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Attitudes change during an Integration of Modeling Course in Year 10 - The Application of the ABC Model

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ABSTRACT: *Attitude - an important psychology concept has got attention in education research around the world. In Vietnam, research related to students' attitudes towards studying science subjects is still quite new. This study conceptualizes and operationalizes attitudes, and measures students' attitudes toward learning mathematics. Building on previous studies, we designed an instrument that based on the ABC model of attitudes to measure how 128 high school students in Hue City changed their attitudes towards mathematics when participating in modeling tasks. The results showed that many students (59.4%) expressed their dislike of Mathematics even though they perceived Mathematics as an important subject. However, student attitudes have gradually changed in a positive direction after taking a mathematical modeling course; they shared their love towards authentic tasks. This shows the students had changed their attitudes about mathematics and were cognizant of its utility.*

KEYWORDS: **Mathematics, attitude measurement, students.**

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1. Introduction

Gardner (1975) emphasized the importance of positive affective aspects, such as happiness, excitement, and satisfaction towards learning. Attitudes influence behaviors and these behaviors have a great impact on individuals and society (Reid, 2006). Realizing the importance of attitudes in mathematics education, researchers have measured students' attitudes toward mathematics (Aiken, 1972, 1974, 1979; Aiken & Dreger, 1961). Attitudes have gradually received much more attention in mathematics education recently. For example, Lim and Chapman (2014) argued that research on students' attitudes towards mathematics in the world has been quite exciting. Many models and instruments to measure students' attitudes towards mathematics have been adopted and developed such as *The Attitude toward Mathematics Inventory (ATMI)* (Lim & Chapman, 2014).

In Vietnam, affective aspects have not received enough attention in education research. Only a few studies have developed and tested a scale to measure high school students' attitudes towards Chemistry (Phuong, 2021). Research on the affective domain in mathematics education is still scarce, which needs more attention. This study focuses on measuring how Grade 10 students' attitudes toward mathematics change when they engage in a course that integrates mathematical modeling into their normal class. It addresses the following research question:

How do Year 10 students' attitudes towards mathematics change due to the integration of modeling into the curriculum?

2. Theoretical framework

Affective aspects have received attention in mathematics education (McLeod, 1992). One line of research focuses on the role of emotion in mathematical thinking and problem-solving (McLeod, 1992). Another line focuses on the role of affection in learning and in the social context of the classroom. The emotional status can represent learning attitudes or predicting future success. The concept of affection is an important part of cognitive theories (Snow & Farr, 1987). In mathematics education, Mandler (1989) applied these ideas to teaching and learning how to solve mathematical problems. Mandler (1989) considered three aspects of affection including beliefs, attitudes, and emotions. Most of the studies in mathematics

education have used one or more of these concepts. However, the theoretical background underneath these concepts has not been clear. Attitudes have perhaps the longest history in mathematics education (DeBellis & Goldin, 1997). Several authors (e.g., Di Martino & Zan, 2001) have shown that attitudes have a vague structure; they are often used without a clear definition and should have a theoretical development.

It has been challenging to come to a consensus on defining attitudes in psychology. For example, Allport (1935) defined attitudes that incorporate: *"an individual's psychological processes that determine the individual's reactions in society (p. 6)"*. With regard to experiences, attitude is defined as: *"a psychological and neurological state ready to organize through experiences that influence or be the driving force for an individual's response to all objects and situations related to it"* (p. 8). From another perspective, *"attitude is the emotional level of satisfaction or dissatisfaction with an object or a value"* (p. 10). Psychologists (e.g., Bagozzi & Burnkrant, 1979; McGuire, 1985) regarded that attitudes consist of three components (cognition, affection, and behavior), which are not necessarily mutually exclusive. The concept of attitudes related to affect, behavior, and cognition is considered as a theoretical framework underlying later studies and is referred to as the ABC (affection, behavior, cognition) model. For example, Joseph (2013) refers to attitudes as the tendency for an individual to respond positively or negatively to an object, situation, or view of someone. It is also related to an individual's beliefs that reflect their views (cognitive) and affective, sometimes manifest in behaviors. Joseph used this model to understand the attitudes toward mathematics of 869 elementary and middle school students from the African region by measuring the following aspects: (a) perceived usefulness (cognition); (b) confidence, anxiety, enjoyment (affection); and (c) intrinsic motivation (behavior).

