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The Relationship of Active Learning Based Courses and Student Motivation for Pursuing STEM Classes

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Abstract—**Decline of the students' registration in Science, Technology, Engineering, and Mathematic (STEM) is one of the main challenges of today's academia. STEM classes are becoming less appealing and lose their attraction. This has resulted in decline in number of students who register for STEM classes every year. Several researches have stated that the introductory college classes in STEM are more theoretical oriented and freshman students have limited opportunities to gain hands on experiences with joy of the learning thought doing. In another word, freshman students get demotivated through the tedious teaching styles of faculty talking and students listening. A lot of studies have attempted to measure the success of project-based and active learning methodology that are proposed to motivate students in the classroom environment. However, a few studies have examined the impact of such methodologies on students' tendency toward STEM classes. Although Active learning studies have shown the overall satisfaction of students in project-based classes, there is not enough evidence to show any attitude changes toward STEM course.**

The Technology Acceptance Model (TAM) examines human's intention toward adaptation of a particular behavior based on his/her perception of usefulness and ease of use. According to the TAM, human's behavior has a direct relationship with his/her motivation and intention can be modeled by human's attitude. Also, human attitude can be modeled by some human belief such as perceived usefulness and perceived ease of use.
This study is attempting to examine the relationship between active learning methodology that has been introduced in one of the freshman classes for a span of two semesters and students tendency to register in STEM courses. In order to test this relationship this study utilizes TAM as a core model to assess the effect of active learning based classes on students' intention and attitude toward STEM course. Moreover, this study has examined the effects of external factors such as social influences, and internal factors such as anxiety and self-efficacy toward STEM courses.

Keywords—STEM; Student Motivation; TAM; Social Influence; *(key words)*

I. Introduction

Low enrollment in in Science, Technology, Engineering, and Mathematic (STEM) classes is one of the main challenges that the universities are facing in this era. The traditional lecture methods in which professors talk and students listen have dominated college and university classrooms [1]. As a result, freshman students get demotivated through the tedious teaching styles of faculty talking and students listening. Although these methodologies have been widely used to teach college students, they are not adequate for new generation of college students who are intelligent, talented and energetic [2-3].

Today's students need to do more than just "sit and listen" to the tedious lectures. They need to actively be involved in instructional activities; continuously be challenged by exiting problems, and work in a team [1, 2, 7]. It has been reported that students' retention of the information will not be gained only by receiving it verbally or visually. It rather needs to be utilized toward problem solving [2, 8, 9, 10]. Several studies have shown that students in project based course not only achieve and attain better knowledge but also they have been more satisfied [11, 12].

A lot of studies have attempted to measure the success of project-based and active learning methodology that are proposed to motivate students in the classroom environment. However, a few studies have examined the impact of such methodologies on students' tendency toward STEM classes. Although Active learning studies have shown the overall satisfaction of students in project-based classes, there is not enough evidence to show any attitude changes toward STEM course.

This study is attempting to examine the relationship between active learning methodology that has been introduced in one of the freshman classes for a span of two semesters [11] and students' tendency to register in STEM courses. In order to test this relationship this study utilizes TAM as a core model to assess the effect of active learning based classes on students' intention and attitude toward STEM course. Moreover, this study has examined the effects of external factors such as social influences, and internal factors such as anxiety and self-efficacy toward STEM courses in one of the freshman course entitled "ET100: Introduction to Engineering Technology".

II. Methodology

Technology Acceptance Model (TAM) along with theory of reasoned action and theory of planned behavior [13] have been used widely in different domain to predict individual intention to adopt or not adopt a specific behavior. According to the TAM, individual will adopt a behavior or technology if the feel that specific behavior is beneficial and easy to do. Also, the individual behavior affected by several other external factors such as peers, parents, media, to name few. Since this study has utilized the robotic projects [11, 12] as an active learning methodology, the researchers define the following constructs to measure the impact of the Project-Based course on students' tendency to register in more STEM courses:

