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Technological Pedagogical Selection Content Knowledge (TPSACK) framework on the Achievement of Pre-service Mathematics Teachers in Mathematics Education

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ABSTRACT

The role of Mathematics educators in teaching – learning process cannot be exaggerated. This paper presents Technological Pedagogical Selection Content Knowledge (TPSACK) framework on the achievement of pre-service Mathematics teachers in College of Education Mathematics. One hundred and fifty (150) Pre-Service Mathematics teachers in Adeniran Ogunsanya College of Education, Otto – Ijanikin, in Lagos State, Nigeria were chosen for this research. Random Sampling technique was used to select the sample. The sample chosen includes second year male and female pre-service mathematics teachers in the Department of Mathematics. Seventy five (75) of them were placed in an Experimental Group and the other seventy five (75) were placed in Control Group without any bias. The experimental group was exposed to the lectures taught with a well-organized TPSACK framework on some selected Mathematics courses in college mathematics while the Control Group was subjected to the traditional lecture method (constructivist instruction mode) on the same selected Mathematics courses in college mathematics. The duration of the pilot test last for ten (10) weeks. Mathematics Achievement Test (MAT) instrument was used to measure the performance of the students in the two specified groups. 2 tailed t-test statistics was used to analyse the numerical data got from the Mathematics Achievement Test. The result shows that the students in the experimental group taught subject to TPSACK framework outperformed their counterparts in the control group taught with traditional lecture mode. Hence, the adaptation of TPSACK framework in teaching and learning process has significant positive effect on the achievement of Pre-service mathematics teachers in mathematics. It then becomes a key reference for the Mathematics educators to equip themselves with TPSACK framework adaptation to enhance teaching and learning process in Colleges of Education.

Keywords: TPSACK framework, Mathematics Educators, Pre-Service Teachers, College Mathematics, Teaching and Learning, Achievement.

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Introduction

The roles of Mathematics Educators in teaching and learning process of mathematics cannot be overemphasized. Mathematics Educator could be seen as the “driver” of whatever goes on in the teaching – learning process in mathematics class. Mathematics as a subject could be described as the ‘heart’ of science and technology. The functional roles of mathematics to science and technology are complex and diverse in the sense that every area of science, technology and business enterprise cannot do without applying it. The quality of teaching – learning process that is obtainable in Mathematics class is a function of the Mathematics educator skills of presentation, pedagogy of teaching/learning adopted, the medium/media through which the content of the lesson is delivered to the students, and the learning environment among other key factors. Ukeje (1986) in his research has defined mathematics as the mirror of civilization in all the centuries of painstaking calculation, and the most basic discipline for any person who would be truly educated in any science and in many other endeavours. Ebele et al (2008) finds that mathematics laboratory has positive impact on the achievement of mathematics students in mathematics.

Pre-service Mathematics teachers are teachers on training (trainee teachers) i.e. students in higher institution of learning studying mathematics education. Higher institutions saddled with the responsibility of producing teachers in Nigeria are solely categorized as: University of Education and Colleges of Education. The minimum requirement to become a teacher in Nigeria is to obtain Nigerian Certificate in Education (NCE). This study is carried out on Pre-service Mathematics teachers in their second year of training in Adeniran Ogunsanya College of Education, Otto/Ijanikin, Lagos State in Nigeria.

However, many students in the college of education finds it very difficult to comprehend the various mathematics courses taught in abstraction. The abstractness is encouraged by traditional pedagogical lecture approach and this by extension translates to poor mastery of the content of mathematics courses offered. The poor mastery of the students eventually led to failure in the mathematics courses taught. This problem may be due to the teaching of the topic in abstraction which is more or less the traditional approach which we referred to in this paper as constructivist instruction mode. This paper seeks to find out if a well-organized Technological Pedagogical Selection Content Knowledge (TPSACK) framework will improve pre-service teacher’s performance in Mathematics courses. We hope the TPSACK framework will benefit the teaching and learning process in the following regards:

- The dynamism of the framework will arouse the interest of the pre-service teachers in learning mathematics courses.
- It will make teaching and learning of Mathematics courses more meaningful to both the Mathematics Educators and the Pre-service teachers.
- It will remove boredom away from the students’ faces.
- It will make Mathematics lectures more practical-oriented and students centred.
- The students will become the master of their own learning as the teaching and learning process is enhanced by Technology which encourages them to search and explore on the content of Mathematics courses.
- It will improve pre-service mathematics teachers’ academic performance in mathematics courses at large.

