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

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Abstract

Low student interest in pursuing science, technology, engineering, and mathematics (STEM) degrees remains as one of the main current concerns of American society. Several research studies have stated the introductory college classes in STEM are very theoretical and provide freshman students with limited opportunities to gain hands-on experience. Also, the tedious teaching styles of faculty talking and students listening, along with large classes, have contributed to freshman students' lack of motivation in pursuing STEM-related programs. A number of studies have attempted to measure the success of project-based and active learning methodologies in respect to students' motivation in the classroom environment. However, few studies have examined the impact of such methodologies on students' tendency toward STEM classes.

This paper attempts to examine the effects of using an active learning methodology on students' tendency to enroll in STEM courses. The technology acceptance model (TAM) has been used to test the effect of active learning based classes on students' intention and attitude toward STEM courses. The effects of external factors such as social influences as well as internal factors such as anxiety and self-efficacy toward STEM courses have also been considered. The results of this research show that the theoretical framework of TAM could be used to predict a student's intention of pursuing and enrolling in more STEM courses.

Introduction

In recent years, the decreasing enrollment in STEM-related fields has been one of the main concerns of academia as STEM classes are becoming less appealing and less attractive to students. The traditional lecture method [1], where professors talk and students listen, has been the dominant method in college and university classrooms. As a result, this tedious teaching style [2, 3] has become a demotivating factor for a new generation of college students who are more technology-oriented and active in utilizing technology in their daily lives.

New college students need to do more than just "sit and listen" to tedious lectures. They need to actively be involved in instructional activities [1, 2, 7], be continuously challenged by

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existing problems, and work in a team. It has been reported [2, 8-10] that students' retention of information is not only gained by verbally or visually receiving it but also is complemented through a problem-solving process. Several studies [11, 12] have shown that students in project-based courses not only attain a better grasp of knowledge, but also they have been more satisfied.

Although utilizing active learning methodologies have shown an overall degree of student satisfaction, there is not enough evidence to show any change of attitude toward STEM courses. Several studies [11, 13] have attempted to measure the success of project-based and active learning methodologies and their relation to students' motivation; however, a few have considered the impact of such methodologies on increasing the students' tendency toward enrolling in STEM classes.

The technology acceptance model (TAM), along with theory of reasoned action and theory of planned behavior [13], has been widely used in different domains to predict individual intention to adopt or not adopt a specific behavior. TAM examines intention toward adaptation of a particular behavior based on individual perception of usefulness and ease of use. In addition, individual behavior is affected by external factors, such as peers, parents, and media. According to the TAM, human behavior has a direct relationship with individual motivation and intention that can be molded by a person's attitude. Also, attitude can be molded by beliefs such as perceived usefulness and perceived ease of use.

This paper examines the relationship between an active learning methodology [11] used in a freshman class, ET100: Introduction to Engineering Technology, in the College of Technology at Eastern Michigan University and students' tendency to pursue and enroll in STEM courses. The study used TAM as a core model to assess effectiveness of robotics activities as an active learning tool to increase the students' intention and attitude toward STEM courses. Moreover, the paper presents the effects of external and internal factors such as social influences, anxiety, and self-efficacy.

Methodology

This study has used robotic projects [11-12, 14-15] as its active learning methodology. The following constructs [15-17] are utilized for measuring the impact of a project-based course on students' tendency to enroll in more STEM courses:

1. Behavioral Intention (IN)	degree to which a person has formulated conscious plans to perform or not perform some specified future behavior
2. Attitude Behavior (ATT)	general feeling toward performing certain action
3 Perceived Usefulness (PU)	perception of usefulness toward performing an action
4. Ease of Use (EU)	perception of how easy it is to perform a specific action
5. Social Influence (SI)	an external factor that impacts people's perception toward adoption of a behavior

6. Self-Efficacy (SE)	people's judgments of their capabilities to organize and execute courses of action required for attaining designated types of performances
7. Anxiety (ANX)	anxious feeling toward performing an action

Based on these constructs, a research model as presented in Figure 1 was constructed with the following hypotheses:

