International Journal of Latest Research in Humanities and Social Science (IJLRHSS)
Volume 06 - Issue 07, 2023
www.ijlrhss.com || PP. 49-57

A survey of high school teachers' opinions on using the APOS theory to help students develop problem-solving skills while studying the coordinate method in the plane in class 10

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Abstract: APOS theory is an instructional theory on how to learn the mathematical concepts studied; the application of APOS theory to the teaching of mathematics to help build students' understanding of various mathematical concepts. APOS theory creates a detailed structure consistent with learning mathematical concepts. APOS theory also assumes that mathematical knowledge results from the one-on-one construction of knowledge and helps students build a good academic spirit and understanding of mathematical ideas. The application of APOS theory to teaching mathematics helps to improve the ability to understand concepts, contributing to the formation and development of mathematical competencies for students. This study surveyed 43 high school teachers' general understanding and views on math competencies, problem-solving abilities, and APOS theory in teaching and learning the coordinate method in the plane in class 10; the research is carried out to serve as the basis for applying APOS theory to teaching the topic of coordinate method in the plane in class 10. Research results show that most teachers understand and see the importance of teaching in developing students' competencies (especially the ability to solve mathematical problems). However, most of the teachers in this survey barely knew the APOS theory.

Keywords: APOS theory, problem-solving, the coordinate method in the plane, teacher's opinion.

1. Introduction

In a world that is in the process of innovation, development and integration, it is necessary not only to achieve the goals of socio-economic development and environmental protection but also to pay attention to the renovation of education - training; in Vietnam, education towards the 2030 Sustainable Development Goals is "Ensuring quality, equitable and inclusive education and promoting lifelong learning opportunities for all."

The goal of the current educational reform with the motto "Students-centered" is the innovation of teaching and learning methods to promote the activeness of students' learning and enhance self-study ability. , self-discovery. In Vietnam on education, the Resolution of the 4th Conference, the Central Committee of the Communist Party of Vietnam (Term VII) pointed out: Education and training must focus on training working people to be autonomous, creative, capable of solving common problems, thereby actively contributing to realizing the great goal of the country of a rich people, a strong country, and a just and democratic society.

Over the years, the quality of education at all levels has been improved, internationally recognized and appreciated. The quality of general education has changed well in both mass and spearhead; Primary and secondary education universalization was maintained, had positive changes and improved quality. The number of teachers and educational administrators has increased in quantity and improved in quality. Education management has been gradually renewed, with quality management attached importance; initially well implemented the policy of promoting autonomy and accountability of educational institutions. To achieve the above results in recent years, the innovation of teaching methods in Vietnam has had some positive changes. School educators and teachers have researched and applied modern teaching methods, such as discovery and problem-solving, constructivist teaching, discovery teaching, etc., through each lesson and exercise. These innovative teaching methods have the same requirement to make students active in cognitive activities. Students must actively explore, discover and verify acquired knowledge into a useful knowledge system for each individual and community. That teaching method has initially been effective and is considered one of the main directions of the innovation of teaching methods. In current teaching methods, teachers use many models and theories, including Bruner Theory, Gestalt Theory and RME, in which APOS theory makes an important contribution to teaching in high schools.

In Mathematics, according to the 2018 general education program, there are requirements to achieve specific competencies "Math contributes to the formation and development of students' mathematical competence (the most concentrated expression of computational competence) including: includes the following core components: mathematical thinking and reasoning abilities; mathematical modeling ability; ability to solve

mathematical problems; mathematical communication competence; ability to use tools and means of learning mathematics". The ultimate goal of learning is to solve real-life problems, overcome difficulties and find optimal solutions to problems that arise outside of practice. Therefore, the ability to solve problems is considered one of the very important general competencies that need to be formed and developed early for students in learning and life [1].

When researching problem-solving capacity, scholars worldwide generally have similar opinions about the concept and components of problem-solving capacity. This is considered one of the abilities with an important position for people to adapt to the development of society. According to Polya, the problem-solving process consists of four steps: Understand the problem, plan to complete it, solve it according to the plan, and finally check all the steps taken. Recent studies on problem-solving processes in teaching mathematics are often developed based on Polya's problem-solving process [2], typically in the mathematics document PISA (the international program for student assessment). The problem-solving phase is to build a formula, form a mathematical model and finally give a solution [9].

