The flipped classroom and college physics students' motivation and understanding of kinematics graphs

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Reversing the traditional classroom activities, in the flipped classroom model students view lectures at home and perform activities during class period inside the classroom. This study investigated the effect of a flipped classroom implementation on college physics students' motivation and understanding of kinematics graphs. A Solomon four-group design employing quantitative and qualitative methods was used to gather data. Four college physics sections participated in this study. Two groups received a researcher-developed, flipped classroom, instructional material over the course of 8 sessions. Test for Understanding Graphs in Kinematics (TUG-K) gain scores (post-test - pretest) were significantly higher for the experimental groups (M=1.87, SD=2.909) compared with the control groups (M=0.54, SD=1.853). However, Physics Motivation Questionnaire II (PMQII) did not show a significant difference. The flipped classroom may enhance students' learning of kinematics graphs by improving their level of understanding, but was shown to have no effect on their motivation.

Introduction

The mission of science education is to prepare individuals develop a certain level of scientific understanding after their formal education in school (Wang & Schmidt, 2001). However, science education has remained relatively unchanged for the last half-century at least, and this has been similar across the developed world (Tytler, 2007). The way science education is delivered seems not to meet the demands of the times. Thornburg (2009) posed five challenges for science education that need to be considered by educators to regain the quality much desired by the society: (a) the shortage of qualified teachers; (b) learning about science as a vibrant human activity; (c) cutting back on hands-on science; (d) science as a process of inquiry and real projects; and (e) connecting science to other subjects. Addressing one or more of these challenges would greatly improve science education and would help in addressing global issues that are fundamentally technical — climate change, energy resources, food production, genetic modification, and so on — that demand basic scientific literacy so that wise decisions can be reached about how to address them (Weiman, 2008a).

Science education is one of the many disciplines that could accelerate learning by utilising available technologies. Teaching and learning have been improving much since technology was introduced in the classrooms (El Hassouny, Kaddari, Elachqar & Alami, 2014; Halverson & Smith, 2009). Students' experiences in utilising the technology can be tapped to further develop their interest in learning. In this information age, the trend in education has been towards utilising technology to support teaching and learning (Fadel, 2010; Molebash, 2000). Educators try to use technology to keep abreast with the changing audience (Purcell, Heaps, Buchanan & Freidrich, 2013), as well as the emergence of educational technologies (Klopfer & Osterweil, 2009; Prensky, 2008), which are useful in the classroom. Interactive technology has helped to enhance student learning in physics (Weiman, Adams & Perkins, 2008).

Physics is a basic science (Young, 2012) with its scope of study encompassing not only the behaviour of objects under the action of given forces, but also the nature of gravitational, electromagnetic and nuclear force fields. It is the science of matter, motion and energy. Its laws are typically expressed in the language of mathematics. Physics, as a science, requires specific skills to be able to grasp concepts and ideas like understanding graphs, which is one of the skills a scientist must have to visualise patterns and see trends (Beichner, 1994).

Graphs of kinematics variables - position, velocity, and acceleration - are essentials in physics and mathematics courses (Hale, 2000). Understanding these concepts builds a strong foundation to succeed, as physical concepts become more abstract and more complicated to model mathematically (Archambault, Burch, Crofton & McClure, 2008). However, studies have revealed the difficulties encountered by students in interpreting kinematics graphs (Hale, 2000; McDermott, Rosenquist, & van Zee, 1987). These studies have to address the difficulties by implementing interventions thought to be effective in overcoming the problem.

Educators are now making ways to personalise learning by using technologies such as video, digital simulations, and computer games. But the traditional teaching model remains, and technologies such as these will have limited effects (Hamdan, McKnight, McKnight & Arfstrom, 2013). Traditional classroom learning comprises a lecture in the classroom and assignments, exercises or activities at home. In the classroom, teacher may use direct instruction, video presentation, computer simulation, and/or actual demonstration. One problem with conventional teaching lies in the presentation of the material (Mazur, 2014). Most of the time it comes straight out of textbooks and/or lecture notes, which gives students little incentive to attend classes. Most of the time, the traditional presentation is nearly always delivered as a monologue in front of a passive audience, the students (Mazur, 2014). Only exceptional lecturers are capable of holding students' attention for an entire lecture period. The traditional way of checking if students were attentive during lecture is by giving homework. When students are given a task to be done at home, more often than not, they will have no one to help them (Maranell, 2014).