1. Behavioral Intention (IN) defines as students' intention to register for more STEM courses and utilizing robotic subjects in future.
2. Attitude Behavior (ATT) defines as students' attitude toward using robotic projects in classroom.
3. Perceived Usefulness (PU) defines as students' feeling toward the usefulness of utilizing robotic projects in classroom.
4. Ease of Use (EU) defines as how easy it is to use robotic projects in classroom.
5. Social Influence (SI) defines as an external factor that impacts students' perception toward using the robotic projects and STEM courses.
6. Self-Efficacy (SE) defines as people's judgments of their capabilities to organize and execute courses of action required attaining designated types of performances.
7. Anxiety (ANX) defines as students' anxiety toward utilizing robotic projects in class environment.

By considering the above constructs this study will form the research model that is presented in figure 1. Moreover, the following hypotheses from H1 through H13 as following:

H1. There is a significant relationship between Perceived Ease of Use and Perceived Usefulness

H2. There is a significant relationship between Perceived Usefulness and Intention toward registering in STEM courses and utilizing robotic projects.

H3. There is a significant relationship between Perceived Usefulness and Attitude.

H4. There is a significant relationship between Social Influence and Attitude.

H5. There is a significant relationship between Social Influence and Intention.

H6. There is a significant relationship between Anxiety and Attitude.

H7. There is a significant relationship between Anxiety and Intention.

H8. There is a significant relationship between Ease of Use and Attitude.

H9. There is a significant relationship between Self-Efficacy and Attitude.

H10. There is a significant relationship between Ease of Use and Intention.

H11. There is a significant relationship between Attitude and Intention.

H12. There is a significant relationship between Self-Efficacy and Intention.

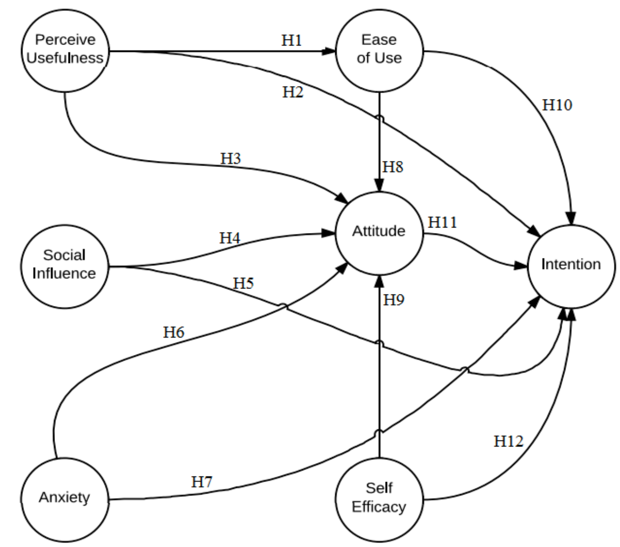

Fig. 1. Research Model and Hypotheses

A. *Instrumentation*

After carefully review the literature, this study have selected the constructs that have been validated and have higher loading. This study has formed the following survey to measure each constructs in the research model:

1. Demographics:
   a. Age
   b. Sex
   c. Major
   d. Years of Education
   e. Have you had any exposure to project-based classes
   f. Have you worked on Mindstorm robotic projects
2. Ease of use:
   a. It is easy to use robotic project in class room
   b. It is easy to build a robotic structure.
   c. It is easy to program a robot.
   d. I can easily figure out how to use robotic.
   e. Learn to operate a robot is easy.

f. It is easy to become skillful in using robotic.