In this study, we consider attitudes as an affective state that manifests through behavioral expressions, based on cognition. As such, attitudes consist of three components: cognition, affection, and behavior (see Figure 1). The cognitive component includes opinions or beliefs about the object. For example, students believe (cognitive) mathematics is an important subject that will be the cornerstone of attitudes, which are manifests in students' behavior such as actively participating in mathematics activities. Of course, the performance in the behavior is also greatly influenced by the affective state: like or dis-like, self-confidence or lack of confidence, positive or negative emotions.

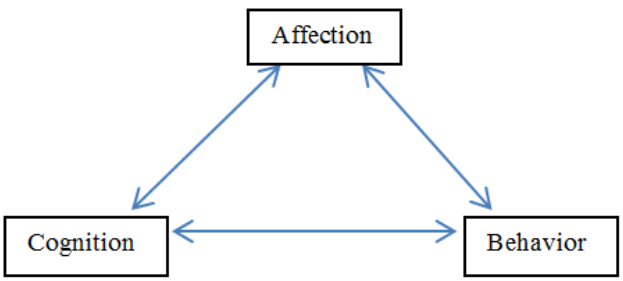

Figure 1. Model of attitude

Personal behaviors, cognition, thinking, and response to any subject or person are controlled by attitudes, which can influence the person's judgments and decisions. Therefore, if a learner is having difficulty in a topic, this can hinder the individual's learning process. For example, during the process of learning mathematics, students gain knowledge and, at the same time, may have a (negative or positive) attitude towards mathematics. Negative attitudes towards mathematics may lead to students avoiding further study. In short, attitudes are important and central to many aspects of education because they allow students to have a conscious assessment of the knowledge, affect, and behavior.

Previous studies focused only on one or two sides of the model (ABC). Davadas and Lay (2018) study how students' beliefs and competencies are influenced by teacher support. Sakiz (2007) focuses on students' emotional aspects. Some researchers combine all three aspects in one study (e.g., Alenezi, 2008; Joseph, 2013; Syyeda, 2016); however, these studies target primary and junior high school students in the African region. For example, in a study related to attitudes towards learning and teaching mathematics, Alenezi (2008) investigated 1346 students aged 14-16 attitudes towards mathematics and

their effects on memory capacity and academic achievement. Many studies argue that students' attitudes towards mathematics are influenced by their experience in the math classroom and thus may be influenced by changes in teaching methods (McLeod, 1992). The current research aimed to measure high school students' attitudes toward mathematics change when they engage in a course that integrates mathematical modeling with authentic tasks into the classroom.

3. Research Method

3.1. Course Setting

This is part of a bigger project that implements mathematical modeling into the current curriculum. We used an island approach of integration - a pilot project including design thinking, invention education, and participatory design (Bulmer & Haladyn, 2011) to augment modeling tasks into the current curriculum in Grade 10 classrooms. We adopted the hierarchy of modeling tasks (Tran & Dougherty, 2014) in designing and integrating tasks that fit with the curriculum. Three types of problems were used: word problems, standard applications, and true modeling problems. Word problems are merely the "dressing up" of a purely mathematical problem in words referring to a segment of the real world (Niss et al., 2007, p. 11). Standard applications, problems in which the solution strategy is immediately at hand *"without further regard to the nature of the given real-world context"* (Niss et al., 2007, p. 12) and the translation of the problem's information to the mathematical analysis is relatively straightforward. Standard applications reflect some level of translating from the real-world context to the mathematical problem and thus are different from word problems. Finally, true modeling problems involve the full modeling cycle: Start with a question, then formulate a model, and finally solve, interpret and validate within a mathematical and contextual situation (Niss, Blum, & Galbraith 2007; Tran & Dougherty, 2014).

