

**AC 2009-2535: A STUDY ON THE CHANGES OF ATTITUDE TOWARD STEM
AMONG SENIOR-HIGH-SCHOOL GIRLS IN TAIWAN**

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A Study on the Changes of Attitude toward STEM Among Senior High School Girl Students in Taiwan

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Abstract

This study aims to explore the change of attitude toward STEM among senior high school girl students after participating in a solar automatic trolley contest. The questionnaire survey and focus group interviews were adopted as research methodologies. The data was analyzed through attitude scale and the quantitative data and qualitative materials of interview contents. The subjects were the 11th grade girl students in a senior high school who participated in the solar automatic trolley contest in teams. A total of 77 students participated in 18 teams. The results found that 1) books and teachers were their important sources of scientific information and practical teaching was more likely to trigger learning motivation; 2) the advantage of the technology learning was the enhancement of the sense of achievement; the disadvantage was the effect of the effectiveness of work; 3) the learning engineering could cultivate systematic thinking, problem-solving ability; 4) mathematics is an indispensable tool in daily life and teachers have played an important role in mathematics learning. Therefore, the research proposed that school should create more successful learning opportunities as well as provide the models of successful women; schools and businesses should encourage women to grasp learning and working opportunities in STEM field; teachers should strengthen integrated professional knowledge about STEM through special topic production curriculum, strengthen students' integrated knowledge about STEM.

Keywords: senior high school girl students, STEM, attitude

I. Introduction

In an era of ever-changing technology, American education authorities found that the elementary and high schools could not provide their students with necessary knowledge and skills of science and technology. Since 1980s, America has aggressively been improving the curriculum of science, engineering and mathematics. Therefore, in 1985, American Association for the Advancement of Science (AAAS) launched a long-term project called “Project 2061” that committed to reform science, mathematics and technology education. The plan made recommendations for reforming teaching strategy of science, mathematics and technology. The planners argued that the past scientific method emphasized on the description of scientific knowledge and less on the provision the learning of applied mathematics or technology for students ¹. Besides, traditionally, the subjects of mathematics, science and technology emphasize on departmental teaching that students could not understand their relationship ². The learners will be benefited from the integration of teaching policies in linking their knowledge about mathematics, science and technology and daily life ³.

The American Society for Engineering Education (ASEE) also established a K-12 engineering research center to develop STEM integrated approach. In September 2003, ASEE issued engineering new guidelines for more than 350,000 middle school students across the country that helps the students to be familiar with the engineering technology at an early date⁴. So until today, many schools from elementary schools, middle schools and universities have implemented STEM integrated teaching method that the students may be interested in science, mathematics, engineering and technology at early date and join the study. Besides, according to the report in 2006, National Academy of Science drafted “Rising above the Gathering Storm” and presented four recommendations: improving the STEM education from kindergarten to 12th grade to enrich American talent pool, strengthen long-term basic researches develop and retain most prominent students, modify tax policy to encourage domestic investment in research and development ⁵. Therefore, we could find that American government, schools and businesses have committed themselves to the promotion of STEM integrated teaching.

After completing the study on the girls who participated in a contest, DeBartolo & Bailey ⁶ concluded that the number of girls who recognized that the engineering could solve the problems in daily life increased and they were more precise on the affirmation of engineering products. Women participated in the Robot plan showed positive changes in both of perceptibility and work interest in STEM field ⁷. Rebecca ⁸ conducted a study on the 8th to 12th grade of students and pointed out that after participating in workshop, the ratio of girls who consider studying technology in future increased.

In order to further understand if women’s attitude toward STEM field in recent years has

been different from traditionally stereotyped impression of female by the society, the researchers tried to understand senior high school girl students' viewpoints and attitude toward STEM in Taiwan through a solar automatic trolley.

II. Literature Review

A. STEM Integrated Teaching

STEM is to integrate the curriculum of scientific exploration, technology, engineering design, mathematic analyses as a teaching pattern in which “science” is to pursue and explore the principles of nature, “engineering” is taking advantaging scientific findings to design the tools needed by the society, “technology” is to practically manufacture the tools designed by the engineering for the convenience of people’s life, “mathematics” is the basis for acquiring scientific knowledge and conducting analyses and statistics in combining science⁹. The basic goal is to improve the teaching of science, technology, engineering and mathematics in campus, interest students and help ethnic minority, female, rural students to study or teach in the related departments. Its functions are: 1) cultivating good communication skills through team work; 2) helping student link theory and events in daily life; 3) cultivating do-it-yourself, independent thinking, creative thinking and problem-solving ability; 4) linking the scientific curriculum with engineering, technology, mathematics through the practical process of operation¹⁰⁻¹³. In order to improve the past traditional method in teaching science and mathematics, the researchers worked out main teaching policies including cooperative learning, exploratory and experimental teaching, the using of teaching media, new evaluation and giving teaching opportunity¹⁰.