Statement of Problem

The past results of many Pre-service mathematics teachers in College mathematics Education is not encouraging in the department. Many of the pre-service teachers in the college of education has very low grade in Mathematics courses and large number of them failed mathematics courses and need to re-write the examinations in the following year. Some students' case was very pathetic that one may suspect that they have Mathematics Dyscalculia as they couldn't cope till they were being rusticated out of the College. In an effort to improve the mathematics performance of pre-service mathematics teachers in Colleges of Education, we intend to experiment if the proposed TPSACK framework will enhance teaching and learning process and by extension translate to better achievement of the pre-service teachers in College Mathematics Education.

In developed countries appropriate use of Information and Communication Technology (ICT) in school education is considered a key factor in improving quality of teaching and learning process. Unfortunately, in the third world countries such as Nigeria, Tanzania, Ghana, Cameroon, Togo, Benin republic, just to mention but few, Technological Pedagogical application in teaching and learning process has not been explored to its fullness. This without doubt will have an enormous negative effect on the teaching- learning in our schools and by extension dictate the quality of teachers we produce. High inflow of unequipped (half-baked) teachers into many of schools system after graduation from teachers' producing higher institutions has haphazard effect on the education standard and the growth of the society we live. If one continues to do things in the same way, such person will always have the usual unpleasant result. With Technological Pedagogical Selection Content Knowledge (TPSACK) framework adaptation in teaching and learning process, we hope better result will be achievable.

Research questions

1. What effect does TPSACK framework have on the mathematics achievement of pre-service mathematics teachers?
2. What impact TPSACK framework have on the gender achievement of pre-service mathematics teachers in College Mathematics Education?
3. Could TPSACK framework adaptation makes teaching and learning process meaningful and interesting to pre-service teachers?
4. What effect Technological Pedagogical Selection has on the content knowledge in the process of prepared lecture delivery to pre-service mathematics teachers?

Research Hypothesis

Ho_1: There is no significance difference in Pre-test and Post-test Mathematics Achievement of pre-service Mathematics teachers in the Experimental Group.

Ho_2: There is no significant difference in Mathematics achievement of pre-service mathematics teachers taught with TPSACK framework in the experimental group and their counterpart in the control group taught with *constructivist mode of instruction (lecture mode)*.

Ho_3: There is no significant gender difference in the Mathematics achievement of pre-service mathematics teachers taught with TPSACK framework in the experimental group.

Existing Literature Review

Technological Pedagogical and Content Knowledge (TPACK) framework recognizes teaching as an extremely complex form of problem pursuing and problem solving using flexible and integrated knowledge. New understanding of the complex, and context-situated nature of teachers' technology integration knowledge or termed as technological pedagogical content knowledge (TPACK) (Mishra & Koehler, 2006; Mishra, P., & Koehler, M. J. 2007; Koehler & Mishra, 2008; Koehler, M. J., & Mishra, P. 2009) has led to questions how this knowledge can be developed and evaluated. Some other authors have carried out research on TPACK framework. Hsueh-Hua, CHUANG, Chao-Ju HO, (2011) carried out an investigation on Early Childhood Teachers' Technological Pedagogical Content Knowledge (TPACK) in Taiwan. A descriptive Study of Secondary Teachers' Curriculum-Based, Technology-Related Instructional Technological Pedagogical Content Knowledge (TPACK) was also done by Judith B. Harris and Mark J. Hofer, (2009).

There are seven (7) different knowledge areas obtainable from TPACK model cited in Bakare, Babajide Mike (Jnr) (2019) and these are: (i) Content Knowledge (CK), (ii) Pedagogical Knowledge (PK), (iii) Technological Knowledge (TK), (iv) Pedagogical Content Knowledge (PCK), (v) Technological Content Knowledge (TCK), (vi) Technological Pedagogical Knowledge (TPK) and (vii) Technological Pedagogical Content Knowledge (TPCK).

TPACK framework has also been documented in (Bull, G. & Bell, L. (2009), and Matthew, J. Koehler, Punya Mishra, Mete Akcaoglu and Joshua M. Rosenberg, (2013). The framework is considered useful to teaching and learning process.