Dupe (2013) related academic self-concept and locus of control as factors that influenced students' achievement in physics. Achievement in science courses is often associated with students' interest and motivation. Motivation comes as extrinsic motivation, intrinsic motivation, goal orientation, self-determination, self-efficacy and assessment anxiety (Shepard, 2012; Glynn & Koballa, 2006). In deciding which approach to use, science educators often consider these constructs to when seeking to motivate students to learn science.

Recently, science education has been buzzing about flipped classrooms or flipped learning (Noonoo, 2012; Overmyer, J. 2012). In this model, some lessons are delivered outside the group learning space using video or other modes of delivery. Class time becomes available for students to engage in hands-on learning, collaborate with their peers, and evaluate their progress, whilst teachers can provide one-on-one assistance, guidance and inspiration (Hamdan, McKnight, McKnight & Arfstrom, 2013). Cisco Systems Inc (2012) claimed that the flipped classroom has more advantages than weaknesses. Students' performance improved when the flipped classroom was used, which presents a positive feedback for educators (Berrett, 2012; Fulton, 2012a, 2012b; Strayer, 2012). The flipped classroom has been tested in various disciplines such as in business (Findlay-Thompson & Mombourquette, 2013), multimedia (Enfield, 2013), and physics (Bates & Galloway, 2012). The flipped classroom can be explored for addressing issues in the Philippine education system, especially with the recently introduced K-12 curriculum.

The Philippine education system is a product of several reforms (Durban & Catalan, 2012; Florido, 2006). Much work is needed as the Department of Education (DepEd) implements the K-12 program which affects the higher education curriculum. The Commission on Higher Education (CHED) has laid out the *Revised General Education Curriculum* (CMO 20 s2013) in conjunction with the K-12 Program of the Department of Education. This memorandum outlines the general education outcomes which include higher levels of comprehension (textual, visual, etc.); proficient and effective communication (writing, speaking and use of new technologies); application of computing and information technology to assist and facilitate research; ability to negotiate the world of technology responsibly; and problem solving (including real-world problems) (CHED, 2013, pp. 4-5).

With continuing changes in the basic education curriculum, teachers need to upgrade themselves in order to properly implement these changes (Durban & Catalan, 2012). Some educators innovate and utilise technology to counter the lack of budgets for instructional materials (Ahmad, 2004; Arimbuyutan, Kim, Song & So, 2007). By maximising the use of readily available technologies, the flipped classroom can help remedy students' decreasing interest in science. The flipped classroom model can be used to optimise the benefits derived from technologies. The purpose of this study is to investigate the effects of utilising the flipped classroom as a teaching model on the motivation and understanding of kinematics graphs by college physics students. It was hypothesised that college physics students can develop a better understanding of kinematics graphs and a higher motivation to learn physics with implementation of the flipped classroom model.

The findings of this study will benefit society, considering that physics plays an important role in science and technology today. Physics is an important element in the education of chemists, engineers and computer scientists, as well as practitioners of the other physical and biomedical sciences (IUPAP, 1999). The greater demand for graduates with good physics backgrounds justifies the need for more effective teaching methods. Schools who apply recommended methods derived from this study will be able to train students better.

This study combines understanding and motivation to assess the effectiveness of a new teaching method. Researchers from different fields and topics have contributed their findings (Lee & Osman, 2012; Haron, Shaharoun, Puteh & Harun, 2012), but with conflicting results. Lee & Osman (2012) found out that the module they used only improved understanding and not motivation. The analysis of case studies by Haron et al. (2012) revealed that engineering students' level of motivation in learning engineering statics has a direct relationship with their understanding of the subject. This study can be utilised to further analyse or generalise Lee & Osman's claims. This study can also be extended to other topics as well as other courses, to promote active and self-paced learning.