3. Usefulness:
   a. I believe working with Robotic projects help me to better understand the class concepts
   b. I believe using Robotic projects is beneficial.
   c. I believe working with Robotic projects is useful.
   d. I believe using robotic projects help to increase my performance in class
   e. My learning in Robotic helps my analytical skills.
   f. Robotic Projects improve my problem solving skills.
   g. I feel robotic projects are useless.
   h. I feel robotic based class help me to work better as a team player.
   i. I believe robotic based class help me to better communicate my ideas with other team members.
4. Attitude
   a. Using the robotic project in class is a good idea.
   b. The robotic project makes learning in class more interesting.
   c. Working with the robotic project is class is fun.
   d. I like working with the robotic project in class.
5. Intention
   a. Assuming I have access to a robotic platform, I intend to use it
   b. Given that I have access to a robotic platform, I predict that I would use it
   c. I prefer to register for robotic-based classes if it is possible
   d. This course motivate me to register for more science oriented classes in future
   e. This course motivates me to take more Engineering oriented classes in future.
   f. This course motivates me to take more Mathematic oriented classes in future.
   g. This course motivates me to take more Technology oriented classes in future.
   h. I predict I would use the robotic platform in future.

6. Social influences:
   a. People who influence my behavior think that I should use the robotic based project.
   b. People who are important to me think that I should use the robotic based project.
   c. My instructors support me to work with robotic based projects.
   d. My school (professor, peers) encourages me to take more classes in technology field.
   e. My school (professor, peers) encourages me to take more classes in engineering field.
   f. My school (professor, peers) encourages me to take more science classes.
   g. My school (professor, peers) encourages me to take more mathematic classes.
7. Anxiety
   a. I feel apprehensive about using a robot.
   b. It scares me to think that I could break the robot when I am using that.
   c. I hesitate to use the robot for fear of making mistakes that I cannot correct.
   d. Robotic projects are somewhat intimidating to me.
8. Self-efficacy
   I could complete a task/project using robot.....
   a. If there was no one around to tell me what to do as I go.
   b. If I could call someone for help if I got stuck.
   c. If I had a lot of time to complete the job for which the software was provided.
   d. If I had just the robot manual for assistance.
   e. I feel confident create different programing function of robot.
   f. I feel confident build different structure robot.
   g. I feel confident learning advanced skills within a robot.

The validity of the questioner have been ensured by carefully selecting each questions and consulting it with panel of experts, which have been formed by three faculties at Eastern Michigan University. Finally, the authors created an online survey and test the research hypotheses by asking students in one of the freshman courses (Introduction to Engineering Technology) to response for the period of two semesters. Moreover the reliability of the questioner has been tested by measuring through statistical software of Smart PLS (13). The software has been used to measure the Cornbachs Alpha and Composit Reliability, which has been illustrated in table I.

TABLE I. RELIABILITY

	AVE	Composite Reliability	R Square	Cronbachs Alpha	Communality
ANX	0.6807	0.8930	0.0000	0.8385	0.6807
ATT	0.7688	0.9430	0.6115	0.9235	0.7688
EU	0.6193	0.9065	0.0000	0.8768	0.6193
INT	0.6457	0.9357	0.7460	0.9212	0.6457
PU	0.6545	0.9443	0.4100	0.9332	0.6545
SE	0.5659	0.9007	0.0000	0.8725	0.5659
SI	0.6430	0.9152	0.0000	0.8889	0.6430

According to the table 1, the value of the Cronbachs Alpha and Composit Reliability for all of the constructs is bigger than 0.7, which confirm the reliability of the constructs (14). Moreover the outer loading of each factor within each construct, which is good representative of questioner has been presented in table II.

