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A FLIPPED APPLIED MATHEMATICS CLASSROOM : NIGERIAN UNIVERSITY STUDENTS' EXPERIENCE AND PERCEPTIONS

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Abstract

This study was designed to determine university students' experience and perceptions in a flipped Applied Mathematics classroom. Survey research design was employed to measure students' responses after a successful seven-week deployment of the flipped model of instruction delivery in a University in North Central Nigeria. An intact class of 32 students was used for the study, out which 21 students returned the adopted Feedback Questionnaire on Flipped Classroom Activity. Analysis of the results of the study shows a positive level of students' perception (grand mean = 2.765) and an enriched learning experience in terms of curiosity, engagement and enlightenment. Based on the findings of the study, it was recommended that teachers at all levels of mathematics education should always seek instructional approaches that are student-driven like the flipped classroom to sustain interest and improve academic performance.

Keywords: Flipped classroom, Mathematics education, Learning experience, Student-driven instruction

Introduction

The knowledge of mathematics is a basic pre-requisite in the quest for present-day scientific and technological advancement. The idea of numbers, structures and relationships which mathematics connotes stand out in medicine, business, education, agriculture, and every field of human endeavour. In the 21st century in particular, sound mathematical background is needed for life sustenance and workplace competence.

Obviously, the pivotal relevance of mathematics has positioned the subject as a converging force across all forms of curricular efforts. Mathematics as taught in schools is full of teacher-centred procedures that have to be mastered. Basically, learning and doing mathematics entail effective problem solving, exploration of mathematical concepts, ability to dynamically link representations of ideas and develop meta-cognitive skills in planning and checking solutions. To attain success, mathematics instruction delivery must be demystified to enable students exert more choice over how they approach study, with the teacher acting as a guide rather than a director.

Present-day instructional delivery in mathematics education hinges on mathematical proficiency. Kilpatrick and Findell (2001) maintain that effective mathematics teaching and learning is said to be guided by the integration and balanced development of all five strands of mathematical proficiency. These five central focuses are conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. The last strand, productive disposition, is the habitual inclination to see mathematics as sensible, useful, and worthwhile, couple with a belief in diligence and one's own efficacy (Kilpatrick & Findell, 2001). This productive disposition could be enhanced in students through the adoption of methodologies that integrate the use of modern pedagogies such as flipped learning.

Flipped learning is the strategic reversal of the traditional classroom. Colmenares (2014) explained that in the flipped model, initial student exposure or exploration of learning content happens outside of the classroom in order to allow for clarification and active engagement of learning content inside of the classroom. In the flipped classroom approach, what used to be homework is now done in the classroom, after students have extensively gone through instructional content at home (Heo & Choi, 2014). Instructional contents are mostly packaged as easily playable videos commercially produced, obtained via Open Educational Resources (OER), or directly (locally) produced by instructors.

The aim of flipping is to essentially free up more time for fruitful student-teacher-interactions, and coaching students in directly assimilating their subject matter content (Shafique & Irwin-Robinson, 2015). In this context, the students move at their own pace, the teacher can customize and update content with ease, and the use of technology is very much flexible and appropriate for 21st century learning (Fulton, 2012). The flipped learning approach encourages students to develop a high sense of goal orientation, autonomy, behavioural engagement and personal student-generated examples.

Mathematics as a subject area is highly amenable to the flipped model of instruction delivery because of its loaded contents and the need for in-depth practice. Since students have surpassed simple understanding and memorizing level, having been exposed to provided lecture videos, higher level of studying can be done in the class. Heo & Choi (2014) related that this approach fully utilizes the analysis, evaluation and creation levels of Bloom's Taxonomy. In this mode, students are able to explore the mathematical details of the content and sustain curiosity to the highest levels. These dynamic possibilities are even more pertinent to courses in Applied Mathematics in which students are required to analyze geometric properties of conic sections and resolve equations.