Research method

Participants and treatments

In this study, two teachers were assigned to four sections of Physics 11 (Teacher A assigned E2, C1 and C2; Teacher B assigned E1). These teachers were part-time teachers with less than 3-years' experience in teaching Physics 11. These teachers were graduates of the University under the Bachelor of Secondary Education major in Physical Sciences Program. The teachers studied about 50 units of specialisation courses in maths and physics during their undergraduate period. The teachers facilitated the class by asking questions using an audience response procedure (referred to here as 'modified clicker') and assessing whether or not the students have acquired the level of understanding to perform the in-class activities. 'Modified clicker' utilised a set of five coloured cards provided for each student, whereby they could raise the coloured card corresponding to their answer for a 'clicker question' presented by the teacher. Teachers were available in the classroom, especially during exercises; they responded to students' inquiries and assisted the students when they encountered difficulties. Teachers also responded to an interview which gathered their feedback using an interview schedule after the implementation of the intervention.

The students who participated in this study were second year college students enrolled in College Physics I, a course regularly offered during the first semester. Students who failed, or those who transferred from other courses or schools, comprise the normal enrolment in College Physics I during the second semester. A total of four sections were opened for the second semester of School Year 2014-2015.

Classes for the control and treatment groups were conducted separately with control having the traditional classroom discussion and the treatment having the flipped classroom. A summary of the differences in the conduct of teaching and learning for the two groups are presented in Table 1.

Instrumentation

This study used established and standardised instruments to measure the constructs of motivation and understanding, and supplemented this data with interviews that constituted the qualitative part of the study. For measuring the level of motivation, the *Physics Motivation Questionnaire II* (PMQ II) has a total of twenty five items constructed on a

Table 1: Differences in the conduct of teaching and learning in the treatment and control groups

Control	Treatment
Students attend class lecture/discussion.	Students watched videos assigned by the teacher.
Teacher utilises class time to cover assigned topic.	Students can play, pause and replay assigned videos as they wish.
Students are given homework activities.	Students do in-class activities with teacher supervision
Students' inquiries on the activity are left for the following meeting or during scheduled consultation period.	Teachers immediately attend to students inquiries during class activities.

four point Likert scale (Glynn, Brickman, Armstrong & Taasoobshirazi, 2011). The maximum score for the PMQ II is 100 and the minimum is 0. For measurement of students' understanding of kinematic graphs, the *Test for Understanding Graphs in Kinematics* (TUG-K) (Beichner, 1994) was used. This multiple choice questionnaire contains twenty items with five choices each.

An interview schedule was also prepared to capture the challenges experienced by the teacher in implementing the flipped classroom.

Research design

This study adopted an experimental research design, specifically the *Solomon Four-Group* design to provide good control of threats to internal validity. A Solomon Four-Group design has two pretested groups and two without pretest. One of the pretested groups and one of the non-pretested groups received the experimental treatment, and then all four groups took the post-test.

Motivation in learning science and understanding kinematics graphs were tested separately. Using the draw by lots for randomising the groups yielded two different set-ups. Table 2 set-up was for the *Test for Physics Motivation Questionnaire II* (PMQ II) and Table 3 was for the *Understanding Graphs in Kinematics* (TUG-K).

Table 2: PMQ II Experimental set-up using the Solomon four-group design

Group	Treatment	Pretest	Independent variable	Post-test
E1	Pre-test, treatment X, post-test	Y1	X	Y2
E2	Treatment X, post-test	---	X	Y2
C1	Traditional lectures, post-test	---	---	Y2
C2	Pre-test, traditional lectures, post-test	Y1	---	Y2

The first and fourth rows of Table 2 compared the gain scores of the experimental and control groups. This revealed the pretest influence over the post-test results. The second row verified the effect of pre-testing. The third row helped validate the changes that would occur between the Pretest (Y1) and the Post-test (Y2).

Table 3: TUG-K Experimental set-up utilising the Solomon four-group design

Group	Treatment	Pretest	Independent variable	Post-test
E1	Pre-test, treatment X, post-test	Y1	X	Y2
E2	Treatment X, post-test	---	X	Y2
C1	Pre-test, traditional lectures, post-test	Y1	---	Y2
C2	Traditional lectures, post-test	---	---	Y2

The first and third rows compared the gain scores of the experimental and control groups. This revealed the pretest influence over the post-test results. The second row verified the effect of pre-testing. The fourth row helped validate the results that would occur between the Pretest (Y1) and the Post-test (Y2). The conduct of the experiment started from the randomisation of students belonging to a section which was done at the Registrar's Office during enrolment. The Registrar opened four sections with 35, 35, 47, and 38 students, respectively. For the four sections' random assignment of intact groups, drawing of lots was done by the researchers. The results of the drawing of lots are shown in Table 4.