Our proposed TPSACK framework stems from TPACK framework by adding another key parameter “S” representing “Selection” to the existing framework TPACK. However, the description of TPSACK framework will not be too different from the parent framework TPACK proposed some years back except by the inclusion of ‘selection’. The purpose of adding the term “Selection” is centred on the fact that wrong selection of technology, pedagogy and content can even do more harm to teaching and learning process. In order to circumvent this, we wish to make it clearer to pre-service teachers in mathematics and educators the need for possessing selection knowledge of the key components highlighted in TPACK framework. Educators need to consider the content of the lesson to be taught, the knowledge he/she has about the content, the knowledge of the pedagogy suitable for the content among many other available pedagogies, knowledge of the appropriate technology for teaching the content effectively from many other technologies. The knowledge of selection determines the quality of choice he/she makes in adapting TPACK framework.

An overview of the proposed TPSACK framework

In an addition to the existing TPACK framework, we consider the inclusion of the term “Selection” such that we have “Technological Pedagogical Selection and Content Knowledge” (TPSACK) framework. The justification for such inclusion is as a result of the fact that it is not enough to design a Technological Pedagogical Content without having the understanding of the appropriate Selection of Technology and Pedagogy suitable for the delivery of the lesson content to the learners. Consequently, the following terms emanated from this proposed TPSACK framework: Technological Selection Knowledge (TSK), Pedagogical Selection Knowledge (PSK), and Content Selection Knowledge (CSK). We then characterized teachers’ knowledge on the following four broad cores from TPSACK framework as: Technology, Pedagogy, Selection and Content.

The TPSACK framework is then summarised to have the following components:

(i) Technology Selection Knowledge (TSK), (ii) Pedagogical Selection Knowledge (PSK) (iii) Content Selection Knowledge (CSK), (iv) Technological Selection Content Knowledge (TSCK), (v) Pedagogical Selection Content Knowledge (PSCK), (vi) Technological Pedagogical Selection Knowledge (TPSK) and (vii) Technological Pedagogical Selection Content Knowledge (TPSCK). For easy pronunciation, we refer to the seventh component which is the universal set of all the components as (TPSACK) Technological Pedagogical Selection and Content Knowledge.

Methodology

A well-organized teaching aided by TPSACK framework adaptation was conducted on the experimental group to study if the proposed framework will have any significant impact on teaching and learning of Mathematics achievement of students.