To sum up, STEM integrated teaching is to use the integration of thematic approaches and combine the related curriculum of science, technology, engineering and mathematics for students to learn complete knowledge. It is different from the fragment of information in the past. Besides, it will help students to link the knowledge with what they learned in daily life in the real world. Furthermore, through the integrated teaching, students could think of the difficulties in daily life and find out solutions and thus apply their learned knowledge to their daily life.

B. The Relationship between Gender and Attitude toward STEM

The research by Kahle¹⁴ pointed out that the difference of achievement in genders is related with what ordinary people think about the mathematics and science education that boy and girl students have received, that is, it will be related to the prejudice of gender roles. Such

difference also leads to different interests, attitudes, achievements and admittance registration situation in junior and senior high schools. Besides, those differences could make great difference in senior high school education and the choices of occupations by the girl students. The research by Dawson ¹⁵ also found that there was a significant difference between genders in students' attitude toward science. The boy students showed significant positive attitude toward science.

As for learning attitude, the research by Verrall ¹⁶ pointed out that 70% of girls of 11 to 16 years old were willing to study science. They made the decision due to stimulation and challenges. The research by Janis ¹⁷ pointed out that the female's view had following changes and breakthroughs: 1) the gap between gender in mathematics performance has been smaller; 2) the difference of gender expectation in biology and mathematics has also been shortened; 3) have begun to emphasize on new achievement fields such as engineering and computer; 4) almost the same as the male, the female have earned higher level of academic degree in all subjects; 5) has refined our focus in other fields, such as biology to nature science; 6) in fact, comparing to the male and the majority, the female and the minority have performed better. Therefore, we could see that the today' female people have different learning attitude toward the STEM field from the past female people.

On the attitude towards occupation choices, the research by Hill and Wheeler ¹⁸ pointed out that if we described the scientist and engineers as white males, either bald head or confusion curls, wearing a pair of spectacles and white experimental clothes and do some dangerous experiments, how many young girls would say "I wish some day I could be one of them"? The research by Shelley ¹⁹ pointed out that the self-evaluation of mathematics ability by male was higher than that by female that the ratio of choosing science, mathematics, and engineering as their occupations was always high. But because females may have not been advised to prepare at early date for choosing scientific or technological work as their occupation, the topic of gender in workplace, persistent sex discrimination and the male-dominated occupation, the pressure of difficult trade offs between family and personal responsibilities when females engage in technologic work, most of the female people are not willing to pursue career in technology ²⁰⁻²¹. So females will be affected by the factor including the stereotyped impression of STEM workers by the society, no early preparations for the occupations in related with STEM, sex discrimination and role conflict. Davias ²² found that due to the significant lower interest in science by females, not many girl students will choose science as their life-long career. Also recognizing the fact, AAAS included the gender into Project 2061 with a hope that it could enhance their positive attitude toward science and urge females to choose science as their life-long career.

To sum up, the most of researches by scholars found that students' attitude toward STEM might be different due to the prejudice of gender roles; on the learning attitude, females have some breakthroughs and changes and are willing to, and able to, perform well in the STEM field, it is different from the past; on the attitude toward the occupation, the factors such as self-evaluation, outside stereotyped impression of the occupation, no early preparations for the occupation and role conflict will affect female's choice of occupations.

III. Research Design and Implementation

A. Subjects

The subjects of research were girl students from the Ping-tung Senior High School in southern Taiwan. A total of 80 questionnaires were sent out to those subjects. There were 77 questionnaires returned with a return rate of 96%. The 77 questionnaires were all valid questionnaires.

B. Research Tools

1. STEM Attitude Scale

The STEM scale is the tool developed by the researchers. The content includes four domains: science, technology, engineering, mathematics. The 77 senior high school girls filled out the scale based on their attitude toward STEM, learning attitude, career attitude after they participated in the solar automatic trolley contest. The scale was the 10-point Likert scale. With 0 as the middle point, it was divided into positive and negative five points each for choosing by the students. The scale was filled out by the students according to their changes of attitude toward STEM when they finished the contest. In order to establish validity for the scale, the researchers adopted three expert content validity after consulting with three experts. Besides, the researchers also conducted a factor analysis of scores obtained by 113 pre-test samples to obtain the construct validity of the questionnaire. The cumulative explained were 78% and the Cronbach's α of total scale was .92, indicating the reliability and validity of internal consistency of the questionnaire were good.