Problem-solving is one of the most fundamental goals of teaching math and one of the most elusive for students. The thinking process of strategic problem-solving requires organizational ability. It will give students critical, logical and creative thinking. One study also showed that students are often only interested in the final answer without understanding how the answer is processed, and they find it difficult to determine which concepts are used to solve the problem [12].

APOS is a constructivist learning theory originally developed by Dubinsky et al. (2014); APOS stands for the words action (Action), process (Process), object (Object) and finally (see Figure 1) [16]. Schemas are the thinking structures students must build to understand a new mathematical concept deeply [6], [10].

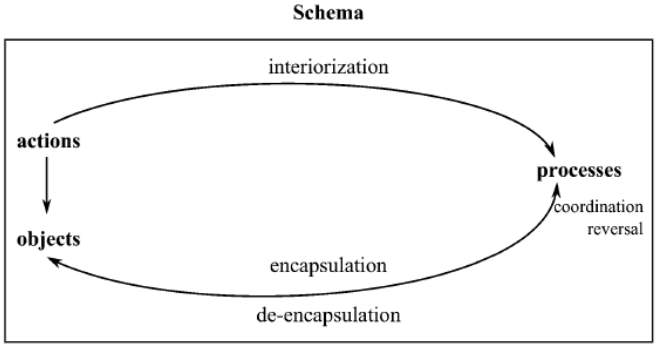

Figure 1: APOS Theory [4]

Understanding a mathematical concept begins with manipulating previously constructed mental structures or a physical object to form activities, which are then followed. collected into processes and will continue to be summarized to form new objects. New objects can be de-encapsulated back to the process in which they were formed. Finally, actions, processes, and objects are reorganized to form the schema [4], [5],[8].

APOS theory is applied to teaching mathematics through the ACE learning cycle, which is a pedagogical strategy consisting of three components: (A) Activities; (C) Classroom discussion and (E) Exercises done outside of the classroom. In arranging learning activities, APOS theory requires an assumption of a mathematical concept. The result of this analysis is called a genetic decomposition [6], [11].

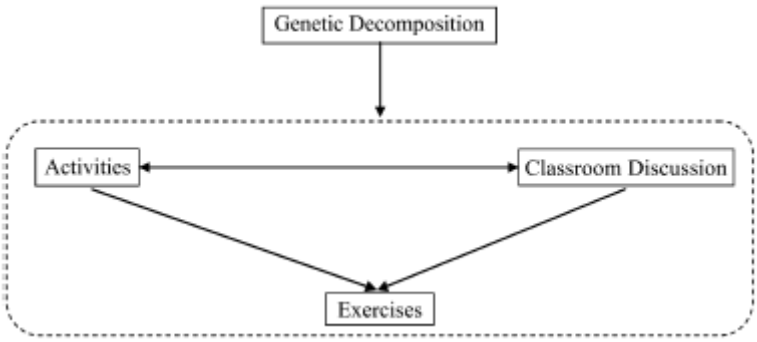

Figure 2: The relationship between genetic decomposition and the ACE cycle [4]

According to Figure 2, the genetic decomposition of a mathematical concept is a sequence of mental structures to construct a mathematical concept that develops in one's mind. Thus, genetic decomposition requires a mental structure of actions, processes, objects, and schemas that describe certain mathematical concepts [14].

Some typical works related to APOS theory in math teaching can be mentioned as follows:

Author Maharaj discussed several measures to help improve students' understanding of two concepts of the coordinate method in the 10th plane when using APOS theory to analyze students' understanding of these two concepts [1, 2]. Similarly, APOS theory is used to discover students' thinking mechanisms and structures as they perform demonstration activities to develop some measures to assist students in building formal proof [10]. APOS theory has been applied in combination with OSA theory to analyze the understanding of 10th-grade students when learning about the topic of coordinate methods in the 10th plane (sample of 80 students) has shown that most of them have difficulty in learning the topic of coordinate methods in the plane in class 10 [15].