Table 4: Assignment of groups

Assignment	No. of students	Class schedule	Instructor
Experimental group 1 (E1)	47	3:00-4:00 MWF	Instructor B
Experimental group 2 (E2)	38	4:00-5:30 TTH	Instructor A
Control group 1 (C1)	35	2:30-4:00 TTH	Instructor A
Control group 2 (C2)	35	2:00-3:00 MWF	Instructor A

Prior to the implementation, a survey of available and useful technology for the implementation of flipped classroom was conducted. This was followed by a workshop to train the teacher implementers on how to go about facilitating a flipped classroom model. Five teachers handling physics subjects attended the workshop, but only two participated in this study.

Data analysis

Data were analysed using *SPSS*. Normality of group data was determined using the Shapiro-Wilk test of normality to determine whether to use the parametric tests for comparison of means. T-test was used to test differences between the pre-test mean scores of the experimental and control because of its superior quality in detecting differences between two groups (Dimitrov & Rumrill, 2003). Pretest data for experimental and control groups were compared using an independent samples t-test to determine whether the level of understanding and motivation of the groups were similar or not. The gain scores (Post-test - Pretest) of pretested groups were determined and tested for significance using a paired sample t-test. Post-test scores were compared using an independent samples t-test to evaluate whether pretesting influenced the post-test results or not. Qualitative analysis was used to analyse the interviews with the teacher implementers.

Results and discussion

Levels of motivation of the groups with pre assessments (E1 and C2)

The *Physics Motivation Questionnaire* [PMQ II] determines the level of motivation of the students towards physics. These tests were administered according to the research design in Table 2. The following are the results of the pre-assessments given to the student during the conduct of the study.

Table 5: Levels of motivation of pretested groups

Assessment	E1 (n = 47)			C2 (n = 35)		
	M	SD	Level	M	SD	Level
Pretest	72.21	12.457	high	71.69	12.693	high

Motivation levels using the PMQ II are categorised into low-motivation [0 to 50] and high motivation [51 to 100] (Glynn, Brickman, Armstrong & Taasoobshirazi, 2011). The means of 72.21 and 71.69 out of 100 were considered high-motivation which could be seen in the PMQ II pretest results of the control and experimental groups. The standard deviations of 12.457 and 12.693 for the experimental group and the control group, respectively, showed that the groups' responses were equally dispersed. This can be considered comparable in terms of motivation of the students in the two groups.

Levels of understanding of the groups with pre assessments (E1 and C1)

The *Test for Understanding Graphs in Kinematics* [TUG-K] evaluated the students' level of understanding of kinematics graphs. These tests were administered according to the research design in Table 3. The following are the results of the pre assessments given to the students during the conduct of the study:

Table 6: Levels of understanding of pretested groups

Assessment	E1 (n = 47)			C1 (n = 35)		
	M	SD	Level	M	SD	Level
Pretest	3.66	1.564	A	4.49	1.522	B

The data were analysed to determine the general distribution properties of the data. Results showed a normal data set which permitted the use of parametric tests for comparison of means (Landau & Everitt, 2004, p. 38). The standard deviations of 1.564 and 1.522 for the experimental group and the control group, respectively, showed that the groups' responses were equally dispersed. This can be considered comparable in terms of the levels of understanding of the students in the two groups.

Five categories of scores were created for the *Test for Understanding Graphs in Kinematics*. An interval of 4 points per category was set and labelled very low, low, average, high and very high levels of understanding as shown in Table 7.

Table 7: Category of understanding based on scores in TUG-K

Category	Label	Score range
A	very low	0-4
B	low	5-8
C	average	9-12
D	high	13-16
E	very high	17-20

Referring to the mean scores of TUG-K, the experimental Group 1 Pretest had the very low level, belonging to category A, while the control group to category B. The scores were relatively low compared to the possible perfect score of 20.