H1. There is a significant relationship between PU and EU.
H2. There is a significant relationship between PU and IN toward registering in STEM courses and utilizing robotic projects.
H3. There is a significant relationship between PU and ATT.
H4. There is a significant relationship between SI and ATT.
H5. There is a significant relationship between SI and IN.
H6. There is a significant relationship between ANX and ATT.
H7. There is a significant relationship between ANX and IN.
H8. There is a significant relationship between EU and ATT.
H9. There is a significant relationship between SE and ATT.
H10. There is a significant relationship between EU and IN.
H11. There is a significant relationship between ATT and IN.
H12. There is a significant relationship between SE and IN.

The constructs were validated and were selected with higher loading. The following survey was designed to measure each construct in the proposed research model:

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?

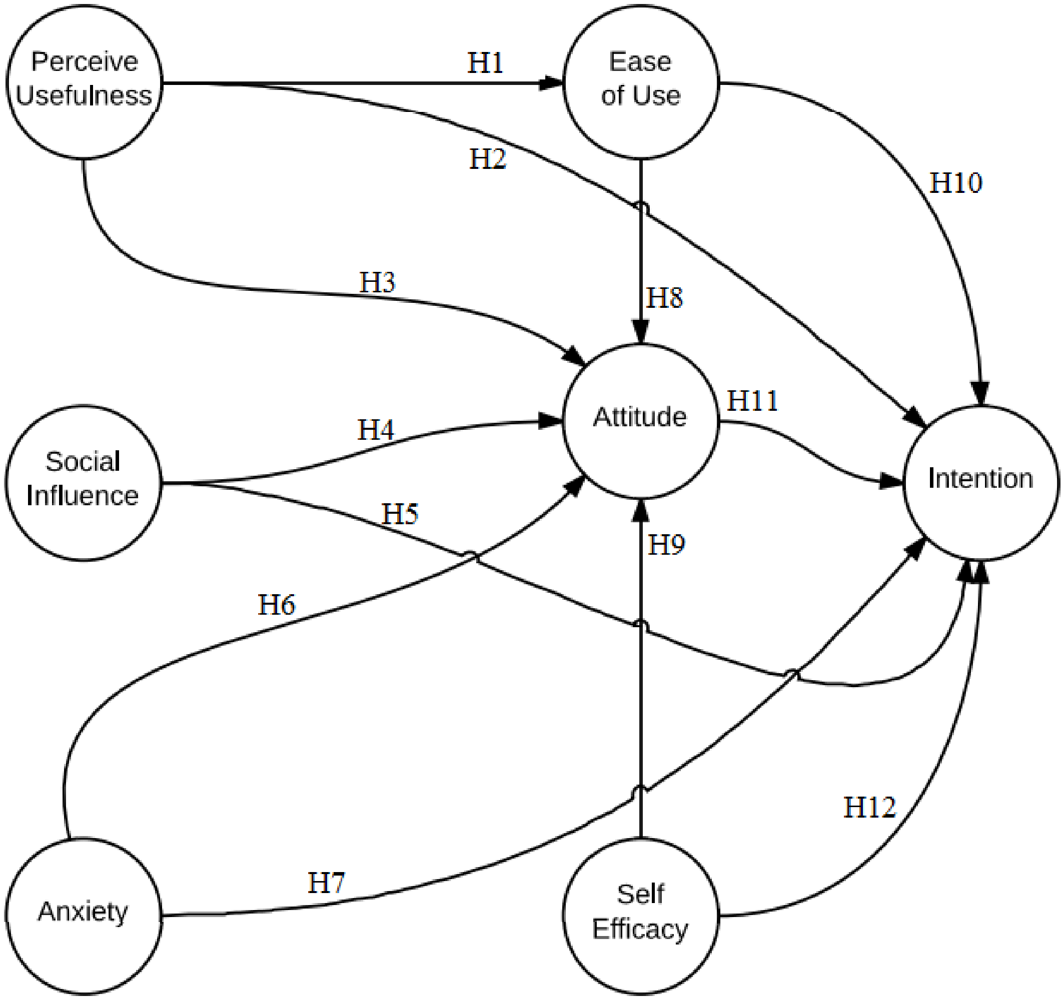

Figure 1. Research model and hypotheses

Ease of Use

g. It is easy to use robotic project in classroom.
h. It is easy to build a robotic structure.
i. It is easy to program a robot.
j. I can easily figure out how to use robots.
k. It is easy to learn how to operate a robot.
l. It is easy to become skillful in using robots.