2. Interview Outlines

The researchers adopted semi-structure method to conduct interviews. The outline of the interview is described as follows:

Item	Content	
Science	Attitude	1. What kind of help do you think science could offer for natural phenomena?
	Learning	
	Attitude	2. Will you continue to learn higher level of scientific knowledge?
	Career	
Technology	Attitude	3. Will you be interested in engaging into science-related occupation?
	Learning	
	Attitude	1. What do you think technology could help you to achieve?
	Career	2. Will you study technology-related courses in future?
Engineering	Attitude	3. Will you engage into technology-related occupation?
	Learning	
	Attitude	1. Before and after contest, what are your views on engineering? What abilities it could bring to you?
	Career	2. Do you have confidence in advanced engineering courses in future?
Mathematics	Attitude	3. Is learning engineering helpful to applying a job in future?
	Learning	
	Attitude	1. What kind of help or effect do you think mathematics will bring to you?
	Career	2. Do you like to attend mathematics courses?
	Attitude	3. Is mathematics knowledge helpful to your future job?

C. Research Implementation

The problem situations designed by the research are: asking students to manufacture a solar automatic trolley of high speed and innovative shape with existing solar battery, motor and gear sets and complete six stages of task, the contents of task of each stage are: 1) confirming problem: ask students to confirm and describe through discussions the key questions of solar battery, motor and gear sets; 2) clarifying problems: based on the keys of the problem and problem-solving points described in the first stage, solve the problems through discussions and find out related knowledge about science, technology, engineering or mathematics; 3) planning: its content include outlines of the planning, framework, functions of the solar trolley, manufacturing process and steps and the difficulties that could encounter during manufacturing; 4) contingency plan: describe contingency plans and steps when encounter with difficulty in each stage; 5) realizing planning: according to drafted contingency, complete the initial model of solar automatic trolley and give simple introduction and characteristics description of the model; 6) assessment: with reference to the initial model completed in the fifth stage and conduct final test and modification of solar automatic trolley and describe process and what has learned from the test and modification as shown Figure 1 and Figure 2.

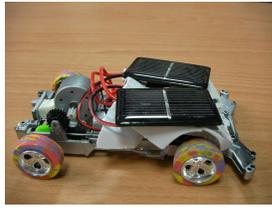


Figure.1



Figure.2

D. Research Methodology

1. Questionnaire Survey

The researchers conducted questionnaire survey among senior high school students in Taiwan to try to understand their attitude toward STEM learning. But the limit of the method is that the questionnaire could give an in-depth exploration into the feeling and thinking of the survey. Besides, the number of subjects and questionnaire return rate must be great enough to really bring the strong points of the method into full play. Therefore, the researchers adopted an appropriate and effective way to maintain a quality, feasibility, high reliability and high validity of questionnaire. In the meantime, the researchers had to conduct effective instant tracking, raise return rate to minimize the disadvantageous effect.

2. Focus Group Interview

Focus group interview could serve as an observation in a short time a great amount of language interaction data for research topics. As a result, the researchers adopted a semi-structured problem design of interview outline. Top five teams were selected with a total of 14 students in the contest to form a focus group. Furthermore, the researchers guided the group to conduct interactive dialogues on the attitude and results.

E. Data Analysis Method

1. Single-Sample t-Test

The researchers used one-sample t-test to explore if the average score of STEM attitude of the girl students of the senior high school after contests is significantly superior to the test value 0 set by the research.

2. Description of Analysis of Interview Data

In the context, the researchers cited part of interview data for description and evidence, the cited format was described as follows:

- a. When the researchers cited materials, the words of the surveyed were shown with bold front and the citation will be encoded to indicate the source like (B1). There are two codes for the citations; the first code represents the team of the surveyed while the second code represents the surveyed herself. For example (P3) represents Team P and the 3rd surveyed.
- b. To avoid repeating length, the cited words are important paragraphs which are separated by □...□ in the front and back of the citation.

IV The Research Results and Discussion

A. The Aspect of Attitude toward Science – The Key Source of Scientific Information Was Books and Teachers

Conducted “single-sample test” to examine its significance, the results indicate that the student felt that the experiment and observation were the important source of their scientific information (as shown in Table 1). Participants also concluded that science could provide reasonable explanation and useful prediction of natural phenomena and help them to solve the problems in daily life. Therefore, the students’ attitude toward science was positive.

Table 1

The Descriptive Statistics and Analysis of the Aspect of Attitude toward Science

Questionnaire Item	Average	Standard Deviation	t Value
Science could provide reasonable explanation and useful prediction of natural phenomena	2.81	1.417	16.48***
experiment and observation were the important source of their scientific information	3.59	1.229	24.30***
Science could help them to solve the problems in daily life.	3.59	1.155	25.86***

***p<.001; test value=0

From the interview, the researchers find that students recognized that chemistry and physics could offer explanation of natural phenomena and the scientific conception, such as capillary phenomena, could help them to solve the problems in daily life. But in addition to observation and experiment, most of students recognized that books and teacher were the important sources for obtaining scientific information. The changes of the conception could be seen in following words:

“Chemistry – jack-o-lantern is caused by the phosphorous in the bones in the grave. You will find that if you ride faster, it will follow you (because of air current) Could break up superstition; physics – the conduct of voice (I1).”