Population sample and sampling technique

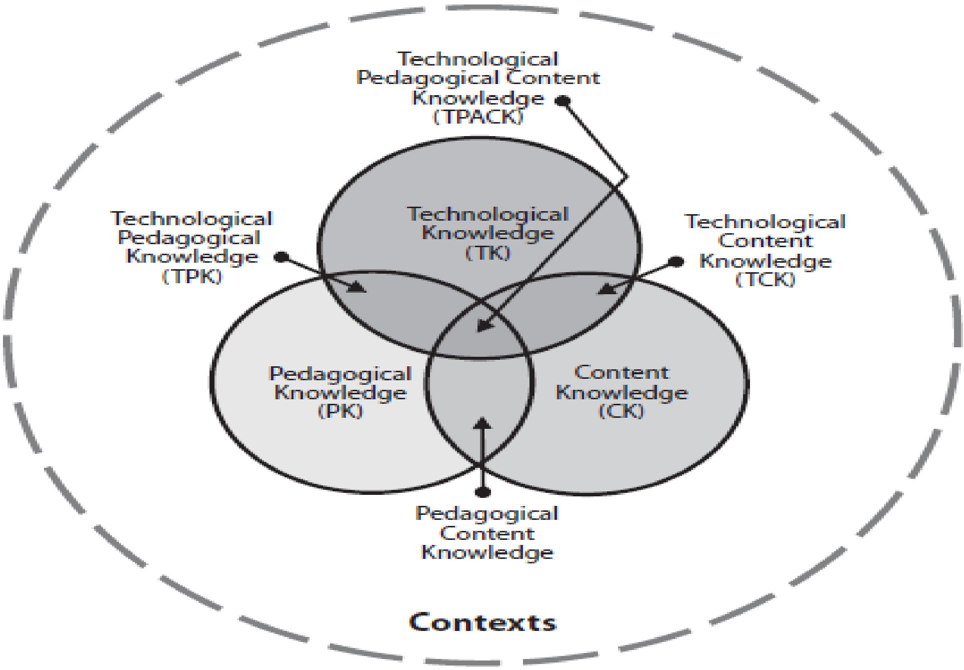

Figure 1: TPACK Framework

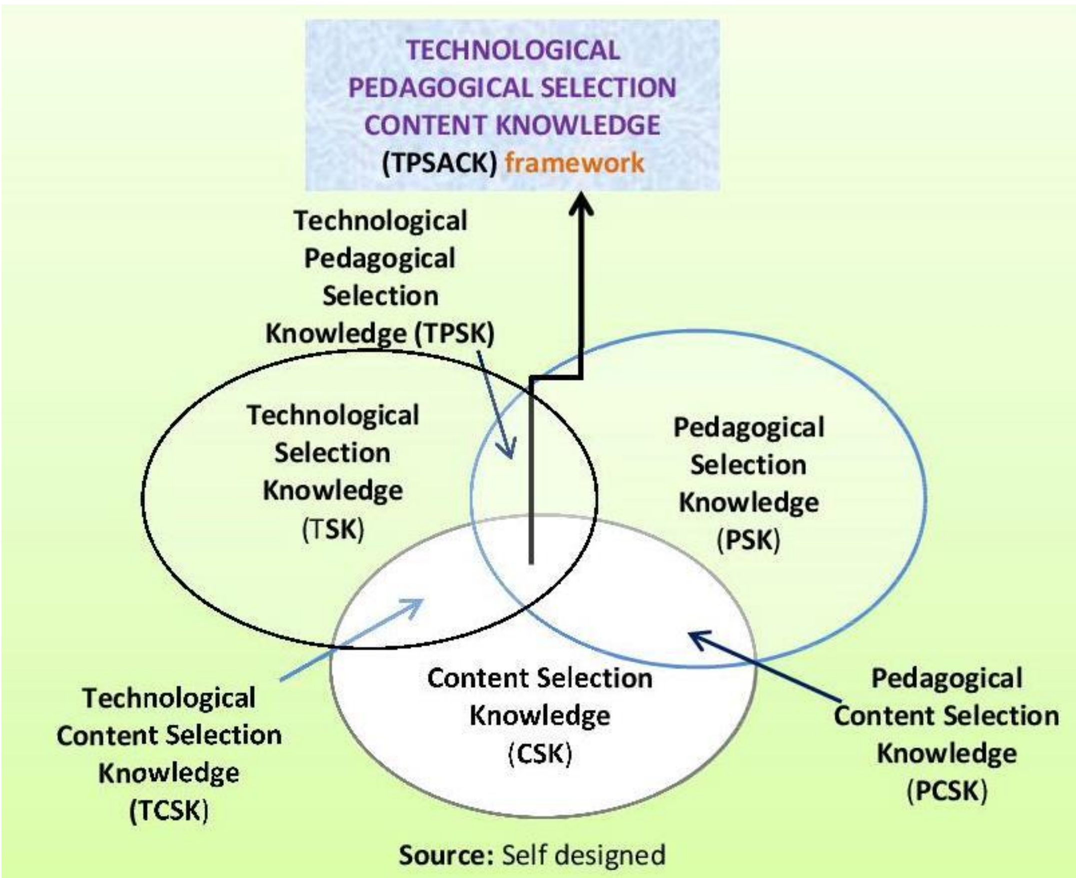

Figure 2: Proposed TPSACK Framework

One hundred and fifty (150) Pre-Service Mathematics teachers in Adeniran Ogunsanya College of Education, Otto – Ijanikin, in Lagos State, Nigeria were chosen for this research. Random Sampling technique was used to select the sample. The sample chosen includes second year male and female pre-service mathematics teachers in the Department of Mathematics. Seventy five (75) of them were placed in an Experimental Group (TPSACK framework) and the other seventy five (75) were placed in Control Group (Lecture mode) without any bias. The sampling technique adopted in placing the students to the above named groups is simple random sampling.