Students engaged with word problems and standard application problems throughout the course. At the end of the study, students finished a true-modeling problem, designing a bridge for Hue city, which is a real project happening in the city at the time of conducting the teaching experiment. As this paper focuses on the attitude aspect, we will discuss next the instrument design and data collection.

3.2. Research Instrument

The ABC model was used as a framework to design the instrument. The survey instrument was designed by using a combination of the following methods: Likert, Semantic, or Rating. Alenezi (2008) argued the advantages and disadvantages when using different approaches to measuring attitudes. We adapted items used in previous research (Alenezi, 2008) to design a survey that consists of 57 statements focused on four constructs: (a) *importance of mathematics* and (b) *student beliefs in math learning* (cognition); (c) *preference* (positive/negative interest) and (d) *confidence in math learning* (emotion) (see Table 3.1).

Table 1. Four constructs in the survey

Content	Statements	For example
1. The importance of math	10	(1d) I think math is a useful subject
2. Preference	16	(1b) I don't like math exercises
3. Confidence in math learning	10	(3a) You are pretty confident in math class
4. Belief with math learning	21	(1c) You must have an innate ability to be good at math

The instrument includes two open-ended questions: *"Write three sentences to explain why you like or dislike mathematics."*, and *"Do you think mathematics is an important subject? Explain why."* to collect extra qualitative data about students' attitudes.

The survey was first administered to 90 students for face validity. This was to check language clarity and consider if the instrument was to measure the constructs. After revising the instrument based on the feedback in the pilot study, we administered the instrument twice during the semester: first in Week 5 Semester 1 2018-2019 before students started to engage in modeling tasks and second

in Week 15 after they finished the true-modeling project at the end of the semester.

Participants include 128 Grade 10 students from Hai Ba Trung High School (one class) and Thuan Hoa High School (two classes), Hue City, Vietnam. This is a convenience sampling. Notwithstanding, the students of these two schools differ in geography and academic entry. Both schools are located in the center of Hue city, but Hai Ba Trung high school students live mainly in the city and have higher entrance requirements. Thuan Hoa high school was established in 2013, run by the University of Education, Hue University taking students from all over the region; however, most of them are from Huong Thuy District. These 10th-grade students were selected to participate in the teaching experiment. This grade level was chosen as it is the transition period from middle school to high school and also the age that PISA chooses to assess modeling competencies. The students spent 45 minutes, each time completing the paper-and-pencil survey. Data were collected and transferred to Excel for further analysis.

The data were coded using the SPSS 20 statistical software for descriptive statistics analysis. The change in the pre-and post-survey was documented by comparing how the students responded to the items. Open-ended responses were coded by first applying the ABC model to classify if the part of the statement refers to cognition, affection, or behavior (a priori coding). Finally, an emergent coding for analyzing themes related to student interest and student preference for mathematics was applied. The current study focuses mainly on two aspects of cognition (C) and affection (A), the other aspect of behavior (B) is evaluated in another study through students' participation in mathematical modeling.

4. Results

4.1. The statistical test of the difference in students' cognition and affection towards mathematics through two surveys.

Table 2 shows descriptive statistics of attitudes regarding the pre and post-survey. The data were coded in numerical form and grouped into two groups related to cognitive and affective aspects. Then, the mean was calculated by the SPSS program to compare the change between groups in mean and the significance level of that difference.