“Sometimes the clothes was rub off on something, we could take advantage of capillary phenomenon and use vacuum cleaner to absorb the stains (P3). Using pot to boil the water often produce water scale, it will be effective if we wash it with lemon vinegar or acetic acid because the white ones is calcium carbonate that could be dissolved (J2).”

“I feel that it is my personal experience, if you did not touch those things, I will forget them even I have seen them. If I experienced and thought about them, I will remember and it becomes real (J1). I think the books will do. Because the information from Internet or media may be rumor only and has no scientific evidence (P3).”

B. The Aspect of Attitude toward Science Learning – Class Performance Could Trigger More Learning Motivation from Students

Conducted “single-sample test” to examine its significance, the results were shown in Table 2. It showed that the student were willing to learn more scientific knowledge because learning science was very interesting and if they could not attend scientific courses again, they will feel terrible. Therefore, the students’ attitude toward science learning was positive.

Table 2
The Descriptive Statistics and Analysis of the Aspect of Attitude toward Science Learning

Questionnaire Item	Average	Standard Deviation	t Value
I am willing to learn more scientific knowledge	2.94	1.360	17.97***
Learning science was very interesting	-1.28	2.222	-4.77***
If I could not attend scientific courses (biology, physics, chemistry) again, I will feel terrible.	.99	1.944	4.21***

***p<.001; test value=0

From the interviews, the researchers find that students thought learning scientific knowledge could solve some difficult problems in daily life, and further to obtain the sense of achievement. Meanwhile, they did not recognize that learning science was a boring and not interesting thing ²³ because 1) personal interest, and 2) allow in-depth exploration of its principles, such as electrostatic force. Besides, from the interview materials, the researchers learned that if a teacher could practically perform complex principles with vivid and vigorous teaching, students’ interest could be enhanced dramatically. The changes of conception could

be seen in following words:

“I should continue to learn...will be helpful to daily life, could be used to solve some difficult problems in daily life (P3). ... because myself is interested in them. ...understanding them will have great sense of achievement (P2).”

“I think I will study biology, so learning more about chemistry will be helpful to my future work. ...such as biological technology, veterinarian, genetic engineering... (I1). ... Because now is intelligence economy, knowing more means more competitive, so understanding more could help me in finding good job (P4)”

“I feel more fun, ...something, ...I don’t know why, I feel suddenly enlightened, ...such as electrostatic force ...(J1). I feel it will better if we could use experimental way to learn science, ... if you teach principles, using lively and simple way may more interest me (P1).”

C. The Aspect of Attitude toward Science Career – Even If Not Engage in Scientific Work, They Would Like to Continue to Learn Scientific Knowledge

Conducted “single-sample test” to examine its significance, the results showed that students thought understanding science is helpful to their future work and would consider engaging in science-related occupations (as shown in Table 3). Therefore, the students’ attitude toward science career was positive.

Table 3

The Descriptive Statistics and Analysis of the Aspect of Attitude toward Science Career

Questionnaire Item	Average	Standard Deviation	t Value
I won’t consider engaging in science-related occupation	-.58	2.335	-2.06*
My future work need science	1.42	1.866	6.32***
Understanding science is helpful to making a living	2.22	1.513	12.17***

***p<.001; test value=0

From interviews, the researchers find that the students who had made life planning thought that understanding science was helpful to making a living and would consider engaging in science-related work in future. But for some students who had other life planning, although it might be less possible for them to engage into science-related works, they were still pleased to learn the general conception of science. That is, even some students would not like to engage into science-related work, they were still willing to learn knowledge about science. The changes of the conception could be found in following words:

“I also think it will be helpful, because now is an era of intelligence economy, knowing more means more competitive, so understanding more could help me in finding good job (P4)”

“I would engage into science-related work, because I may need to use a lot of instruments in my future work and will be more possible for using instrument because of the development of technology. I hope I could engage into medicine, that is why I think that there will be many chances for me to apply science (P3). In future, it will be not possible to engage into scientific work because I have not much interest in it, but I am willing to learn science-related common sense (J2).”

D. The Aspect of Attitude toward Technology– There Are Advantages and Disadvantages of Technology for Us

Conducted “single-sample test” to examine its significance, the results indicated that students thought that although technology caused pollution, it could help us solve the problems in daily life and make things better (as shown in Table 4). Therefore, the students’ attitude toward technology was positive.