The specific intent of this study is to leverage on the abundant benefits of flipped learning to enhance the delivery and learning of a basic course in Applied Mathematics. The ubiquity of smartphones among university students in Nigeria (Anyor & Abah, 2014) provides an already-made platform for content distribution and in-depth study. The implication is that the course contents can be circulated in a wide range of formats, including videos, pictures, and portable document format (pdf). The carefully structured activities utilized in flipping this Applied Mathematics class may have enriched the students' mathematics learning in very specific ways. Students' experience and perceptions in this mode of teaching may open up other frontiers hitherto untapped in university learners' quest for student-driven learning.

Literature Review

The Flipped Learning Network (2014) sees flipped learning as a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into dynamic interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter. Larsen (2015) reported that Bergman and Sams (2012) coined the phrase “flipped classroom” in 2012 in reference to affordances provided by increasingly accessible technologies to deliver content asynchronously out of class time while dedicating class time to student learning. Over the years, several researches have tried to establish the theoretical footprint of the flipped mode of instruction as well as provide empirical evidence supporting its efficacy.

Years of practice and refinement has yielded what has come to be termed the “four pillars” of flipped learning, represented by the letters F-L-I-P. According to the Flipped Learning Network (2014), these pillars are Flexible environment, Learning culture, Intentional content, and Professional educator. Flexible environment implies the ease with which educators can switch among variety of learning modes, allowing for flexibility in their expectations of student timelines for learning, study space, group work and assessments. This flexibility allows students to learn and demonstrate mastery. The Learning culture of the flipped model of instruction is learner-centred, with educators using Intentional content to maximize classroom time via active learning that is dependent on school level and subject matter. While Professional educators take on less visibly prominent roles, they remain the essential planners that enable flipped learning to occur. The end product of the flipped model is to capitalize on students’ preparation to integrate and apply their knowledge, checking on each student’s understanding, and helping to develop students’ procedural fluency (Muir & Chick, 2014).

The application of flipped learning in mathematics has generally resulted in very positive findings. Ingram, Wiley, Miller and Wyberg (2014) reported better differentiated instruction in the flipped classrooms, team spirit among students, challenging of higher-level learners, and more time available to complete math-related projects among elementary grades students. Apart from improvement in academic performance, Altstadt (2016) observed that the flipped classroom approach is especially valuable for low-income, older students returning to school. McLaughlin, Roth, Glatt, Gharkholonarche, Davidson, Griffin, Esserman, and Mumper (2014) arrived at the conclusion that the flipped classroom empowers professional health students to develop higher-order cognitive skills and to engage in meaningful learning that will ultimately improve the delivery of health care.

Technology used to achieve a flipped classroom may include newly developed technologies or older technologies repurposed for the task (Colmenares, 2014). Depending on the amount of resources available to professional educators implementing the flipped classroom, the production of content can be teacher-based or sourced from third-party vendors. There are however, several development platforms for the instructor to package his content for the flipped experience. These include Movenote, thinglink, GoAnimate, PowToon, AdobeCaptivate, Jing, Windows Snipping Tool, and Zolla. For instance, Osigbemeh, Eze, Imouokhome and Omaka (2015) achieved full cognitive plausibility in teaching intent based on their teaching of STEM subjects with the Zolla software. Heo and Choi (2014) also established that home learning of instructional videos exerts positive effects on students' achievement. Charles-Ogan and Williams (2015) of the University of Port-Harcourt, Nigeria, distributed copies of tutor-made video CDs in a flipped mathematics class in a secondary school and reported a mean gain of 28.60 in the experimental group against a mean gain of 6.62 for the control group.

Puarungroj (2015) employed Google Classroom as a tool for managing course materials for a flipped programming class and observed improvement in student-instructor interaction, student engagement, and self-paced learning. Kadry and El Hami (2014) reported overall results which indicate that students perceived the video-viewing portion of the flipped classroom as beneficial to their leaning and preparation for Calculus II class. In a study of students' behaviours and perceptions in a flipped undergaraduate mathematics classroom, Triantafyllou, Timcenko and Kofoed (2015) observed a high sense of competence, relatedness, autonomy and expertise among students. Similarly, Yoshida (2016) reported that when an educational technology class was flipped for Japanese university students, it was affirmed to result in high perceived usefulness in terms of enhancement of classroom instruction, learning effectiveness, and productivity. LanCastle, Barlow and Davison (2016) in the same vein observed that the flipped classroom particularly benefits engineering education students who struggle with traditional lectures, and who may otherwise fall behind.