Based on the genetic decomposition, Salado & Trigueros designed activities in the ACE learning cycle to teach the concepts of feature values, eigenvectors and vector spaces [3]. In a study examining the impact on student achievement of applying APOS theory to the teaching and learning of elementary Linear Algebra, Arnawa conducted a study on 65 students from the University of Andalas, which includes 35 students of the experimental class and 30 students of the control class. Research results show students' understanding level increases when applying APOS theory to teaching linear algebra [5], [7]. Applying GeoGebra software combined with flexible teaching methods, based on APOS theory, to clarify the limited "conceptual image" to improve students' ability to understand the concept of limits [13]. This finding opens up an excellent opportunity to propose technology-integrated math curricula.

Coordinating methods in the plane in class 10 is an important piece of knowledge in high school; when it comes to geometry, it is impossible not to be interested in analytic geometry, a subject that can see the link between geometry and algebra. Analytic geometry studies geometrical objects using algebra based on the coordinate method. The coordinate method on the plane is the position of each point determined by the intersection of two points (called two points of coordinates) belonging to two different coordinate objects. The coordinate method is an achievement of the seventeenth and eighteenth centuries but has its roots in ancient history. However, at this stage, the development of the coordinate method was restrained due to the lack of written symbols and the lack of a general view of numbers.

The French savants Fermat and Descartes made the greatest contribution to the construction of analytic geometry, using the literal notation proposed by the French savant, both Fermat and Descartes (independently). At the same time, he contributed to science a new method - the coordinate method, which served as the basis for the analytic geometry they built in the 7th century. The transfer of the coordinate method into three-dimensional space was carried out only at the end of the seventeenth century and continued in the eighteenth century in the works of several scientists, such as Moreover, at the end of the eighteenth century, analytic geometry became a complete science taught in the first years of university education.

To investigate an overview of the difficulties students face when learning coordinate methods in the plane in class 10. Coordinating methods in the plane in class 10 is important; many application contents are in real life. Table 1 is a table of minimum requirements for students in the topic of coordinate methods in the plane in class 10 of high school.

Table 1: Requirements for knowledge and skills on the topic of coordinate methods in the plane in class 10

Lessons	Achieved requirements	
	Knowledge	Skills
Coordinates of vector	Help students understand: - Understand the concept of coordinate axes, and coordinate systems. - Understand the coordinates of vectors and points on the coordinate axes. - Understand coordinate expressions of vector operations. - Understand the coordinates of the point and the coordinates of the vector in the plane. - Understand the coordinates of the line segment's midpoint and the triangle's centroid. - Understand the application of	Forging for students: - Determine the coordinates of the point and the coordinates of the vector on the axis. - Can calculate vector operations. - Calculate a vector's algebraic length when its two endpoints' coordinates are known. - Find the midpoint of the line segment's coordinates and the triangle's center of gravity's coordinates. - Determine the condition that two vectors are perpendicular. - Determine the two-way condition.

	coordinate expressions of vector operations.	- Calculate the length of a vector - Calculate the distance between two points Calculate the angle between two vectors.
Line in the coordinate plane	Help students understand: - The concept of direction vectors and normal vectors of lines. - Formula for writing parametric equations, general equations of straight lines. - Relationship between the graph of the first-order function and straight line. - Relative position between two lines. - Angle between two lines. - The interval from a point to a straight line.	Forging for students: - Determine the direction vector and the normal vector of the line. - Determine the point on the line. - Write parametric equations and general equations of straight lines. - Know the relationship between graphs of first-order functions and straight lines. - Determine the relative position between two lines. Calculate the angle between two lines. - Calculate the distance from a point to a line.
Circle in the coordinate plane	Help students understand: - Define the equation of a circle with a given center and radius. - The condition for an equation to be developed is a circle equation. - Equation of a tangent to the circle.	Forging for students: Determine the center and radius of the circle. Write the equation of a circle with a given center and radius. Write the equation of a circle passing through 3 points. - Identify the expanded form of a circle equation and determine the center and radius. Write the equation of the tangent to the circle.
Three Conic lines in the coordinate plane	Help students understand: - Definition of Ellipse - The canonical equation of the ellipse - Definition of Hyperbola - Hyperbola's canonical equation - Definition of Parabola - Parabola's canonical equation	Forging for students: - Identify the elements of the ellipse - Know how to write the canonical equation of the ellipse. - Identify the factors of Hyperbole - Know how to write the canonical equation of Hyperbola. - Identify the elements of the Parabola - Know how to write the canonical equation of the Parabola.