TABLE II. OUTER LOADING OF EACH FACTOR WITHIN EACH CONSTRUCT

	ANX	ATT	EU	INT	PU	SE	SI
ANX1	0.6124	0	0	0	0	0	0
ANX2	0.8835	0	0	0	0	0	0
ANX3	0.9197	0	0	0	0	0	0
ANX4	0.8493	0	0	0	0	0	0
ATT1	0	0.9008	0	0	0	0	0
ATT2	0	0.8772	0	0	0	0	0
ATT3	0	0.9086	0	0	0	0	0
ATT4	0	0.9376	0	0	0	0	0
ATT5	0	0.7473	0	0	0	0	0
EU1	0	0	0.7998	0	0	0	0
EU2	0	0	0.6929	0	0	0	0
EU3	0	0	0.7011	0	0	0	0
EU4	0	0	0.8266	0	0	0	0
EU5	0	0	0.8344	0	0	0	0
EU6	0	0	0.8512	0	0	0	0
INT1	0	0	0	0.8321	0	0	0
INT2	0	0	0	0.8039	0	0	0
INT3	0	0	0	0.7918	0	0	0
INT4	0	0	0	0.7961	0	0	0
INT5	0	0	0	0.8515	0	0	0
INT6	0	0	0	0.7562	0	0	0
INT7	0	0	0	0.8463	0	0	0
INT8	0	0	0	0.7439	0	0	0
PU1	0	0	0	0	0.8480	0	0
PU2	0	0	0	0	0.8545	0	0
PU3	0	0	0	0	0.8195	0	0
PU4	0	0	0	0	0.8029	0	0

PU5	0	0	0	0	0.8604	0	0
PU6	0	0	0	0	0.7984	0	0
PU7	0	0	0	0	0.6537	0	0
PU8	0	0	0	0	0.8114	0	0
PU9	0	0	0	0	0.81333	0	0
SE1	0	0	0	0	0	0.6716	0
SE2	0	0	0	0	0	0.7715	0
SE3	0	0	0	0	0	0.7465	0
SE4	0	0	0	0	0	0.6769	0
SE5	0	0	0	0	0	0.7742	0
SE6	0	0	0	0	0	0.8633	0
SE7	0	0	0	0	0	0.7450	0
SI1	0	0	0	0	0	0	0.7858
SI2	0	0	0	0	0	0	0.7851
SI3	0	0	0	0	0	0	0.7637
SI4	0	0	0	0	0	0	0.8281
SI5	0	0	0	0	0	0	0.8364
SI6	0	0	0	0	0	0	0.8096

III. METHODOLOGY

From 98 collected responses during two semesters, demographic data shows that there are 10 female (10.20 %) and 88 male (89.80 %) and the ages of the students varies from 17 to 66 and the average of the age among the subjects is 21 years old. Also, the subjects in average have been at school for 2.2 years after high school.

The major of students were Simulation and Gaming, Computer Engineering Technology, Electrical Engineering Technology, Mechanical Engineering Technology, and Finance. The Smart PLS analysis was used to find the path coefficient values in the proposed model as presented in figure 2. The numbers inside each construct are Rsquare values and each construct is presented with its items and factor loading.