The studies reviewed here have generally attested to the robustness of the flipped classroom across several fields. The particular reviews in mathematics from Nigeria pointed out the relative efficacy of the flipped model at the lower level of mathematics education with emphasis on core mathematics. This present study however, is geared towards ascertaining Nigerian university students' experience and perceptions of flipped learning in a specific course in Applied Mathematics.

Research Questions

The following questions were raised to guide this study.

i. What are university students' perceptions of the flipped Applied Mathematics classroom?
ii. What are university students' personal experiences in the flipped Applied Mathematics classroom?

Methodology

This study employed the survey research design, with instruments administered after a successful seven-week implementation of the flipped classroom in an intact undergraduate class at the University of Agriculture, Makurdi, Nigeria. The sample comprised 32 third-year (300 Level) students of B.Sc.(Ed.) Integrated Science, taking the course "Applied Mathematics for the Sciences" in the first semester of the 2015/2016 academic session. Out of the 32 students, 21 returned the instrument for data collection to the instructor.

The flipped learning was implemented via prior circulation of videos and pdf lecture notes to students by the course instructor (the researcher). These contents (videos and pdf lecture notes) were obtained from YouTube and other parts of the web as Open Educational Resources (OER) and distributed to students' smartphones and other mobile devices via flashare and Bluetooth. The contents were scrutinized by the instructor to ensure conformity to the course description and objectives. Specific aspects of the course used for this study include Introductory Analytic Geometry, Conic Sections, and Kinematics.

Students were informed of the research and updated on the basic features of the flipped classroom before the commencement of this study. They freely gave their consent and openly displayed enthusiasm towards the prospects of flipped learning, even when they were told that grades for the course will not be awarded based on participation in the exercise.

For each major sub-topic, related instructional contents were circulated among students for self-paced study with a full week window to internalize the materials. The in-class discussions, students-instructor interactions, and solving of difficult problems arising from the previewed contents takes up the two hours per week allocated for the course. At a point, the class was split up into groups to allow students collaborate in developing a term paper on applications of the concept of parabola in the design of car head lamp, suspension bridge, and parabolic television antennae.

The study fully adopted the Feedback Questionnaire on Flipped Classroom Activity (FQFCA) developed and validated by Barua, Gubbiyappa, Baloch and Das (2014). The reported measure of internal consistency of the instrument is 0.91 using Cronbach alpha (Barua et al, 2014). The FQFCA comprises of ten (10) items calibrated on a five-point Likert scale with Strongly Disagree (SA) = 0, Disagree (D) = 1, Neutral (N) = 2, Agree (A) = 3, and Strongly Agree (SA) = 4. On the instrument, students were also asked to give a brief description of their experience in one to three sentences.

The data obtained from the FQFCA were analyzed using mean and standard deviation. The benchmark for decision is a mean of 2.0, that is, a mean score above 2.0 implies acceptance while a mean of 2.0 and below indicate rejection.

Results

The results of data analysis from this study are presented here according to the research questions.

Research Question One

What are university students' perceptions of the flipped Applied Mathematics classroom?

Table 1
University Students' Perception of the Flipped Applied Mathematics Classroom

S/No.	Items	Mean	SD	Remark
1	Pre-reading materials (Videos, Pdfs & Lecture Notes) were made available to the class for flipped classroom activities.	2.857	1.682	Accepted
2	Adequate time was provided to spend on the pre-reading materials before the flipped classroom activity.	2.761	1.044	Accepted
3	Pre-reading materials were relevant for the flipped classroom activity.	2.953	1.023	Accepted
4	The classroom arrangements were conducive for the flipped classroom activity.	2.619	1.071	Accepted
5	The activities during flipped classroom session increased my understanding of the key concepts.	3.191	0.873	Accepted
6	The flipped classroom session inspired me to pursue further learning for the course.	2.857	1.062	Accepted
7	More lectures should be conducted in the flipped classroom mode.	2.286	1.007	Accepted
8	The Instructor was able to engage me in the flipped classroom activity.	2.714	1.007	Accepted
9	The Instructor was able to provide clarification on difficult concepts during the flipped classroom activity.	2.619	0.805	Accepted
10	The Instructor was able to expand on videos and pre-reading materials during the flipped classroom activity.	2.191	1.67	Accepted
	Grand Mean	**2.765**		**Positive**

The results displayed in Table 1 indicate a positive level of students' perception of the flipped Applied Mathematics classroom. The results show that the flipped learning activity inspires students to pursue further learning and improve their engagement in the subject matter.