Concepts related to the topic of coordinate methods in the plane in class 10 are very abstract and complex for high school students; they find it difficult to learn directly the concepts related to the topic. Therefore, the study and application of APOS theory in teaching the topic of coordinate methods in the plane in class 10 will create many benefits in teaching math on the topic of coordinate methods in the 10th plane in particular, as well as Mathematical geometry in general, contributing to the development of students' mathematical ability.

2. Method

This is a study conducted to survey the views of teachers, the current situation of teaching in the direction of capacity development in general and the ability to solve mathematical problems in particular, as well as the ability to apply APOS in teaching Mathematics (especially for the topic of coordinate methods in the plane in class 10). Specifically, the study includes the following surveys:

1) The level of teachers' interest in teaching in the direction of capacity development in general and mathematical problem solving in particular.
2) Teachers face difficulties and challenges when teaching mathematics in the direction of competency development.
3) Teachers' understanding of APOS theory in teaching mathematics and the feasibility of applying APOS theory to teaching the topic of coordinate method in the plane in class 10.

The research process is depicted in the diagram below (see Figure 3):

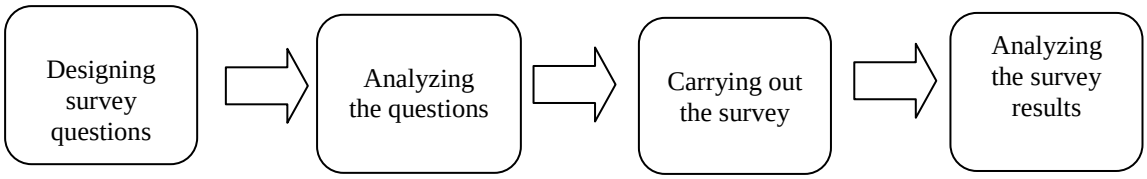

Figure 3: The process of research

A survey was conducted with 43 teachers teaching Mathematics in high schools in Vietnam, including high schools in Soc Trang City and some neighboring provinces such as Hau Giang, Bac Lieu, and Ca Mau. The survey consists of 10 questions to collect information about teachers' opinions on teaching and developing mathematical competence in the topic of coordinate method in the plane in class 10(especially problem-solving ability) and information related to APOS theory.

3. Result and Discussion

Question 1. What is the extent of the teacher's understanding of the Mathematical General Education Program issued in 2018?

Table 2: Statistics of teachers' opinions on question 1

Scale	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
f	0	0	0	35	8
%	0	0	0	81.4	18.6

The 2018 Mathematics General Education Program is considered a guideline for new teaching methods in the coming time; this question is designed to investigate the level of understanding of middle school teachers for this program. The results obtained from Table 2 show that most teachers have learned about the 2018 Mathematics General Education Program (with a rate of 81.4%). This indicates that the teachers at the high schools have the necessary knowledge about the objectives, content, teaching methods and assessment under this program. Also, applying new teaching techniques that the Ministry of Education and Training support is advantageous in this situation.

Question 2. When teachers participate in teacher training/retraining sessions, how often is the teaching content to develop students' mathematical ability mentioned?

Table 3: Statistics of teachers' opinions on question 2

Scale	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
f	0	0	0	39	4
%	0	0	0	90.7	9.3

Question 2 was surveyed to investigate teachers' access to teaching content in the direction of competency development. The results from Table 3 show that 90.7% of teachers have attended training sessions where the content teaching-oriented to develop competence in the spirit of the General Education Program in Mathematics 2018 is frequently mentioned. Thus, for this survey, the results show that most teachers have access to teaching methods oriented to developing students' mathematical abilities. This demonstrates that capacity development-oriented teaching content interests most of the provinces in the survey.

Question 3. How do you evaluate the importance of the goal of forming and developing mathematical competence for students?

Table 4: Statistics of teachers' opinions on question 3

Scale	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
f	0	0	0	35	8
%	0	0	0	81.4	18.6

Table results of the teachers' interest in developing students' mathematical competence are shown in Table 4 of question 3. The percentage of teachers who realize the importance of this goal accounts for more than one-half of the total number of teachers participating in the survey (ratio 81.4%). In general, the survey results of this question show that most teachers are in high agreement to form and develop students' mathematical competence. The application of novel teaching techniques is advantageous under these circumstances.

Question 4. How do you assess the importance of the goal of developing math problem-solving abilities for students?

