration of observation with more coverage of physics topics and more sampled schools spread across the country.

Keywords: Flipped classroom; control group; experimental group; achievement; active learning; higher order thinking skills; motivation.

1. INTRODUCTION

Quality-teaching arises from classroom practices and child centeredness. This indicates that today's classroom environment should be student-centered where students take an active role in learning and exploring deeper. The seven standards of Bhutan Professional Standards for Teachers are elaborated with 37 focus areas by incorporating content and pedagogical knowledge. Teachers are able to use appropriate pedagogy based on the content knowledge and evolving ideas of the subject [1]. Moreover, the National School Curriculum, Instructional Guide for class IX and X physics emphasizes transforming textbook-based knowledge to competency-based learning and experiential learning [2]. Further, it adopts the flipped classroom methods of learning where teachers act as guide and facilitator in the classroom. Therefore, the flipped classroom approach as a new pedagogy becomes an important aspect of the teaching-learning process to enhance students' learning. Jonathan Bergmann and Aaron Sams, high school chemistry teachers of Colorado develop a video lesson thereby flipped classroom approach (FCA) was introduced in 2007 [3].

Despite the FCA being an exciting new topic in educational research, there is a lack of agreement on what exactly is flipped learning, and there is also limited scholarly research on its effectiveness [4]. However, [5] stated that learning is not limited to the classroom where students can learn at their own pace based on individual needs, thus switching to flipped classroom instruction [4] define flipped classroom as an educational practice in two different ways such as interactive learning activities that happen inside the classroom and direct computer-based individual instruction outside the classroom. FCA allows students to learn and engage in interactive activities [6]. Furthermore, researchers highlighted that FCA utilises technology to introduce learning materials to students outside the classroom [7]. As a result, it leads students to fully engage in watching the videos and reading the learning materials on thermal energy. The independent learning at home makes students become more active in the classroom enabling them to think deeper on thermal energy and moreover, students get equal opportunities to participate in the learning process. According to Islam and Slam [8] FCA makes students to become more active and teachers as facilitator instead of active role in lecturing. Flipped Classroom has a positive effect on the engagement and learning experience of the students and enables an active teaching-learning process [9,10], allowing students to experience a friendly and collaborative learning environment [11]. Teachers assist students and enable them to participate actively in the learning process. In Bhutan, the study revealed that teaching is a chalk and talk for more teachers with emphasis on teacher-centered classrooms and students are deeply root towards the traditional approach teaching (24). Further the students get limited time to think, comprehend, and demonstrate their learning in the classroom with use of a teacher-centered approach. This also leads to poor performance of learning where students are dominated by teachers in the classroom. So far, there have been many studies conducted on a flipped classroom globally but very limited research was carried out in Bhutan. Further, there remains lack of evidence on the impacts of FCA in teaching and learning specifically on physics discipline in a Bhutanese classroom. Hence, to fill this gap, the study aims to examine the impacts of FCA on students learning of thermal energy in class nine physics.

1.1 Aim and Objectives

The main aim of this study was to investigate the impacts of a flipped classroom approach on class nine students' learning of thermal energy. The objectives of this study are:

- To compare physics learning achievement of experimental group and control group.
- To find out students' opinions on the impacts of a flipped classroom approach on their learning in thermal energy.
- To draw the correlation between flipped classroom approach and higher order thinking skills.

1.2 Research Questions

What are the impacts of a flipped classroom approach on learning thermal energy by class nine students?

1.3 Research Sub-Questions

1. Is there a significant difference in learning achievement of students in experimental group and control group?
2. What are students' opinions on the impacts of flipped classroom approach on their learning in thermal energy?
3. What is the correlation between flipped classroom approach and higher order thinking skills?