Table 2. Paired Samples Statistics

		Mean	N	Std. Deviation
Cog.	Pre-cognitive	3,18	128	0,493
	Post-cognitive	3,47	128	0,560
Aff.	Pre-affective	2,24	128	0,649
	Post-affective	2,459	128	0,5750

The statistical test shows that the mean of cognition aspect in the pre is 3,18 and is 3,47 in the post; the mean of affection in the pre is 2,24 and the post is 2,46. Regarding the cognitive aspect, the mean is calculated for the statements of the Likert scale with five levels (strongly agree, agree, neutral, disagree, strongly disagree). Therefore 3,18 can be considered as close to neutral and 3,47 in the post-survey is gradually more cognitive. For the affective aspect, besides the statements of the Likert scale, there are also two-choice statements (eg, like or dislike) so we only compare the mean in the post is higher than that of the pre and the details would be analyzed for the specifical statements in the survey.

Table 2 shows paired t-tests for the pre and post-survey. The differences were statistically significant for both the affective and cognitive constructs, in which students' attitudes change toward a positive direction at the end of the course ($p < 0,05$).

In general, both of the cognitive and affective constructs improved at the end of the course. Next, we will describe the details of changes with examples.

4.2. Cognitive Aspect

The importance of mathematics is related to realizing the usefulness of learning and applying mathematics in life. The results showed that 77 (60,2%) students agreed and strongly agreed that mathematics was a useful subject in the pre-survey. However, only 55 (43,0%) students agreed and strongly agreed with the statement

Table 3. Paired Samples Test

		Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Cog.	Post-cognitive Pre-cognitive	0,289	0,775	0,069	4,219	127	0,000
Aff.	Post-affective Pre-affective	0,2164	0,8424	0,0745	2,907	127	0,004

"I found that my mathematical knowledge is useful for life". These results were similar in the post-survey, 78 (61,0%) for the first statement and 57 (44,5%) for the second. This shows that many students perceived mathematics as a useful subject but less than half found mathematics have any practical application in their life.

However, in the pre-survey, the vast majority (88,3%) of the students thought *"math is an important subject?"* when responding to the open-ended item. They thought mathematics is important for exams and future work. The student replied, *"Yes, thanks to math that we can apply to other subjects and math are present in most of the exams"*; *"Yes, it is an important subject, in the exams training into college, useful for some future work"*. About 94,5% saw the importance of mathematics as a subject in the post-survey. It suggests that almost all students thought mathematics as important because that subject is present in entrance exams and mandatory in the high school graduation exam.

Beliefs in students' mathematic learning focus on the inborn nature of mathematics ability and ways to learn mathematics effectively. Very few students agreed that they need to have an inborn ability to learn math (8,6% in the pre-survey and 14,9 % in the post-survey). That means they thought that students need to practice much in this subject. Furthermore, the students also believed that mathematical tasks will become easier if presented in pictures, diagrams (66,5% in the pre and 62,6% in the post), and authentic tasks (86,7% in the pre and 82,1% in the post). In both pre-and post-surveys, the students believed that math tasks are easier if they are represented graphically rather than algebraically. The students also preferred practical over abstract problems. The analysis suggests that the students desired to learn mathematics by understanding and seeing the applicability of Math in life.

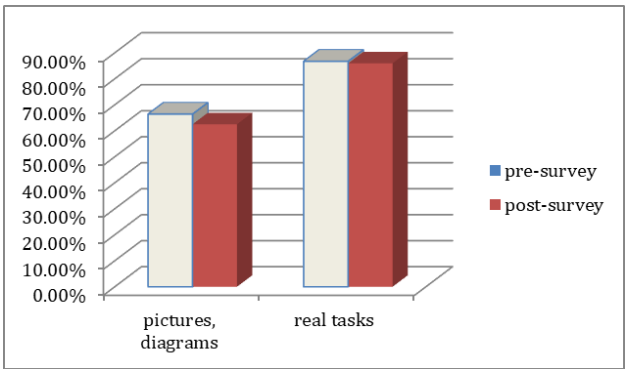

Figure 2. Methods to support understanding mathematics

In the post-survey, more students thought mathematics is important and useful for every life. When choosing options for why they should learn mathematics, most (%) students selected *"it teaches me how to think logically"* and *"there are many jobs that need to use math"* instead of *"it's important for some other subjects."* Besides, more students believed that mathematics tasks become easier if they are presented in pictures, diagrams, and practical tasks. With questions regarding which methods will aid in understanding mathematics, students highlighted using mathematics to solve real-life problems in the post-survey instead of using computers and searching the internet in the pre-survey.