Table 5: Statistics of teachers' opinions on question 4

Scale	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
f	0	0	0	41	2
%	0	0	0	95.3	4.7

Question 4 was designed with the purpose of testing teachers' interest in developing students' ability to solve math problems. The results obtained from Table 5 give a similar result to the results obtained from Question 3. The number of teachers who perceive the importance of developing math problem-solving competence for students accounts for more than the total number of teachers participating in the survey (41 teachers, 95.3% rate). With such a result, it can be observed that the research on applying APOS theory to develop math problem-solving abilities for students will be easily accessible to most high school teachers.

Question 5. Do you have advantages when teaching to develop students' general ability and math problem-solving?

Table 6: Statistics of teachers' opinions on question 5

Scale	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
f	0	5	15	20	3
%	0	11.6	34.9	46.5	7.0

Question 5 aims to discover the difficulties teachers often face when teaching to develop mathematical competence, especially the ability to solve math problems for students. The results from Table 6 show that the most serious difficulty for teachers is the time needed to organize activities to develop problem-solving capacity for students (with five teachers who did not agree, the ratio of 11.6%).

Uneven knowledge between classes is also a big obstacle for teachers (with 15 teachers being less favorable, accounting for 34.9%). With the survey results on difficulties such as those related to teaching in the direction of capacity development in general and the ability to solve math problems for students in particular, the application of APOS theory to teaching learning to develop problem-solving capacity for students is urgent; the ACE teaching cycle is a simple learning cycle (only three phases: Activity, class discussion, and homework. home) will contribute to overcoming the difficulties encountered by teachers above, helping students to understand concepts deeply and thereby improve students' ability to solve math problems.

Question 6. What typical situations do you find necessary to design and organize teaching in order to develop students' ability to solve math problems?

Table 7: Statistics of teachers' opinions on question 6

Scale	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
f	1	1	2	39	0
%	2.3	2.3	4.7	90.7	0

The question investigates teachers' perceptions of building situations to develop students' ability to solve math problems. According to Table 7's findings, most teachers believe that creating realistic situations to teach problem-solving is the key to problem-solving ability lies in choosing solutions from relevant mathematical knowledge, so students need to understand concepts and theorems to solve problems well. The ACE Teaching Cycle (a learning cycle built on APOS theory) will help students better understand math concepts by building activities that promote the construction of mental structures for a mathematical concept.

Question 7. How did teachers learn APOS theory in teaching Math?

Table 8: Statistics of teachers' opinions on question 7

Scale	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
f	42	1	0	0	0
%	97.7	2.3	0	0	0

This question was designed to grasp the teacher's initial APOS theory. The results from Table 8 show that almost all teachers participating in the survey have not learned about APOS theory in teaching mathematics (42 teachers have not heard at all, a rate of 97.7%). This is a surprising result because APOS is a popular learning theory worldwide. The follow-up questions of the survey focused on exploring teachers' views on teaching and learning to develop mathematics competencies in the topic of coordinate method in the plane in class 10 and the feasibility of applying APOS theory to teaching.

Question 8. How is the teacher interested in developing students' ability to solve mathematical problems in teaching coordinate methods in the 10th-grade plane?

Table 9: Statistics of teachers' opinions on question 8

Scale	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
f	0	0	2	38	3
%	0	0	4.6	88.4	7.0

The results of Table 9 have shown the teachers' interest in the ability to solve mathematical problems, and the purpose of question 8 is to determine the teachers' interest in developing problem-solving competence in the topic of coordinate method in the 10th-grade plane. Survey results from Table 9 indicate that 38 teachers (accounting for 88.4%) pay attention to developing problem-solving capacity for students in this topic. However, two teachers (accounting for 4.6%) still have little interest in developing students' problem-solving ability in the topic of coordinate methods in the 10th-grade plane. The research orientation is evident here. Additionally, teaching and developing problem-solving capacity in coordinating methods in the plane in class 10 is practical and will receive the attention and agreement of most high school teachers.

Question 9. When teaching situations on the topic of coordinate methods in the plane (especially teaching concepts), how is the teacher's interest in issues related to the origin of that concept?