2. LITERATURE REVIEW

Flipped classroom is a new methodology that addresses the needs of different students in the classroom [12]. In the flipped classroom, students watch the video lesson before attending the course, besides studying outside the class, and have hands-on activities in class [13]. The class becomes the place to work through problems, advanced concepts and engage in collaborative learning. According to Hamdan, flipped classroom is defined as learning outside the class, in which students can access learning materials from anywhere, anytime, create the learner-centered activities of the lesson and provide individual support in the classroom [14]. In addition, the flipped classroom is referred to as a student-centered approach to learning, in which the learner is more active than the teacher in class learning [13]. A flipped classroom is an innovative learning instruction currently practiced by educators around the world. It is generally agreed that the flipped classroom creates an immersive learning culture that helps create collaborative learning among the students themselves, involving the teacher as facilitator and allowing students to use the prior knowledge they had from the video instructor prior to class, participate well and foster communication skills.

The flipped learning has changed the culture of students' learning from teacher-centered to learner-centered, with emphasis on students' activities. Vimala (2012) claims that flipped classroom is a 21st century learning style that is learner-centered approach which focuses on use of technology in the learning process [15]. However, teachers are not replaced by flipped learning, rather professional teachers are more important in flipped classrooms to guide and expand learning experience [16]. Such a classroom really expects a professional teacher to guide, provide insights, and facilitate learning for student's discovery. In addition, Chen et al (2014) claim that student-centered culture provides exploring topics in greater depth and creating richer learning opportunities [16]. The flipped learning approach allows us to use class time in progressive ways leading to learning by doing. This offers efficient methods of instruction for teachers and provides opportunity for students to experience hands-on learning with the given materials. Hence, self-learning promotes self-exploration and experiential learning.

Flipped classroom approach promotes active learning and enhances students' engagement. Active learning is defined as teaching and learning strategies that actively involve students in the learning process [12]

The flipped Classroom was also found to help students transfer their knowledge between contexts, thereby strengthening their conceptual understanding of thermal energy. Ankora concluded from the findings that the benefits of using the flipped classroom as it enhanced the students' interest and enriched their learning experience [17].

However, they also reported that engagement to learning will not be effective if students do not take responsibility in flipped learning. Islam et al (2018) mentioned that teachers use the lessons to involve students in activities such as small group discussions, problem solving, peer grading, and experiential learning activities [8]. This indicates the activity-oriented nature of flipped classrooms are progressive activities that engage students learning meaningfully. The

study conducted in the Netherland on flipped classrooms showed that 75.5% of them were motivated to learn with flipped lessons [18].

A review of studies from different countries found that flipped classrooms bring significant learning outcomes. However, [19] argued that there is no significant difference in students' learning outcomes but it has significant difference on student satisfaction, knowledge, skill and attitude. Moreover, the study indicated that students' interactions and engagement in flipped learning had no correlation on the levels of achievement.

3. METHODOLOGY

This study employed a quantitative research method. The research design in this study was True-experimental design, especially a pretest-posttest control group design. The pretest and posttest consist of 15 items in physics learning achievement test on thermal energy. The pretest was administered prior to the teaching-learning process to determine the learning outcomes of the students for two groups. The two groups of total 50 were assigned randomly, the one group as experimental group and another group as control group. The experimental group (EG) was treated using intervention so called flipped classroom approach whilst the control group (CG) was taught using the lecture method. After three weeks of implementation of flipped classroom approach and lecture method, the posttest was conducted for both the groups. Moreover, a survey design was adopted in this study to find the impacts of flipped classroom approach in learning thermal energy. The survey questionnaires included 5-point Likert scale of 30 items measuring the students' opinion on accessibility, motivation, self-learning, higher order thinking skills, learning experiences and challenges on learning thermal energy on using FCA. The items on the questionnaire were scored as follows: Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). The 5-Point Likert Scale interpretation and distribution of values was adapted from Pimentel [20]. The interpretation of 5-Point Likert Scale description is as reflected in Table 4.

The study was conducted in one of the Middle Secondary Schools under Chhukha district. The convenience probability sampling was used to select the school because of the researcher's convenience and its geographical location. The purposive sampling technique was used for survey questionnaires. As they are treated with intervention, they are purposely selected to be participants.