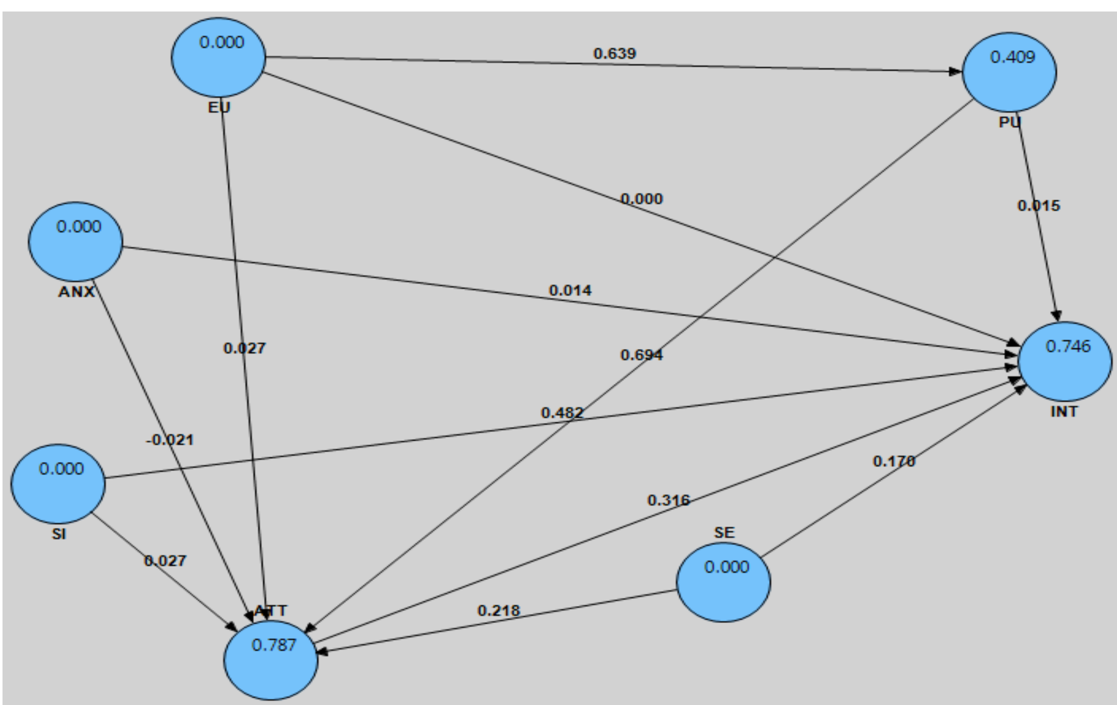

Fig. 2. Path Coefficient and Rsqure

According to the figure 2 and measured Rsquares for the latent variables of Perceived Usefulness (PU), Attitude (ATT), and Intention (IN) we can make the following conclusions:

a. 40.9 percent of the Perceived Usefulness has been explained by Ease of Use.
b. 78.7 percent of the Attitude has been explained by Self efficacy, Social Influence, Ease of Use, and Perceived Usefulness.
c. 74.6 percent of the Intention has been explained by Self-efficacy, Attitude, Social Influence, and Perceived Usefulness.

Moreover this study has used the Smart PLS to evaluate the loading of the each question in each constructs that is shown in the figure 3 and table 2.