Comparison of the levels of motivation of the groups with pre-assessments (E1 and C2)

Pre-assessment results of student motivation were used to determine the levels of motivation of the experimental group and the control group. The independent samples t-test was used in the analysis. Results indicate that there was no significant difference between levels of motivation of the experimental group (M = 72.21, SD = 12.457) and the control group (M = 71.69, SD = 12.693), $t(80) = -0.188$, $p > 0.05$ (alpha level = 0.05).

For motivation of students, the PMQ II pre assessments showed no significant difference between the experimental and control groups. Their levels were at par and at the high level category. This indicates that students in the experimental and the control group exhibited an equal footing at the start of the study in terms of their motivation. The high level category at the start might have reduced the possibility of getting a significant gain for students' motivation at the end of the study.

Comparison of the levels of understanding of the groups with pre-assessments (E1 and C1)

To determine the levels of understanding of the control and the experimental groups, the pre-test results of TUG-K were analysed and compared. The independent samples t-test was used in the analysis. Results showed that the control group (M = 4.49, SD = 1.522) had significantly higher level of understanding compared to the experimental group (M = 3.66, SD = 1.564), $t(80) = 2.393$, $p = 0.019$ (alpha level = 0.05). This shows a significant difference in the TUG-K pretest between the experimental and control groups, where the control group was higher than the experimental group.

Pretest results of TUG-K showed that the control group had better level of understanding (category B) compared to the experimental group (category A). This happens to oppose the usual procedure of insuring that the tested samples, in this case E1 and C1, are statistically comparable at the beginning. This however, was not avoided because of the limited sections available for the study and it proceeded with this limitation.

Levels of motivation in the post assessment

All groups took the PMQ II after implementing the intervention for the experimental group, at the same time as the control group covered the topic in kinematics graphs. Table 8 shows the levels of motivation in the post assessment.

Table 8: Post assessment levels of motivation

Post-test assessment	M	SD	Level
Experimental E1 (n = 47)	69.64	14.143	high
Control C1 (n = 35)	77.31	9.371	high
Experimental E2 (n = 38)	73.95	11.366	high
Control C2 (n = 35)	72.11	14.383	High

The levels of motivation during the post assessments were all at the high level motivation category. There may be differences in the means, but when subjected to the category criterion, the means all belonged to the same category.

Levels of understanding in the post-tests

The TUG-K was taken by all the four groups after implementing the intervention for the experimental groups and after covering the topic in kinematics graphs for the control groups. The TUG-K post assessments were given to the students after accomplishing the PMQ II. Table 9 shows the levels of understanding in the post assessment.

Table 9: Post assessment levels of understanding

Post-test assessment	M	SD	Level
Experimental E1 (n = 47)	5.53	2.527	B
Control C1 (n = 35)	5.03	1.886	B
Experimental E2 (n = 38)	5.29	1.642	B
Control C2 (n = 35)	4.43	1.632	B

All post assessments for TUG-K were all at level B category. E1 and E2 had higher mean scores compared with C1 and C2 mean scores.

Comparison of the post assessment scores for motivation

Experimental groups

The motivation of students in the experimental groups E1 and E2 were also compared to find out whether they had similar results. The independent samples *t*-test revealed that there was no significant difference between the PMQ II post assessments of the experimental groups E1 (M = 69.64, SD = 14.143) and E2 (M = 73.95, SD = 11.366), $t(83) = -1.522$, $p > 0.05$ (alpha level = 0.05).

This result reveals a consistent level of motivation of the students even when introduced to a new instructional model. This result is similar to the claims of Butzler (2014) that flipped-classroom model produces no significant difference in academic motivation.

Control groups
The motivations of students in the control groups C1 and C2 were also compared to find out whether they too had similar results. The independent samples *t*-test revealed that there was no significant difference between the PMQ II post assessment of the control groups C1 (M = 77.31, SD = 9.371) and C2 (M = 72.11, SD = 14.383), $t(68) = 1.792$, $p > 0.05$ (alpha level = 0.05).. For the control groups, there was no indication that the pretest of the PMQ II had an effect on the post-test result. The pre assessments and post assessments of C1 had no significant difference, similar with the experimental group E1.