4. RESULTS

This section presents the key findings of the study on "Investigating the impacts of a flipped classroom approach (FCA) on class nine students learning of thermal energy in Physics**".**

4.1 Comparison of Pre-Posttest for EG and CG

The physics learning achievement test (PLAT) scores were analyzed using paired *t*-tests to determine if the increase in students' scores is significant or not. Table 1 clearly showed the mean difference between pretest and posttest for the EG was 7.08. This indicates that the mean scores of posttest have increased by 7.08 after the implementation of FCA. It is revealed that the intervention is significant based on the *t*-value of 10.68 and which *p*-value is less than 0.05. Likewise, Table 2 indicated the increase in mean difference for CG was 4.32. There is also a significant difference between pretest and posttest scores of the control group as p-value is less than .05. This indicates that both the groups have statistically significant differences between pretest and posttest scores. Upon comparing the mean difference between the pretest and posttest scores of EG and CG, the learning achievement of the EG was far better than the CG Further, an independent sample t-test was conducted to compare the mean posttest scores of the EG and the CG. It is found that there is a significant difference between mean scores of two groups (t (48) = 2.53, $p < .05$) with medium effect size (d=.68) as indicated in Table 3. Thus, there is a significant difference between the EG and CG in the learning achievement of thermal energy.

Table 1. Comparison of pretest and posttest for EG group

	Mean	SD	Mean Difference	t	df	Sig. (2-tailed)
Pretest	8.60	2.74				.000
Posttest	15.68	3.49	7.08	10.677	24	

p<.01

Source: Field data

Table 2. Comparison of pretest and posttest for CG group

	Mean	SD	Mean Difference	t	df	Sig. (2-tailed)
Pretest	9.32	2.27				.000
Posttest	13.64	2.02	4.32	10.51	24	

p<.01

Source: Field data

Table 3. Comparison of posttest score for CG and EG

	Levene's Test for Equality of Variances		t-test for Equality of Means					
	Sig.		Mean	SD	Mean Difference	t	df	Sig. (2-tailed)
Posttest	CG	.035	13.64	2.02	2.04	2.53	48	.02
	EG	Cohen's d =.68	15.68	3.49				

*Note. N=50, *Significant level at p<.05*

Table 4. Qualitative Interpretation of 5-Point Likert Scale Measurements

Likert-Scale Description	Likert-Scale	Likert Scale Range	Level of Interpretation
Strongly Disagree	1	1.00-1.80	Very Low
Disagree	2	1.81-2.60	Low
Neutral	3	2.61-3.40	Moderate
Agree	4	3.41-4.20	High
Strongly Agree	5	4.21-5.00	Very High

Note. Adapted from Pimentel [20]

Table 5a. Students' opinion toward Flipped classroom approach in learning thermal energy

Theme	Mean	SD	Level of Interpretation
Accessibility	4.22	.46	Very High
Motivation	4.09	.59	High
Self-learning	4.23	.55	Very High
Higher Order Thinking Skills	3.97	.43	High
Learning Experience	3.91	.66	High
Average Mean	**4.08**	**.54**	**Very High**

Source: Field data

Table 5b. Students' opinion toward challenges of flipped classroom approach

Theme	Mean	SD	Level of Interpretation
Challenges of Flipped Classroom	1.93	.68	Low

Source: Field data

Table 6. Spearman's rho Correlation Coefficient for FCA and HOTs

			FCA	HOTs
FCA	Correlation Coefficient		1	.828**
	Sig. (2-tailed)			.000
	N		25	25
	Bootstrap[b]	Bias	.000	-0.025
	Std Error		.000	0.068

*** Correlation is significant at the 0.01 level (2-tailed)*
Note. Bootstrap results are based on 50 bootstrap samples

4.2 Impacts of FCA on Learning Thermal Energy

The overall average mean and standard deviation for students' opinions on the impacts of the flipped classroom approach are 4.08 and 0.54 respectively which falls in the "high" category as illustrated in Table 5a, suggesting that flipped classroom approach helps in learning thermal energy. The FCA creates opportunities for students to get accessibility to support (*M*=4.22;*SD*=.46) rated very high, motivate to learn (*M*=4.09;*SD*=.59) rated high, self-learning with the learning materials curated by their teacher (*M*=4.23;*SD*=.55) rated very high, improve their higher order thinking skills (*M*=3.97;*SD*=.43) rated high, reflect on their learning experiences (*M*=3.91;*SD*=.66) rated high and reflect on their challenges (*M*=1.93;*SD*=.68) rated low as shown in Table 5b.