Research Question Two

What are university students, personal experience in the flipped Applied Mathematics classroom?

When participants (the students) were asked to briefly described their experience (feelings) with the flipped learning mode of instruction, they came up with a range of descriptions indicating heightened curiosity, sustained interest and enlightenment. Specifically, the students' description of their personal experience follows the pattern presented in Table 2 (students' names left out).

Table 2
University Students' Personal Experience in the Flipped Applied Mathematics Classroom

Student	Key portions of handwritten description of experience
A:	"The explanation of the calculations were explicit and clear for me to understand"
B:	"Some exercises that looked abstract were explained in more simple and concrete form to ease my understanding … saw new things to add to my store of knowledge"
C:	"The methodology in analyzing some complex forms in the videos is linear and comprehensive, which enlighten my understanding"
D:	"I will suggest that such method be adopted … for more understanding of abstract concepts"
E:	"It is a very nice approach to learning"
F:	"It is very educating having the material (video) at your disposal for effective use at any time"

Discussion

The results of this study have thrown more weight on the benefits of adopting student-driven instructional strategies in mathematics education. The flipped learning approach has been affirmed by participants in this study to be clarifying, inspiring and engaging. This outcome is in consonance with Heo and Choi (2014) who observed that flipped learning stimulates students' curiosity. Also, the findings of this study support the work of Shafique and Irwin-Robinson (2015) who found a positive outcome for the flipped teaching approach. The students' experience reported in this research is in tandem with the increase in engagement and communication observed by Clark (2015). The high level of engagement occasioned by the flipped classroom is bound to translate into heightened academic outcomes on the part of the students.

A key finding of this study is the prompt for further effort and personalized learning resulting from the use of the flipped mode of instruction. Such prompting is a measure of interest indicating how factors such as autonomy and goal setting inter-relate through experience in the flipped learning approach (Larsen, 2015). The participants of this study personally recommended the flipped approach of teaching for other courses in the university, an indication of a comparative advantage over traditional models of instruction. This pattern of positive acceptance agrees with Muir and Chick (2014) who reported students' perception of the flipped classroom being sustainable and transferable to other classes.

Like McLaughlin et al (2014), this study has highlighted a key avenue to enhance learning outcomes, and fully equip students to address 21st century educational needs. Flipped learning affords students the opportunity to break complex school work into manageable bits while improving their capacity to drive more personalized learning.

Recommendations

Based on the findings of this study, the following recommendations are put forward.

1. Teachers at all levels of education should always seek instructional approaches such as the flipped classroom to enrich their instructional delivery. Open educational resources (OER) are often available on the Internet at no cost to the instructor intending to deploy this model of instruction.
2. Students should seek personal improvement by obtaining free online resources to augment their learning of any subject matter, even when the classroom is not flipped by the teacher.
3. Mathematics educator, particularly from Nigeria, should pick the challenge to design OERs that are easy to adapt, freely available, and accessible for basic education use.
4. School administrators at all levels of education should provide adequate multimedia resources to teachers who are interested in producing instructional contents for adaptive flipped learning.

Conclusion

In the quest to demystify mathematics as a subject, this study has attempted to investigate students' experience and perceptions after a semester of flipped learning in an Applied Mathematics course. The findings of the study indicate that the flipped classroom stimulates curiosity, self-paced study and behavioural engagement in the students. Participating students in the study also recommend the approach for the handling of other courses in the school.

Limitations of the Study

An obvious limitation of this study is the very small number of students in the intact class.

Suggestions for Further Studies

Further studies from within Nigeria can expand the sample of this study to cover a wider geographical scope. Also, an attempt can be made at extending the ideas of this study beyond the survey design to a quasi-experimental one.

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