Comparison of the post assessment scores for understanding

Experimental groups
Understanding of kinematics graphs by students in the experimental groups E1 and E2 were compared to determine whether they yielded similar results. The independent samples t-test revealed that there was no significant difference between the TUG-K post assessments of the experimental groups E1 (M = 5.53, SD = 2.527) and E2 (M = 5.29, SD = 1.642), $t(83) = 0.510$, $p > 0.05$ (alpha level = 0.05). Having no significant difference between the post-test score of the experimental groups E1 and E2 for TUG-K means that the pretest given to E1 did not have an effect on the post-test results. Whether or not there was a pretest, the groups would still have the same level of understanding after implementing the intervention.

Control groups
Understanding of kinematics graphs by students in the control groups C1 and C2 were compared to determine whether their results were significantly different. The independent samples t-test revealed that there was no significant difference between the TUG-K post assessments of the control groups C1 (M = 5.03, SD = 1.886) and C2 (M = 4.43, SD = 1.632), $t(68) = 1.423$, $p > 0.05$ (alpha level = 0.05). Consistent results of the TUG-K post-test of the control groups means that pretesting did not have an effect on the post-test outcome of this study.

Comparison of the students' gain in understanding

Gain scores (subtracting the pretest scores from the post test scores) were used to determine the improvement in understanding. Some showed positive gains while there were others showed negative gains. Table 10 summarises results for pre assessment, post assessment and gain in understanding for experimental and the control groups.

Only those groups with pre assessments and post assessments (E1 and C1) were used to determine the gain scores. These groups were representative of the experimental and the control groups.

Table 10: Pre assessment, post assessment and gain in understanding

Assessment	E1 (n = 47)		C1 (n = 35)	
	M	SD	M	SD
Pretest	3.66	1.564	4.49	1.522
Post-test	5.53	2.527	5.03	1.886
Gain	1.87	2.909	0.54	1.853

Within experimental groups

Using a paired samples *t*-test, the pre assessments and post assessments of TUG-K for E1 were analysed and compared. Results for the experimental group E1 showed a highly significant difference of TUG-K post assessment ($M = 5.53$, $SD = 2.527$) and TUG-K pre assessment ($M = 3.66$, $SD = 1.564$), $t(46) = 4.413$, $p < 0.001$ (alpha level = 0.05).

The intervention given to the experimental groups, the flipped-classroom model, had an influence on their post-test results. Unstructured interviews were conducted after the students took the post assessments of the TUG-K. Some statements by students in the experimental group taught using the flipped classroom model may give insights into what enabled the students to perform better.

Students from E2 claimed they were actively participating in the clicker questions by defending their answers to their seatmates which made them remember and understand the concept better.

> We are excited during clicker, if we don't have the same answers, we were given time to talk to our seatmates to convince them of our choice. This makes the class noisy but in the end, when we raised our cards the second time around all of our answers are now correct.

The modified clicker was part of the activities in the flipped classroom model which was done at the beginning of the period. Students were given the video during the previous encounter and the content of the clicker questions were framed to check whether students understood the videos they were watching. Unstructured interviews with the students revealed some reasons for this. Students from the experimental groups gave positive feedback on the videos they watched.

> Interviewer: What were the benefits you derived from the flipped classroom model?
>
> Student 1: Makasabot mi sa video… klaro and discussion and pwede ra nako balikbalikon og view. (*We were able to master reading kinematics graphs because the examples in the video are clear and we can replay it [video] as often as we needed.*)

Filipino students prefer self-learning (Rodrigo, Grosch & Andres, 2013) and are better off in this circumstance. When students manage their own pace, they are in a better position to gather much needed information to supplement or review what they have already learned (Schwartz, 2013, p. 4). Students learning individually acquire mastery because they are selective users of supplemental information they need to understand the topic at hand. Providing this experience in the curriculum could help improve topic mastery.

Not all students experiencing flipped classroom model found the tasks easy. Some interviewed students did not have enough time to watch the video since they were only relying on the computer laboratory ticket for 30 minutes given by the researcher.

> Interviewer: What were the benefits you derived from the flipped classroom model?
>
> Student 2: We had difficulty… kuwang ang 30 minutes nga free time… magextend mi kay usahay lag ang internet… dili pud open and Internet café during our free time in the morning… 9 am pa mag open. (*The 30 minutes free time was too short, we need to extend due to problems with internet connection. The café opens at 9 am and we cannot use our free time in the morning.*)
>
> Interviewer: What did you do given this situation?
>
> Student 2: We have classmates nga nagdownload sa videos sa ila tablets... manghuwam na lang mi. (*Some of our classmates downloaded the videos in their tablets. We borrowed it and viewed the videos in their tablets.*)

The lack of access to the Internet did not always hinder these students from performing what was required of them. They took initiatives to meet what was asked of them.