The participants rated 'very high' category in accessibility and self-learning indicating learning resources are accessible, teachers and friends too are available for support and discussion, students learn on their own pace. . In addition, the participants have rated "low" in the challenges faced by them during the flipped lessons indicating that there were no major challenges using flipped classroom approach. Thus, the implementation of FCA has had positive impact and benefited the students' learning of thermal energy.

4.3 Relationship between FCA and HOTs of EG students

For this purpose, a Spearman's correlation was performed to determine the relation between students' HOTs and FCA as depicted in Table 6. There was a significant correlation between these two variables, where r_s = 0.828, p = .000. The high positive correlation coefficient indicates that the FCA impacts students' HOTs. Thus, FCA enhances students' HOTs.

5. DISCUSSION

The data confirmed that there was a significant difference in learning performance between the two groups (p = 0.02). Experimental group learning thermal energy using the flipped classroom performed better than control group learning using the lecture method. This occurs due to the researcher providing students with interactive video lessons and hands-out on thermal energy before the class session as

students get enough time to learn the concepts anytime at their own pace. Students have enjoyed and engaged the learning at home. It is apparent from the study that FCA helps students to learn thermal energy better. Moreover, the flipped lessons provide an efficient way of teaching and students get immersed in learning materials. It leads students to perform well and learn better. Furthermore, the positive learning outcomes of the students in this study was in line with several studies [1,2,4-7]. The mean score for motivation was 4.09 (*SD*=0.59) indicating that students were motivated to learn thermal energy. The finding was consistent with the findings of Merril [12] where they conducted study on the flipped classroom: supporting a diverse group of students in their learning. Their analysis indicated that 75.5% of students were motivated to learn with flipped lessons. Moreover, present findings were also in congruent with that of study conducted by Du et al. [21] where their study revealed that motivation to learn was one of the advantages of the flipped classroom.

Self-directed learning is rated very high with mean score of 4.23 (*SD*=.55) where students took their own time and place to learn thermal energy. The findings was validated by Ankora [17] that classroom learning was based on student-centered letting them to engage and self-learning. Students experience the change of learning culture from teacher-centered to learner-centered creating students' active learners. The findings were supported by Ovaska and Salmi [22] that the flipped classroom offers active learning and hands-on activities. The quantitative analysis indicated that students preferred FCA than lecture sessions with agreement level of 4.91 and students experienced a positive learning culture due to the student-centric classroom. The flipped classroom as the 21st century allows student-centered learning as reported by Chen et al. [23-26].

6. CONCLUSION

In general, there are positive impacts of flipped classroom approach on learning thermal energy by class nine students. The result of this study showed that EG performs significantly better in the PLAT compared to CG in the posttest. Moreover, an independent sample *t*-test confirmed that there is significance between the EG and CG. Therefore, the findings of this study evidently showed that there was significant improvement in students' academic performance in learning thermal energy.

The second objective of this study was to find out students' opinions on the impacts of a flipped classroom approach on their learning in thermal energy. The FCA enhanced students learning and achievement by incorporating classroom activities focused on student understanding and discussion which promotes HOTs. Students got opportunity to engage actively in class activities by exchanging ideas and solving problems with their friends. It also promotes students' motivation and develops the ability to learn independently at their own pace. Moreover, students get opportunities to interact with learning materials before the classroom sessions. The pre-reading materials helped individual learn thermal energy in the class. Thus, the findings from survey questionnaires showed that there are positive impacts of FCA on learning thermal energy. On other hand, there are some potential challenges that need to be addressed for an effective flipped classroom.