Table 4

The Descriptive Statistics and Analysis of the Aspect of Attitude toward Technology

Questionnaire Item	Average	Standard Deviation	t Value
Technology will make things better	3.28	1.259	21.61***
Technology will cause pollution	2.25	1.603	11.64***
Technology could help us solve the problems in daily life	3.42	1.311	21.68***

***p<.001; test value=0

From the interviews, the researchers find that the students though the technological products, such as TV, computer, MP3, car, high speed rail, etc., could not only help us complete many things but also solve problems we might encounter in daily life. But environment pollution, Internet hacklers were the negative effects. The changes of the conception could be found in following words:

“I think that technology could achieve many things and will achieve more in future. For example, TV could let us not go out in a position to approach the world, we could use MP3 to listen music, computer could store much data. You do not have to write by hand. The only thing you have to do is keying in the words on keyboard. I think it will be developed further in future that we do not need to do many things personally but things will be done (J1, P1).

“Environment pollution...just like CO2 emitted by cars, it will cause greenhouse effect; refrigerant will cause the reduction of ozone layer (I1); Internet hackler violates privacy and hurt the public (I2).”

“Make people more convenient in life, like cars, high speed rail,...(I1). Today, people emphasize on the efficiency. You will calculate by computer instead of calculating by yourself. Like motor, TV wall, and MP3, MP4, they could send us some information at any time or help us complete reports.

E. The Aspect of Attitude toward Technology Learning – The Technology Learning Will Make the Sense of Achievement for the Students

Conducted “single-sample test” to examine its significance, the results showed that students felt that technology was interesting and they were willing to learn more technological knowledge and skills (as shown in Table 5). They also thought that technology is the subject that everyone should learn. Therefore, the students’ attitude toward technology learning was positive.

Table5
The Descriptive Statistics and Analysis of the Aspect of Attitude toward Technology Learning

Questionnaire Item	Average	Standard Deviation	t Value
Technology is the subject that everyone should learn	2.13	1.773	9.98***
I feel that technology is boring	-1.22	2.100	-4.82***
I am willing to learn more technological knowledge and skills	2.38	1.535	12.86***

***p<.001; test value=0

From interviews, the researchers find that the students thought that growing in the technological era, even they were not planning to take technology as main subject in study, everyone should learn technology to enhance his own competitiveness; and learning technology is interesting, like writing computer program, using sewing machine in home economy class, students will give a sense of achievement for the students. Besides, most of students also proposed that ethics curriculum should be added in learning technology to crackdown bad social events. The changes of the conception could be found in following words:

“I think it is necessary to learn because today is a era of technology. Without technology, we will like barbarians in ancient times. Some ethics curriculum could be added that it will be better (P1, P2).”

“I remember that the teacher in home economy class has taught us how to use sewing machine. I feel that knowing how to use sewing machine will give me the sense of achievement (I1).”

“I will study the technology to enhance my own competitiveness, more understanding is, more competitiveness will be (P4, P1). I may to selecting study of technology as my main target, but I would like to know more and understand more about technology. Technology will not become my major, but it will be my extra. Above all, this is future common sense (E2).”

F. The Aspect of Attitude toward Technology Career – People Who Have No Delicate Thoughts Are Not Willing to Engage in Technological Work

Conducted “single-sample test” to examine its significance, the results were shown in Table 6. It showed that students thought that learning technology would be helpful to their future job. They might consider to engage into technology-related jobs. Therefore, students’ attitude toward technological career was positive.

Table 6

The Descriptive Statistics and Analysis of the Aspect of Attitude toward Technological Career

Questionnaire Item	Average	Standard Deviation	t Value
I will choose technology-related job	1.04	1.921	4.51***
My future work needs applied technology	1.29	1.655	6.48***
Learning technology will be helpful for me in making a living	2.12	1.667	10.54***

***p<.001; test value=0

From interviews, the researchers find that the students thought that learning technology, like computer, copy machine and fax machine, would help themselves in making a living in future. Most of students were willing to choose technology-related job ⁷. But a few students who had no delicate thoughts were not willing to engage into the industry because they worried about their carelessness would affect the results of work. The changes of the conception could be found in following words

“I feel it will be helpful because there are many copy machines and fax machines. If you

are not be able to use them, will the boss employ you? (P1) I felt it will be helpful because today computer is everywhere. If you are able to operate computer, you will certainly be employed. In the era of technology, even you typewrite, you have to use computer. You just cannot say you are able to use it (J1).”

“Certainly I will. On one hand, it is because of interest, on the other hand, it will meet the social development, ... If future, I will choose technology-related jobs (I2, E2). I won’t engage into any technology-related job because it is a very delicate industry. I feel that I am easy to forget something. If the mechanic disrupt, it will be terrible. So I won’t engage into the industry (P1, J1).”