Within control groups

Using the paired sample *t*-test, the TUG-K results for the control group C1 revealed that there was no significant difference between the TUG-K pre assessment (M = 4.49, SD = 1.522) and TUG-K post assessment (M = 5.03, SD = 1.886), $t(34) = 1.734$, $p > 0.05$ (alpha level = 0.05). The reason for this may be attributed to the activities done in the traditional classroom model which do not preclude students from extra activities outside the classroom.

Unstructured interviews with some students in the control group revealed that when they were given assignments, most of them would answer the assignments in school with their classmates. Some students did the assignments but were unsure of their answers, while some students resorted to copying the answers of their classmates.

> Interviewer: How do you answer your assignments?
>
> Student 3: Maglisud mi og answer at home kay walay makatigo. Magsalig na lang mi sa amo mga classmates. (*No one can help me at home; I just rely on my classmates to share their answers to me.*)

The problem with assignments is that teachers have difficulty in monitoring their students individually. This came out in an unstructured interview with one of the instructors of the department.

Interviewer: How do you monitor the assignment given to the students?
Instructor C: It is very difficult because I cannot follow-up them all. I will just wait when they turn in their work the following meeting. I can see similarities and some are not reflective of the students' ability.

Between experimental and control groups
Experimental group (E1) had a category A level of understanding during the pre-assessment and a category B level of understanding during the post assessment. This performance was better than C1 in terms of pre assessment and post assessment difference or gain scores. Comparison of the TUG-K score gains of the control group C1 and the experimental group E1 showed a significant difference of the experimental group E1 (M = 1.87, SD = 2.909) against the control group C1 (M = 0.54, SD = 1.853), $t(83) = 2.368$, $p = 0.014$ (alpha level = 0.05). This result is parallel to Overmyer (2014) where flipped classroom model in teaching college algebra produced a slightly higher gain compared with the traditional model.

Students from the control group also expressed their experiences in their traditional classroom setting. Some of them said that most of the students were not paying attention when the teacher was doing the lecture.

Interviewer: What are the activities in the classroom that help you learn kinematic graphs?
Student 4: Our teacher discusses the topic and solves some problems. Sometimes she is fast.
Interviewer: What will you do if the teacher is fast?
Students 4: Sometimes if our teacher is fast, dili na mi makasabot, pero walay mangutana kay maulaw. (*Sometimes, if we cannot catch up with the discussion, we don't bother stopping the teacher because we are ashamed.*)
Interviewer: What do you think can help her improve on this?
Student 4: Unta makahibaw si Ma'am kinsa iya mga studyante og mkasabot siya unsaon pag pasabot sa mga topics nga lisod. (*Our teacher should know her students and she should know how to make the difficult topics understandable.*)

After implementing the flipped classroom model in teaching kinematics graphs the results, however, pointed to the improvement of the level of understanding of the experimental group.

Challenges in implementing the flipped classroom model

Before the teachers taught kinematics graphs using the flipped classroom model, they participated in a workshop facilitated by the researcher. The workshop informed implementers on how to go about conducting a flipped classroom model. They were also inducted on the module they would using during the implementation.

Their classes, both the experimental and the control groups, were observed by the researcher. Upon completing the implementation, an interview conducted individually of the two teacher implementers gathered important feedback in implementing the flipped classroom model in teaching kinematics graphs to college physics students.

Changes brought about by using the flipped classroom model

The teacher implementers shared that they were excited to learn about flipped classroom model during the workshop. Instructor A particularly noted the time she spent with the students increased.

> Before I did the flipped classroom model or even in the traditional classroom I am doing now, only those students who approached me after the class period were the ones I got to notice. Those who don't, I cannot determine which topics they had difficulty with. Flipped classroom model allows me to get to know my students better in terms of the topics they had a hard time understanding. (Instructor A)

Instructor B revealed that he had been asking students to view videos in *YouTube* but he was not specific about which videos to watch. He just gave the topic and the students were the ones looking for appropriate videos. He made *PowerPoint* presentations for problems with long solutions for students to view.