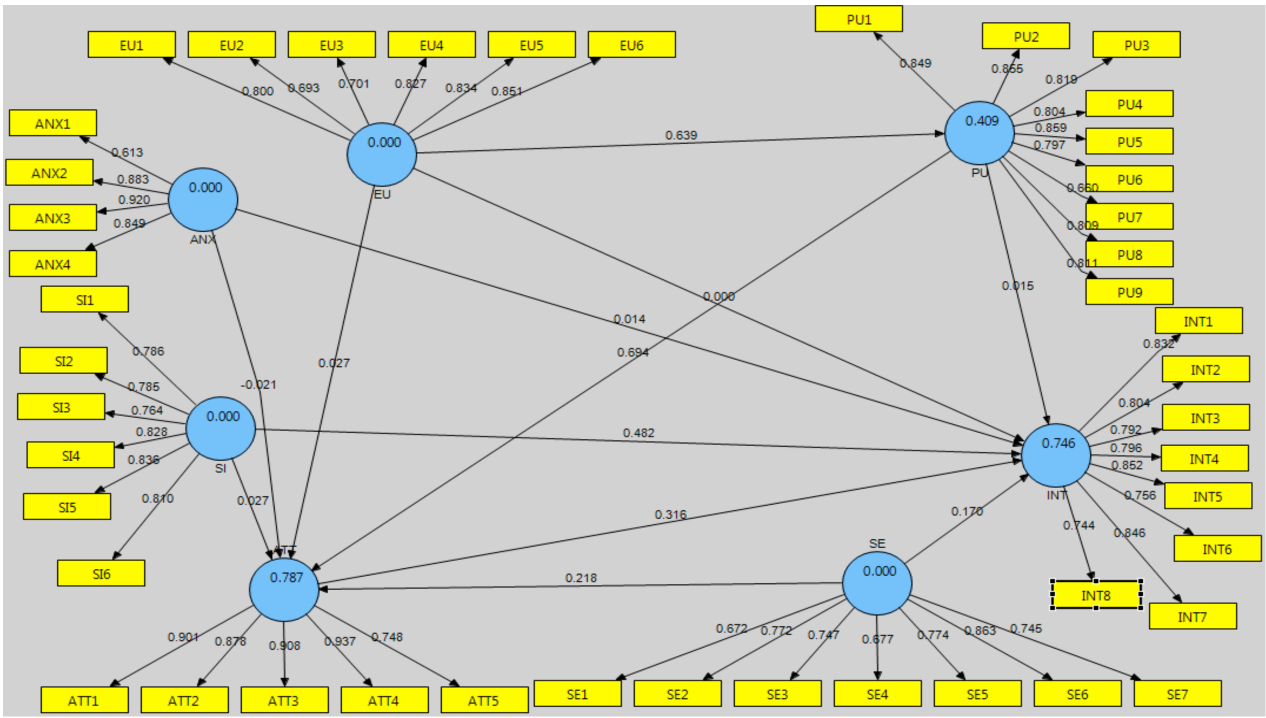

Fig. 3. PLS analysis of the outer loading

In order to examine the formed hypotheses this study calculated the t-value for all the paths and the hypotheses that has shown a t-value above 1.96 is been accepted. The results of the hypotheses testing have been illustrated in table III.

TABLE III. RELIABILITY

Hypotheses	Path	T-Value	Results
H1	EU -> PU	11.4213	Accepted
H2	PU -> INT	2.005	Accepted
H3	PU -> ATT	8.5484	Accepted
H4	SI -> ATT	0.3387	Rejected
H5	SI -> INT	6.3058	Accepted
H6	ANX -> ATT	0.4678	Rejected
H7	ANX -> INT	0.1194	Rejected
H8	EU -> ATT	6.3023	Accepted
H9	SE -> ATT	3.1517	Accepted
H10	EU -> INT	1.7727	Rejected
H11	ATT -> INT	2.3585	Accepted
H12	SE -> INT	2.5729	Accepted

As it is presented in table III each path coefficient has been tested and the T-Value has been presented for tow-tailed t-test with the significant level of 5%. If the path coefficient has a value larger than 1.96 will prove the hypotheses.

According to the analysis of hypotheses that is presented in figure III, the following hypotheses have been approved: H1, H2, H3, H5, H8, H9, H11 and H12. In other words, this study has found the followings: individuals perception of Ease of Use of Robotic project has a positive relationship with their Attitude and their perceived Usefulness; Perceived Usefulness has a positive and direct relationship with Attitude and Intention toward using robotic projects and registering in more STEM classes; Social Influence has a direct and positive relationship with individuals Attitude toward using robotic projects; and Self-Efficacy has a direct and positive relationship with individuals' Attitude and Intention toward registering for more STEM oriented course.

Moreover, the hypotheses of H4, H6, H7 and H10 shows a t-value smaller than 1.96 and has been rejected. In other words, this study could not approved the following positive relationship between Social influence and changing Attitude toward using Robotic projects; any positive or negative effect of Anxiety toward using Robotic project in class room and Attitude and Intention of using Robotic projects in future and registering in more STEM related course; and no positive relationship between perceived Ease of Use and Attitude toward using Robotic projects.

IV. CONCLUSION AND SUMMARY

This study attempts to discover the underlying factors that impact students' attitude and intention to register for more STEM related courses. For this reason, this study has used several theoretical frameworks that explain human behavior to form its research model. As a result of the developed research model twelve hypotheses have formed that only four of them rejected and the rest of them approved. This study has shown that Perceived Usefulness, Social Influence, Self-Efficacy and Attitude have direct and positive relationship with students' intention toward registering in more STEM courses and using Robotic Projects. Also, this study find that there is no positive relationship between Social Influence and individuals' Attitude; Anxiety and Attitude; Anxiety and Intention; and Ease of Used and intention of the students to register for more STEM course.

Due to the fact this study only perform for the period of two semester, this study could not collect any farther data regarding the actual behavior of the students to test if the Intention of registering for more STEM course actually lead to more registration in more STEM course. For this reason, future studies could be performed to test if the behavior of registering for STEM courses is a function of individuals' Intentions. Also, this study only limited the Social influences into family, friend, peers and faculties. Future studies, could focus on the effect of the job market, mass media, and other electronic media on the students' attitude and intention toward working with robotic projects and registering in more STEM course.

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