Experimental process

The experimental group was exposed to the lectures taught with a well-organized TPSACK framework on two selected Mathematics courses: Mat 211 Integral calculus and Mat 222 Vector Analysis in College of Education Mathematics curriculum. The Control Group was subjected to the traditional lecture method (constructivist instruction mode) on the same selected Mathematics courses in College of Education Mathematics curriculum. The duration of the pilot test last for ten (10) weeks. The course contents in the above two chosen mathematics courses were taught carefully selecting appropriate available Technologies in teaching the Experimental group. Although there are shortcomings sometimes in the availability of an appropriate technology to effectively teach some of the topics. We know that TPACK or TPSACK framework is complex. Some of the technological tools used in facilitating the teaching and learning process are: Mobile classroom devices, PowerPoint and Excel, Print resources, productivity tools such as (presentation software like Easy worship, slides, PowerPoint etc.), Mathematical software (Matlab, Mathematica, Maple and GeoGebra), Internet facility, Search Engines, Projector, Projecting screen, Visual enhancement.

SMART Classroom Technology

This would have made the teaching learning process more interesting but not yet available in the Department as at the period of this research. According to Bakare, B.M. (Jnr), (2019), SMART classroom technology is the collaboration of SMART board and other devices and workstations that will help to boost the classroom activities. In agreement with the statement of Bakare, B.M. (Jnr) (2019) above, the use of Interactive board such as Cleverboard and Starboard makes teaching and learning process very effective. It contains and embedded Teaching aids that one can refer to while teaching. The dynamic nature of smart board makes learning very interesting to students and removes boredom.

Instrumentation

Mathematics Achievement Test (MAT) instrument was used to measure the performance of the students in the two specified groups. This consists of standardized Mathematics Achievement Test questions which were given to the Pre-service teachers in both groups at the end of the pilot test. The validity of the questions was determined by some other lecturers in the Department.

Data presentation

In an effort to answer the research questions and hypothesis formulated at the earlier part of this study, Pre-test and post-test of Mathematics achievement Teat were conducted, marked and scored. Student's 2 tailed t-test statistics was used to analyse the numerical data got from the Mathematics Achievement Test administered to both groups before and at the end of the 10^{th} week of rigorous teaching in favour of the Experimental Group under TPSACK framework. We reported the result of pre-test of both groups before the commencement of the pilot test in Table 1 in order to determine the initial level of performance of the pre-service teachers. The post test results were computed using 2-tailed t-test statistics analysis. The results obtained were presented in the Tables 2-4 in sequel.

Table of Results

Table 1: Pre-Test Result for both Control Group (Lecture method) and Experimental Group (TPSACK framework)

GROUP	N	Mean	S.D	df	t Calculated	T Critical	α-level of significance
Control Group	75	48.3	7.2	148	1.98	1.976	**0.05**
Experimental Group	75	45.8	8.1				

Table 2: Pre-Test and Post-test Result for Experimental Group (TPSACK framework)

TEST	N	Mean	S.D	Df	t Calculated	T Critical	α-level of significance
Pre-test	75	45.8	8.1	148	20.50	1.976	**0.05**
Post-test	75	70.4	86.4				

Table 3: Post-Test Result for Control Group (Lecture method) and Experimental Group (TPSACK framework)

TEST	N	Mean	S.D	Df	t-value Calculated	t Critical	α-level of significance
Control Group	75	51.2	7.4	148	16.882	1.976	**0.05**
Experimental Group	75	70.4	6.4				

Table 4: Post-Test Result for Gender effect in Experimental Group (TPSACK framework)

TEST	N	Mean	S.D	df	t-value Calculated	T Critical	α-level of significance
Control Group	34	62.5	7.4	148	20.015	1.992	**0.05**
Experimental Group	41	78.3	6.4				

Results Analysis and Discussions

The Table 1 reports the Pre-Test Result for both Control Group (Lecture method) and Experimental Group. This was measured by given the students general mathematics achievement test to ascertain the level of their performances in each category. The test of the initial data reveals that at 2-tailed t-test analysis α-level of 5%, there is no significance difference in the Mathematics Achievement of both pre-service Mathematics teachers in both groups before the pilot test commenced. Comparing the t-calculated value 1.98 and the t-critical value of 1.976, the two values are at the same level. This result is good as it shows that the two categories of pre-service students are at very close level of performance prior to the experiment.