G. The Aspect of Attitude toward Engineering – Learning Engineering Could Cultivate Systematic Thinking and Problem-Solving Ability

Conducted “single-sample test” to examine its significance, the results were shown in Table 7. It showed that students thought engineering could use science, mathematics and technology to develop feasible and practical plan. It would also cultivate the ability of designing, analyzing and constructing products and is helpful to the solution of problems in daily life. Therefore, students’ attitude toward engineering was positive.

Table7. The Descriptive Statistics and Analysis of the Aspect of Attitude toward Engineering

Questionnaire Item	Average	Standard Deviation	t Value
Engineering could use science, mathematics and technology to develop feasible and practical plan	3.01	1.367	18.32***
Engineering could cultivate the ability of designing, analyzing and constructing products	2.97	1.350	18.28***
Engineering could help us to solve the problems we encounter in daily life	2.97	1.393	17.72***

***p<.001; test value=0

From interviews, we could find that the student thought engineering could only be done through brainstorming and everyone carrying out their duties. Therefore, learning engineering could cultivate our own abilities of systematic thinking, problem-solution ¹², carefulness, team-working. After participating in the research, they found that they had great enhancement in planning ¹¹. Besides, the students also agreed that engineering could be used in solving problems in our daily life. The results was in line with the findings of research by DeBartolo& Bailey ⁵ that after participating in the research, the number of students who thought that engineering could solve the problems in daily life dramatically increased. For example,

communication engineering allows the exchange of information between people and people. The changes of the conception could be found in following words:

“Engineering is a process of cultivating us how to think and how to solve problems. Like the case of solar automatic trolley, after completing the design, you could not magically and directly transform it into a trolley. Everyone needs to continue to discuss, modify, collecting data, experiment before finally manufacturing the best trolley. We need to initially solve the problem, not thinking only when we encounter a problem (T2). We have to learn division of labor because everyone has different strong points (P2). A architect must be very clear about each step (P3).

“Like building pyramid, it is completed under team-work. It could pass the heritage to offspring and retain the history. So engineering could do many things in many fields (E2). Aerospace engineering allow human beings to expand their world view to universe view, like satellite, communications (P1)”

H. The Aspect of Attitude toward Engineering Learning – Interested People Intend to Continue to Challenge Learning Whereas the People Who Have No Delicate Thoughts Are Lack of Confidence

Conducted “single-sample test” to examine its significance, the results were shown in Table 8. The results showed that students felt that engineering is interesting and they would be willing to learn more about engineering knowledge. They also had confidence in learning advanced engineering. Therefore, students’ attitude toward engineering learning was positive.

Table 8
The Descriptive Statistics and Analysis of the Aspect of Attitude toward Engineering Learning

Questionnaire Item	Average	Standard Deviation	t Value
I am willing to learn more about engineering knowledge	1.75	2.096	6.95***
I feel that engineering is boring	-.54	2.125	-2.10***
I have confidence in learning advanced engineering.	1.04	2.192	3.95***

***p<.001; test value=0

From the interviews, we could find that the students who were willing to continue to learn thought that in addition to their own interest, learning engineering could also self-challenge whereas those who were not willing to learn advanced curriculum thought that usually engineering was a huge and complex work and needs delicate thoughts, so they did not have full confidence in trying to learn advanced engineering curriculum. The changes of the

conception could be found in following words

“If there is opportunity, I will. But I only have half confidence. If there is chance to try, I will challenge myself because I have a little confidence in it (I2).”

“One who wants to learn engineering must be very clear about each step. That will make me headache. So there is least possibility because it is very complicated...My attitude will not so initiative,... I am a little lazy and not careful enough. Engineering must emphasize on details that myself will not want to learn (J2, I1.)”

I. The Aspect of Attitude toward Engineering Career – Even If the Students Agreed that Engineering Job Was More Possible to Earn High Salary, They Were Still Not Willing to Change Their Aspirations

Conducted “single-sample test” to examine its significance, the results were shown in Table 9. The results showed students thought that learning engineering might someday bring them in future the opportunities for jobs they like to them and earn higher salary. Therefore, students’ attitude toward engineering career was positive.

Table 9
The Descriptive Statistics and Analysis of the Aspect of Attitude toward Engineering Learning

Questionnaire Item	Average	Standard Deviation	t Value
I am not interested in any job involving engineering	-.54	2.361	-1.886
Studying engineering will help me earn higher salary	1.91	1.678	9.47***
Studying engineering will bring the opportunities for jobs I like to me	1.32	1.875	5.84***

***p<.001; test value=0

From interviews, we could find that most of students thought that learning engineering could train their thinking, their bosses would think highly of them and earned higher salary. But that will not affect their choice of jobs in future. The changes of the conception could be found in following words:

“Many works need to follow the prescribed order, learning engineering could train your thinking (P3). The more knowledge, the better you are. Bosses always like omnipotent employees. If I could understand, I would go there (I1).”