The third objective of this study is to draw a correlation between FCA and HOTs. It was found that there is a strong correlation between FCA and HOTs. Thus, FCA offers an opportunity for teacher to curate learning materials for students, allowing them to interact with the materials before the class. Cass hour is then used for leaning higher levels of content through student participation.

7. RECOMMENDATIONS

The results of this study on investigating the impacts of the flipped classroom on students learning in thermal energy could provide complementary data to inform the physics teachers on FCA and its impacts on students' academic performances and positive learning experiences. In addition, the findings can suggest the colleges of education to provide professional development trainings on using flipped classroom approach. Further, this finding recommended providing schools teachers with adequate modern technology tools, and high speed internet to assist teachers to prepare or curate resources required for the flipped classroom.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) declared that this research is original as NO generative AI technologies have been used.

CONSENT

As per international standards or university standard, participant's written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDICES

Appendix A: Test blueprint for PLAT

Chapter No.	PLAT	Remembering	Understanding	Applying	Analyzing	Evaluating	Creating	Total
1.1	Heat and temperature	PI-MCQ1		PI-MCQ2				2
1.2	Thermal energy		PI-MCQ3, PII-TF 2	PIII-Q2 PIII-Q3	PI-MCQ4,	PII-TF 3	PIII-Q5	6
1.3	Modes of heat transfer	PII-TF 5	PI-MCQ 5		PIII-Q4		PIII-Q1	5
1.4	Specific heat capacity				PII-TF4			1
1.5	Insulation			PII-TF 1				1
Score		2	3	4	3	1	2	15

Note. PI- Part I, PII-Part II and PIII-Part III

Appendix B: Survey Questionnaires

Dear participants

I am conducting a survey with regard to implementation of flipped classroom for the fulfillment of master thesis in Physics. This is basically to investigate the impact of flipped classroom in learning physics concepts. Your response including your identity will be kept confidential. Therefore, your honest response is highly appreciated and valued.

Demographic

Gender: Male ☐ Female ☐

Age: 10-15 ☐ 16-20 ☐ 21 above ☐

Direction: Please tick your response against the statement on **flipped classroom**.
(Note: SD- Strongly Disagree, **D**-Disagree, **N**- Neither, **A**- Agree, **SA**- Strongly Agree**)**

	Impacts of Flipped Classroom Approach						
	I. Accessibility	**SD**	**D**	**N**	**A**	**SA**
1	I can easily get learning materials.					
2	I have gone through the provided study material.					
3	Provided study material was useful					
4	I get the opportunity to communicate with other students.					
5	I get opportunity to communicate with the teacher					
	II. Motivation					
1	I am motivated in a flipped classroom.					
2	I participated more in flipped classroom.					
3	I engaged myself more in flipped classroom					
4	I am happy and satisfied with the flipped classroom					
5	I became more active learner in the flipped classroom					
	III. Self-learning					
1	I get a chance to watch video in my own pace.					
2	I learn the simple concept myself at home.					
3	I explore myself to learn the concept.					
4	I participate in the class discussion when the teacher provides self-learning materials.					
5	I engage in class activities when I am thorough with learning materials.					
	IV. Higher Order Thinking Skills					
1	I learned more and better in the flipped classroom					
2	I devoted myself more to the class activities in the flipped classroom					
3	I learned complex problems in the flipped classroom.					
4	I was made to think more in the flipped classroom.					
5	I have improved high level thinking skills while discussing and interacting in the class.					
	V. Learning Experience					
1	I preferred the flipped classroom than lecture-based classroom					
2	I experienced student-centered in the flipped classroom					
3	I spent more time and effort in the flipped learning activities.					
4	I considered flipped classrooms to be a more effective and efficient way to learn.					
5	I enjoyed the flipped classroom approach in learning.					
	VI. Challenges					
1	Watching video or going through reading materials at home was time consuming					
2	Watching video or going through reading materials gave me too much burden and pressure					
3	The length of the video was too long and boring.					
4	Unable to watch video due to lack of facilities(Internet connectivity, smart phone)					
5	Reading materials and watching videos demotivates me.					

Share your opinions on the impact of the flipped classroom?

Peer-review history:
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