Hypothesis 1 Analysis

Ho_1: There is no significance difference in Pre-test and Post-test Mathematics Achievement of pre-service Mathematics teachers in the Experimental Group.

The Table 2 reports the Pre-test and Post-test result obtained for the Experimental Group at the end of the Adaptation of TPSACK framework. We saw huge difference in the mean score in favour of Post-test. The pre-test mean score was 45.8 while post-test mean score was 70.8 which really revealed that the TPSACK frame work has significant positive effect on the Pre-service Mathematics Teachers Achievement in Mathematics. The null hypothesis 1 was rejected since the t-calculated value of 20.50 > 1.976 of t-critical value at $t_{\{\alpha/2,\ 148\}}$, α = 0.05. Hence, TPSACK framework enhanced the Pre-service teachers' achievement in College Mathematics course.

Hypothesis 2 Analysis

Ho_2: There is no significant difference in Mathematics achievement of pre-service mathematics teachers taught with TPSACK framework in the experimental group and their counterpart in the control group taught with constructivist mode of instruction (lecture method).

The main result of our findings was reported in **Table 3**. Post-Test Result for Control Group (Lecture method) and Experimental Group (TPSACK) framework. The achievement post-test result of the Experimental group outweighs that of Control group with mean score of 70.4 against 51.2 respectively. The t-calculated value = 16.882 while t-critical value = 1.976. Since t-calculated value is greater than t-critical value at α = 0.05, the null hypothesis Ho_2 above was rejected. The 2-tailed t-test statistical analysis of the scores at the chosen level of significance thus shows that (TPSACK) framework has huge positive influence on the Mathematics Achievement of the Experimental Group.

Hypothesis 3 Analysis

Ho_3: There is no significant gender difference in the Mathematics achievement of pre-service mathematics teachers taught with TPSACK framework in the experimental group.

The analysis of result on hypothesis 3 is documented in Table 4 above. The Post-test Achievement of the female Pre-service teachers in the experimental group was 62.5 in mean while the Male mean score was 78.3. Their joint mean score amount to 70.4 as obtained in Table 3. T-calculated value = 20.015, t-critical value = 1.992. The hypothesis 3 was rejected as well since t-calculated value > t-critical value at $t_{\{\alpha/2,\ 73\}}$, α = 0.05. The male pre-service teachers performed better than the female with respect to the TPSACK framework in our investigation. The case may not be the same in other institutions. Also, if the framework is replicated the following year on other set of students, the reverse may be the case in terms of gender result obtained here.

Conclusion

This study investigated the impact of Technological Pedagogical Selection Content Knowledge (TPSACK) framework which was a slight improvement on the popular TPACK framework on Pre-service teachers Achievement in Mathematics. The result shows that the students in the Experimental Group taught using TPSACK framework outperformed their counterparts in the Control Group taught with traditional lecture mode. The general outcome of our findings revealed that TPSACK framework is effectively capable of improving Mathematics achievement of Pre-service Mathematics teachers in college of education Mathematics. In comparison with the findings of Albert et al (2010), it was discovered that ICT in teaching enhances several processes related to teaching and learning in particular, those involving attention, perception, responding mechanisms, application of learning and understanding. Hence, we strongly recommend the adaptation of TPSACK model to enhance mathematics achievement of students generally in mathematics. Mathematics educators are therefore encouraged not to relent in their efforts to make teaching and learning process dynamic. There is no student that cannot learn, one can only have a dull teacher and a dull classroom.

This implies that a resourceful educator can bring transformation to students learning difficulties and make the situation of every learner better. The framework presented in this paper is one of such ways of transforming teaching and learning process.

Recommendations

The following recommendations were made based on our findings.

1. Mathematics educators should inculcate TPSACK framework into teaching and learning.
2. It is expedient for Mathematics educators to undergo regular training on the use of an enhanced Technological Pedagogical Content Knowledge.
3. It is the role of the Mathematics teachers to dictate learning aided by Technology and not technology dictating for the teacher what to do.
4. SMART board should be provided with the necessary workstations in Colleges of Education to enhance dynamism in teaching – learning process.
5. Mathematics educators should see it as a functional role in selecting appropriate technology driven pedagogies suitable for the content of a lecture and deviate from the total traditional lecture method especially in Mathematics class.

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