“It may be true that engineering work will get higher salary, but it will never affect my

choices because there are many other jobs that pay high salary. So you don't have to complicate yourself. An engineering work often cannot be done by oneself and it needs to cooperate with others. If there is any different opinion, it is easy to screw up or stop (E4). I will, because many people do not want to learn engineering, so if you study engineering, you will be on the upper hand. ...(E40)"

J. The Aspect of Attitude toward Mathematics – Mathematic Like Tool, Indispensable in Daily Life.

Conducted "single-sample test" to examine its significance, the results were shown in Table 10, indicating students thought that mathematics could not only train logic thinking and arithmetic capability but also help us solve the problems in daily life, so mathematics was valuable and important. Therefore, students' attitude toward mathematics was positive.

Table 10
The Descriptive Statistics and Analysis of the Aspect of Attitude toward Mathematics

Questionnaire Item	Average	Standard Deviation	t Value
Mathematics is valuable and important	2.75	1.528	14.97***
Mathematics can train logic thinking and arithmetic capability	3.38	1.436	19.54***
Mathematics can help us solve the problems in daily life	2.88	1.711	14.00***

***p<.001; test value=0

From interviews, the researchers find that the students consider mathematic as a tool that it accounted for a large proportion of daily life. It could not only train their logical inference and arithmetic capability but also help them solve various mathematics problems that they might encountered in our daily life, such as time allocations, investment and money management, transactions. The changes of the conception could be found in following words:

"Mathematics exists in every corner of daily life, like time allocations...I cannot imagine how to live without mathematics. In many fields, like physics, chemistry, we need mathematics--trigonometric functions, differential and chemistry--molecular weight (I1)."

"Clear head, clear logical thinking, not get stuck in when I consider matters. Mathematics is a tool that we could use when we need it (J2). Mathematics could help us consider clearly more stronger capability in changing thinking (P2)."

"We can use mathematic to weigh. Without mathematics, we cannot calculate almost nothing. We cannot do anything in our daily life without mathematics (P3). It could calculate

interest of bank, insurance. It could calculate which plan is the best for us (B2, P1). Mathematics accounted for even larger proportions of computer programming. We even have to check angle θ if we want to know what angle a motor rotate. (I2).”

K. The Aspect of Attitude toward Mathematics Learning – Learning Mathematics Will Give Us A Sense of Achievement, But the Premise Is That the Students Must Have a Teacher Who Can Teach Lively

Conducted “single-sample test” to examine its significance, the results were shown in Table 11, indicating students thought that students thought that they could handle most of subjects including mathematics because mathematics was interesting and they had confidence in learning advanced mathematics curriculum. Therefore, students’ attitude toward mathematics learning was positive.

*Table 1
The Descriptive Statistics and Analysis of the Aspect of Attitude toward Mathematics Learning*

Questionnaire Item	Average	Standard Deviation	t Value
I am not the student that could perform well in learning mathematics	-.57	2.862	-1.641
I can handle well most of subjects with the only exception of mathematics	-.81	2.866	-2.35***
I feel that mathematics is interesting and I enjoy it	1.62	1.783	7.56***
I have confidence in learning advanced mathematics curriculum	1.38	2.365	4.837***

***p<.001; test value=0

From interviews, the researchers find that the students thought that comparing to other rigid subjects, mathematics is interesting. Especially when they found a solution, the sense of achievement could not be described by language. In future, most of them were willing to learn advanced mathematics to satisfy their own knowledge-seeking demands. In addition to the above mentioned reasons for the students to love mathematics, teacher was also an important factor. A lively and vigorous teacher who interacted well with students will dramatically enhance students’ learning interest. The changes of the conception could be found in following words:

“I feel that mathematics is very fun. If you understand its principles and continue to calculate, you will have a sense of happiness. When you find a solution, you will have a sense of achievement (P3). Comparing to other subjects, my mathematics capability is stronger that I have more interest in mathematics. I hate anything which needs you to recite. But you only need to think clearly when you learn mathematics, you don’t have to recite something (P2, P3).”

“I will. Mathematics could act as an entertainment in leisure time. When I was in bad mood, I will become happy if I find a solution in calculation. (P3, J1). After understand some superficial knowledge, I would like to further understand it. ... (P2).”