> I have been sharing *PowerPoint* presentation to my students but only for problems with lengthy solutions, I did not know this to have a name and I am glad to learn that this has been backed with theories already. I am now confident to use this model. (Instructor B)

Difficulties in using the flipped classroom model

Instructor A was concerned about the length of time in preparing the videos.

> It would have been better if the videos were prepared during summers breaks so that errors and wrong concepts can be addressed by us or our colleagues. (Instructor A)

Instructor A noted that the difficult part was the preparation of the videos, though she also said, "When the videos are ready, we can use it for several sessions." The teacher implementers were also concerned on how the students would view the video at home particularly on whether they ever watch the video. This they cannot determine because they cannot go to every student's house. Instructor B considered this a problem as it may affect the result.

> When we gave out the videos, the student will have the liberty when to watch the videos. We cannot impose the time [of the day] and the duration of watching the videos. This we cannot check anymore. (Instructor B)

While the clicker questions will provide information on students grasp of the videos, the "convince your neighbour" approach will make it hard to tell which student really watched and understood the videos given.

Changes and/or irregularities in students

The teacher implementers observed better attention by students in the flipped classroom model than in the traditional method. Instructor A observed her students to be sharing their thoughts about the topic and using their own concepts while those in the traditional method were passive and mostly relying on the teacher.

> I did not have to explain or review the concept of kinematics graphs to the students as much as I have before. They can easily understand how the graph works. There are a few who ask me to review some concepts but they managed to answer exercises in dynamics afterwards. (Instructor A)

Instructor B pointed out that students were no longer ashamed to share their ideas to their seat mates.

> I think this is because the videos gave them confidence to express their take on the topics and they can now expound some ideas. (Instructor B)

Changes in the way students understand the succeeding topics

Teachers can use the students' confidence in kinematics graphs in the succeeding topics in physics. This will bring about better reception of the students to new ideas even beyond kinematics graphs. An unstructured interview after the semester revealed the performance of the students beyond kinematics graphs. Instructor A observed a better performance shown by those who were taught using the flipped classroom model as compared to the traditional method.

> The results of the exams by the experimental group I taught kinematics graphs using the flipped classroom were better compared to those who had not experienced the flipped. I need to show more examples to the control groups compared with the experimental group. (Instructor A)

Assessment of the overall experience in using the flipped classroom model

The flipped classroom model was a new idea for the teacher implementers. Instructor B claimed that it was his first time hearing about the term 'flipped-classroom model'. They liked the idea that this model utilised recent technology. According to Instructor A, she found the flipped classroom model interesting, especially the utilisation of the technology which students are now engaged in using. The teacher implementers were positive about the new model when they were asked if they would use the model in teaching other topics. Instructor B is planning to make more videos especially now that he observed better performance by students who participated in the flipped-classroom model for kinematics graphs. They both agreed that this model can enhance learning as they have observed an improvement on the students' understanding of kinematics graphs when applied to other topics in physics after kinematics graphs.

The analysed data and supporting interviews gave a better picture of the results of this study. The motivation level of the students in the experimental and control groups were at the high level category. This indicates that students taking the course [Physics I] were highly motivated and the intervention did not changed their level of motivation. However, the level of understanding of kinematics graphs showed a difference at pretest, with the control group being in level B and the experimental group in level A. However the post-test showed a significant gain by the experimental group compared to the control group. The intervention has positively affected the results of the post-test of the experimental group.

Assessments quantitatively illustrate the changes happening within groups as well as between groups. The interviews supported the results through qualitative data which were equally important in highlighting the reasons for the quantitative results.

Conclusion

Students' understanding of graphs in kinematics is a problem presented by instructors in physics. Understanding graphs in kinematics is considered an important skill to develop and improve. Instructors and researchers are now gearing towards utilising relevant technologies to help address this problem. The flipped classroom model utilises technology to enable students to have home availability of lectures through video recordings given to them. The results show that using the flipped classroom model had a positive effect on students' understanding of kinematics graphs. However, with the same study population, using the flipped classroom model had no effect on students' level of motivation, which was already high from the start.

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