Table 10: Statistics of teachers' opinions on question 9

Scale	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
f	9	8	25	1	0
%	20.9	18.6	58.1	2.4	0

The results obtained from Table 10 show that the level of interest of teachers in the origin of a concept in the topic of coordinate methods in the plane in class 10 is relatively low, with only one teacher (accounting for 2.4%), the number of teachers who care little and do not care is 17 (accounting for 39.5%). The warm-up activities in learning situations in the ACE teaching cycle (a teaching cycle built from APOS theory) will be a hint to help teachers realize the importance of this issue and help students learn new math content more actively.

Question 10. When teaching situations on the topic of coordinate methods in the plane (especially teaching concepts), how interested is the teacher/teacher in the student's homework?

Table 11: Statistics of teachers' opinions on question 10

Scale	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
f	0	0	0	5	38
%	0	0	0	11.6	88.4

Different from the results obtained from survey question number 9, the results from Table 11 reveal that the number of teachers interested in using homework to help students revise and deepen their knowledge is quite large (with 38 teachers, accounting for 88.4%). Thus the third phase (homework) in the ACE teaching cycle will be accessible to most teachers.

4. Conclusion

After conducting the survey and collecting the above survey results, it shows that the majority of high school teachers have access to the general education program issued in 2018; one of the important contents of this program is: teaching in the direction of capacity development, especially the ability to solve mathematical problems. Most teachers recognize the importance of this new teaching method, which is reflected in teachers' positive feedback on sentences related to developing students' abilities. In addition, the survey results also show the difficulties teachers often face when applying teaching methods oriented toward developing math problem-solving abilities. In particular, the greatest difficulty that teachers face is the difficulty in terms of elaborate preparation and time to organize activities as well as the required requirements of the ability to solve mathematical problems, which have also been This section shows the benefits of the training courses of the Ministry of Education and Training on the 2018 general education program.

Thereby another surprising result obtained from this study is that almost all of the teachers participating in the survey are unfamiliar with APOS theory in teaching Mathematics, despite the popularity of this theory when applying it. The application of APOS theory to teaching different topics is quite high, from high school to university level; for example, the studies applying APOS theory to teaching different topics all demonstrate a positive effect on students when applying APOS theory.

Regarding coordinate methods in the plane in class 10, the survey results also show that teachers have realized this is an important topic and paid great attention to developing problem-solving capacity for students (with 88.4% of teachers saying that they are interested and very interested). However, in teaching this topic, teachers often pay special attention to the construction of teaching and problem-solving situations (a rate of 90.70%) and less attention to situations of teaching concepts and theorems (interest rate is only 2.3%). It shows that this is a topic with many abstract and complex concepts; the results are consistent with the research on teaching the topic of coordinate method in the plane in class 10; teachers often stop at the level to help students understand concepts and use the exercise to an example to help students create a problem-solving process, as demonstrated by the teacher giving special attention to the student's homework (accounting for 90.70%). However, this can also be seen as an advantage for applying APOS theory to teaching content in the topic of coordinate methods in the plane in class 10 because the third phase of the ACE learning cycle focuses on using Use homework to synthesize knowledge for students.

In addition to the findings, the study has some limitations. With several 43 teachers participating in the survey and concentrated in neighboring provinces in the same area, the research results are certainly local, reflecting only teachers' views on the development of mathematics competence of students in this area.

5. Recommendations

The content of the study clearly shows the importance of teacher training. Therefore, the teacher training program should include subjects related to capacity development-oriented teaching methods and APOS theory. New studies can be carried out with larger samples, extending the scope of the survey geographically or by grade level. The survey on the current status of research and application of APOS in teaching Mathematics to future teachers at teacher training schools is also of practical significance. The study and application of APOS theory in teaching the coordinate method in the plane in class 10 is completely feasible and will certainly benefit students' development of math problem-solving capacity.

6. References

[1]. D. A. Istikomah and P. Jana, "Mathematical Prolem Solving Ability in APOS Modified Learning Model (M-APOS)," Journal of Physics: Conference Series, Vol. 1264, pp. 1-6, 2019. DOI: 10.1088/1742-6596/1254/1/012071.

[2]. G. Polya, *How to Solve It*, 2nd ed. New Jersey: Princeton University Press, 1985.

[3]. H. Salado and M. Trigueros, "Teaching Eigenvalues and Eigenvectors Using Models and APOS Theory," The Journal of Mathematical Behavior, Vol. 39, pp. 100-120, 2015.