“I like mathematics but not particularly. Teachers have very good interaction with us. I am very interested in the mathematics in textbook but not like examination (I1). Teacher is very important in mathematics class. He has lively demeanor and his age is close to ours (I2)”

L. The Aspect of Attitude toward Mathematics Career–Often Use Mathematics after Leaving School

Conducted “single-sample test” to examine its significance, the results were shown in Table 12, indicating students thought that after leaving school, mathematics will be a subject of frequently using and consider engaging into mathematics-related occupations in future. So they now had to understand more about mathematics for the use in future. Therefore, students’ attitude toward mathematics career was positive.

Table 12
The Descriptive Statistics and Analysis of the Aspect Of Attitude toward Mathematics Career

Questionnaire Item	Average	Standard Deviation	t Value
I will consider engaging into mathematics-related occupation	.70	2.231	2.59***
I need to understand to handle my future works	1.91	1.738	9.14***
I think mathematics is the subject that I will not frequently use after leaving school	-.65	2.448	-2.21***

***p<.001; test value=0

From interviews, the researchers find that the students thought that mathematics is the subject that will be used frequently, and difference is only the degree of use, such as scores calculation, programming, investment and money management, etc. Those who want to be an accountant, computer engineer need to have mathematics capability. So they agreed that mathematics will be used frequently after they leave the school. The changes of the conception could be found in following words:

“I will. Many things today are based on mathematics. For example, physics also needs calculation. It is good to be an accountant who will certainly need to use mathematics. So I feel that mathematic is very important (P2). In fact, most of occupations are related to mathematic, just the difference of degree of use. Programming will need lot of mathematics, so you have to struggle to learn. Today, there is few works that have nothing to do with

mathematics, even a Chinese teacher needs to calculate students' scores.... But I just want to understand the basics not too abstruse (B2). Before retirement, I think I will not engage into mathematics-related jobs. But after retirement, I may need mathematics to manage investment (E2).”

“I do not agree that mathematics is useless after leaving the school because you will use mathematics when you buy something or work (I2).”

V. Conclusions and Recommendations

Based on the findings of this study, four conclusions are made as follows:

A. Conclusions

1. **Books and teachers were their important sources of scientific information and practical teaching were more likely to trigger learning motivation**

From STEM attitude scale and interview data, the researchers found that the students thought the key source of scientific information was books and teacher and practical teaching were more likely to trigger learning motivation. Even they not engage into scientific work, they are still willing to learn scientific knowledge.

2. **The advantage of the technology learning was the enhancement of the sense of achievement; the disadvantage was the effect on the effectiveness of work**

From STEM attitude scale and interview data, the researchers find that the students thought technology was advantageous and disadvantageous. Learning technology would produce a sense of achievement. But for those who have no delicate thoughts, they would worry they were not delicate enough that they would not like to engage into technological work.

3. **Learning engineering could cultivate systematic thinking and problem-solving capability**

From STEM attitude scale and interview data, the researchers find that the students thought learning engineering could cultivate systematic thinking and problem-solving capability. Interested students were willing to continue to challenge learning whereas those who had no delicate thoughts were lack of confidence and even they agreed that engaging into engineering might earn higher salary, they were still not

willing to change their standing ambitions.

4. Mathematics is an indispensable tool in daily life and the teacher plays an important role in mathematics learning

From STEM attitude scale and interview data, the researchers find that the students thought that math mathematics is an indispensable tool in daily life. Learning mathematics would give them a sense of achievement, but the premise is that they need a teacher who teaches mathematics lively. After they leave the school, they would still frequently use mathematics.

B. Recommendations

1. To create more success-learning opportunities and to provide the examples of successful females

In the teaching process of STEM field, the teacher should pay attention to the learning by girl students at any time and give them more learning opportunities that are easier to be successful to help them obtain the sense of achievement. Besides, in classroom, the teacher should provide students with some cases or biographies of the successful females who have performed in the STEM-related field to inspire girl student' motive force of learning.

2. Schools and businesses should encourage the female students to take advantages of learning and work opportunities in the STEM field

We may help the female to be successful if we can provide the female with the opportunities of leadership and exploring new ideas²⁴. So, no matter in the classrooms of school or in the job market, we should encourage and provide the female with learning and work opportunities in the STEM field.

3. To strengthen students' STEM integrated knowledge through special top production curriculum

In Taiwan, most of schools adopt departmental teaching and have fewer opportunities to integrate science, technology, engineering and mathematics-related knowledge for teaching. Therefore, teachers should help students learn STEM integrated knowledge through producing more special topic curriculum.

4. **Teacher should strengthen STEM integrated professional knowledge**

The researchers find that the teacher is an important source for students to acquire scientific information and also play an important role for affecting students in learning mathematics. Therefore, when teachers conduct STEM teaching, they should involve and understand the contents and teaching materials design of the four subjects because the lack of professional capability of related curriculum may affect the curriculum design and teaching results of STEM courses.

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