4.3. Affective Aspect

Emotion towards mathematics is directly related to emotional states of liking or disliking mathematics. At the beginning of the project, in the responses to the open-ended question: *"Write three sentences to explain why you like or don't like math"*, 76 (59,4%) students expressed their dislike of mathematics. The reasons included the subject being difficult or abstract. Most of them recognized the importance of mathematics but disliked mathematics because of their beliefs about the application of mathematics in life and the mathematical connection between life and the

subject seemed very vague. However, in the post-survey, this number has decreased significantly, only 21 students (16,4%) disliked mathematics. One of the reasons is that after the modeling course, students have seen the applicability of mathematics in real life. Some of the students also shared their mathematical applications at home such as planting trees and tracking height to building functions for that growth.

Confidence in learning mathematics is related to how students feel about participating in solving a task and the preferred types of classroom activity because they directly affect their feeling. The students were not confident in learning mathematics and had the pressure to take exams, which in turn affected their feelings towards this subject. The majority of the students did not feel confident in mathematics class (78,9%) and mathematics exams (86,7%). However, they felt more confident when successfully solving a task (68%). In the post-survey, the percentage of students who felt more confident when successfully solving a task was 73,5%.

About the favorite type of classroom activities, the two most-often-chosen options in both surveys were 1) solving real-world problems and 2) working in groups. However, the choices in the post-survey have changed compared to the pre-survey (see Figure 3). There are 26 students (20,3%) who liked solving real-world problems in their classroom and this figure increased 35 (27,3%) in the post-survey. In contrast, 35 students (27,3%) liked working in groups in the pre-survey and only 21 (16,4 %) liked it in the post-survey. Although both of these options were most chosen, in the post-survey, students tended to lean towards the first option which is to solve

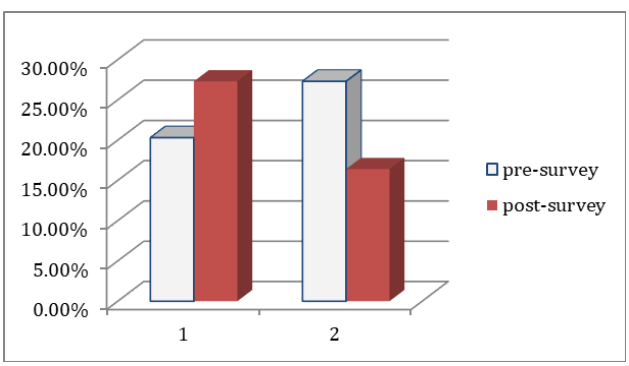

Figure 3. Favorite types of classroom activity

real problems. This shows that students have gradually seen the application of mathematics.

In the post-survey, the number of students who liked mathematics increased significantly by 96 (75%) (Figure 4). The main reason was students thought that mathematics is interesting, beneficial for life, and useful for work and daily life. Students felt more confident when successfully solving a task and understanding what is being learned in class. Also, the number of students who felt confident participating in group discussions has increased.