[4]. I. Arnon, J. Cottrill, E. Dubinsky, A. Oktaç, S. R. Fuentes, M. Trigueros, K. Weller, *APOS Theory. A framework for research and curriculum development in mathematics education*. New York: Springer, 2014.

[5]. I. M. Arnawa, Yanita, Yerizon, B. Ginting, and S. Nita, "Does the Use of APOS Theory Promote Students' Achievement in Elementary Linear Algebra?," International Journal of Instruction, vol. 14, no. 3, pp. 175-186, 2021.

[6]. M. Asiala, A. Brown, D. DeVries, E. Dubinsky, D. Mathews and K. Thomas, "A Framework for Research and Curriculum Development in Undergraduate Mathematics Education," American Mathematical Society, Vol. 6, pp. 1–23, 1997.

[7]. M. G. Baye, M. A. Ayele and T. E. Wondimuneh, "Implementing GeoGebra integrated with multi-teaching approaches guided by the APOS theory to enhance students' conceptual understanding of limit in Ethiopian Universities," Heliyon, Vol. 7, pp. 1-13,2021.
[8]. M. Rohmah, S. Sutiarso, "Analysis Problem Solving in Mathematical Using Theory Newman," Eurasia Journal of Mathematics, Science and Technology Education, Vol. 14, no. 2, pp. 671- 681, 2018.
[9]. S. Saragih and W. L. Habeahan, "The Improving of Problem Solving Ability and Students' Creativity Mathematical by Using Problem Based Learning in the SMP Negeri 2 Siantar," Journal of Education and Practice, Vol. 5, no. 35, pp. 123-132, 2014.
[10]. Syamsuri, Purwanto, Subanji and S. Irawati, "Using APOS theory framework: Why did students unable to construct a formal proof? " International Journal on Emerging Mathematics Education, Vol. 1, no. 2, pp. 135 146, 2017.
[11]. I. M. Arnawa, U. Sumarno, B. Kartasasmita, and E. T. Baskoro, "Applying the APOS theory to improve students ability to prove in elementary abstract algebra," Journal of the Indonesian Mathematical Society, pp. 133–148, Jul. 2012, DOI: 10.22342/jims.13.1.80.133-148
[12]. I. M. Arnawa et al., "Does the Use of APOS Theory Promote Students' Achievement in Elementary Linear Algebra?," International Journal of Instruction, vol. 14, no. 3, pp. 175–186, Jul. 2021, DOI: 10.29333/iji.2021.14310a
[13]. M. G. Baye, M. A. Ayele, and T. E. Wondimuneh, "Implementing GeoGebra integrated with multi-teaching approaches guided by the APOS theory to enhance students' conceptual understanding of limit in Ethiopian Universities," Heliyon, vol. 7, no. 5, p. e07012, May 2021, DOI: 10.1016/j.heliyon.2021.e07012
[14]. H. Alamolhodaei, V. Borji, and F. Radmehr, "Application of the APOS-ACE Theory to Improve Students' Graphical Understanding of Derivative," EURASIA Journal of Mathematics, Science and Technology Education, vol. 14, no. 7, May 2018, DOI: 10.29333/ejmste/91451
[15]. V. Borji and V. Font, "Exploring Students' Understanding of Integration by Parts: A Combined Use of APOS and OSA," EURASIA Journal of Mathematics, Science and Technology Education, vol. 15, no. 7, Apr. 2019, DOI: 10.29333/ejmste/106166
[16]. E. Dubinsky, "Actions, Processes, Objects, Schemas (APOS) in Mathematics Education," Encyclopedia of Mathematics Education, pp. 8–11, 2014, DOI: 10.1007/978-94-007-4978-8_3

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Tran Thi Hong Dao has been the Secretary of the School Union for more than 13 years and is also a teacher of Mathematics at a high school in Soc Trang City, Soc Trang province, Vietnam. In the past 15 years, she has always learned from her colleagues to develop her expertise to improve the quality of teaching for the unit in particular and the whole Vietnam Education industry in general, recognized and awarded certificates of merit by the Central Youth Union, Central Association and the Ministry of Education and Training.

Along with serving as an associate professor and advanced senior lecturer at the School of Education at Can Tho University in Can Tho City, Vietnam, **Duong Huu Tong** also works as an education consultant. He has 19 years of experience and has become knowledgeable in various fields, including mathematics education and the development and evaluation of curricula.