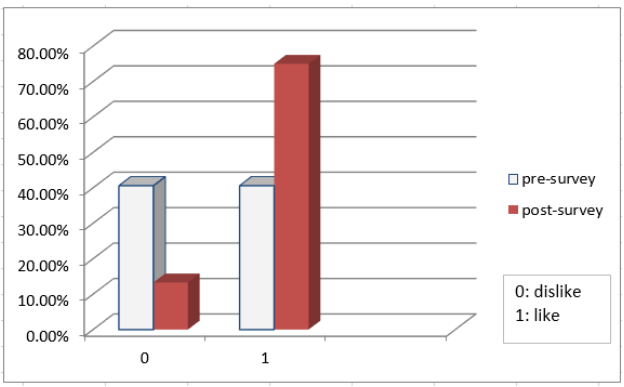

Figure 4. Affective for mathematics

5. Discussion

This study documents how high school students' attitudes towards mathematics change as a course of modeling implementation. The results show that students were aware of the importance of mathematics but disliked it. They disliked it, but still needed to learn it as mathematics is the main subject and somewhat more important than other subjects.

Most students also realized the importance of learning mathematics. It can be seen that the majority of students choose Mathematics because it is important. The subject is present in most university entrance exams and is compulsory in the high school graduation exam. Most of the students realize the importance of mathematics and learning mathematics, but at the same time, they still show a dislike of mathematics because of their belief in the application of this subject in their life; and the connection between mathematics in the classroom and in the reality seems very vague. This may also be one of the cultural factors because most students and

parents in Vietnam view mathematics as the main subject and somewhat more important than other subjects.

Moreover, students mostly think that math is important but do not like math for the main reasons such as difficult math, many formulas, many algorithms, and abstraction. A previous study also found that students had similar views and assumed that math tasks in school consisted of given information and data and were unrelated to reality (Tran et al., 2019). However, after the experiment, the children's attitudes and feelings towards Math have gradually changed in a positive direction. This is also confirmed through the process of participating in modeling, students showed enthusiasm and answered interviews expressing their views on math changed in a more interesting direction after being acquainted with the practical tasks.

Students' attitudes have gradually changed towards a positive direction, especially when they were aware of the connection between mathematics and life through mathematical modeling tasks. A student shared: *"At first, I have found myself forgetting a lot of knowledge. But after doing real-world tasks, I understand better"*. Students think that the real-world tasks are closer and easier to understand, especially when they can explore and discuss with their peers. This makes them feel more confident and that is also the reason why they are more interested in learning Mathematics. Another student also commented: *"Mathematics is interesting, it is a core subject and requires lifelong mathematics. It is not only paper (theory) but also practical application"*. This student has realized the importance of Mathematics and has a desire to be an architect in the future. Many students changed their opinion after four modeling tasks, specifically 96 (75%) students showed an increasing favor of math by 34.38% compared to the pre-survey. These students explained the main reason for the change as follows.: *"I didn't like it at first because it was difficult, challenging, and not useful for future careers"*. However, that view has changed after the modeling course: *"it is difficult but it also interesting and it is beneficial for real life"*. Students also added: *"I don't like abstract exercises and tests. They preferred to study and test real-life problems because there are many opportunities for experimentation"*. The results show that, when students are cognizant of the importance and applications of Mathematics, their attitudes towards learning Math are gradually more positive.

This provides evidence that student experiences change the way they view mathematics, especially the practicality of the subject. Previous research shows multiple trends of students' attitudes regarding mathematics from a cultural perspective (Alenezi, 2008). Here, the difference between Vietnamese culture and other countries is that math is considered a "main subject", which can be seen as a firm belief of Vietnamese. The positive outlook about mathematics might improve their ongoing intake of the subject not just for the exam. Future research can explore the long-term impact of changes on their mathematics performance and disposition towards the subject.

6. Conclusion

In mathematics education, the concept of attitudes often has a vague structure and is sometimes ambiguously distinguished from beliefs (Hannula, 2014). This study examined the concept derived from the psychology model. The ABC (cognitive, affective, and behavioral) model in psychology is used to measure attitudes in a comprehensive way and is specifically applied in mathematical situations.

This study draws on research from mathematics education and psychology. Through the modeling tasks, students' feelings and attitudes towards mathematics gradually become more positive. Thus, when students participate in modeling, they are not only participating in a system that includes only mathematical concepts but also express emotions, attitudes through behavioral expressions.

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