Usefulness

m. I believe working on robotic projects helps me to better understand the class concepts.
n. I believe using robotic projects is beneficial.
o. I believe working on robotic projects is useful.
p. I believe using robotic projects helps to increase my performance in class.

q. I feel my learning in robotic helps my analytical skills.
r. I feel robotic projects improve my problem solving skills.
s. I feel robotic projects are useless.
t. I feel robotic based class helps me to work better as a team member.
u. I believe a robotic-based class helps me to better communicate my ideas with other team members.

Attitude

v. Using a robotic project in class is a good idea.
w. Robotic project makes learning more interesting in class.
x. Working with a robotic project in class is fun.
y. I like working with a robotic project in class.

Intention

z. Assuming I have access to a robotic platform, I intend to use it.
aa. Given that I have access to a robotic platform, I predict that I would use it.
bb. I prefer to register for robotic-based classes, if possible.
cc. This course motivates me to register for more science oriented classes in the future.
dd. This course motivates me to take more engineering oriented classes in the future.
ee. This course motivates me to take more mathematics-oriented classes in the future.
ff. This course motivates me to take more technology-oriented classes in the future.
gg. I predict I would use a robotic platform in the future.

Social Influence

hh. People who influence my behavior think that I should use a robotic-based project.
ii. People who are important to me think that I should use a robotic-based project.
jj. My instructors support me to work with robotic-based projects.
kk. My school (professor, peers) encourages me to take more classes in technology field.
ll. My school (professor, peers) encourages me to take more classes in engineering field.
mm. My school (professor, peers) encourages me to take more science classes.
nn. My school (professor, peers) encourages me to take more mathematics classes.

Anxiety

a. I feel apprehensive about using a robot.
b. It scares me to think that I could break a robot when I am using one.
c. I hesitate to use a robot for fear of making mistakes that I cannot correct.
d. Robotic projects are somewhat intimidating to me.

Self-Efficacy

I could complete a task/project using robots.....

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 software was provided.
d. If I had just the robot manual for assistance.
e, I feel confident to create different programing functions of robots.
f. I feel confident to build different structure of robots.
g. I feel confident to learn advanced skills within a robotic field.

The validity of the questionnaire [16] has been ensured by carefully selecting each question and consulting with panel of experts, formed by three faculties at Eastern Michigan University. Finally, an online survey was created and was used to test the research hypotheses by asking all students who were enrolled in the course in the fall and winter semesters to complete it. The reliability of the questionnaire has been tested by utilizing Smart PLS statistical software [17]. The software has been used to measure Cronbach's alpha and composite reliability as illustrated in Table 1.

Table 1. Survey reliability

	AVE	**Composite Reliability**	**R-square**	**Cronbach's 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 values of Cronbach's alpha and composite reliability for all of the constructs are bigger than 0.7, which confirms the reliability of the constructs [14]. Table 2 presents the outer loading of each factor within each construct, which is a good representative of the questionnaire.

From 98 collected responses during the two semesters, demographic data show 10 females (10.20 %) and 88 males (89.80 %). Ages vary from 17 to 66, 21 years as the average and college enrollment with for 2.2 years after high school. The degree programs of students were simulation and gaming, computer engineering technology, electrical engineering technology, mechanical engineering technology, and finance.

Table 2. 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	0.848	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	0.8133	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	0.745	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

Analysis and Results

Smart PLS was used to analysis and find the path coefficients in the model as presented in Figure 2. The numbers inside each construct are R-square values and each construct is presented with its items and factor loading.

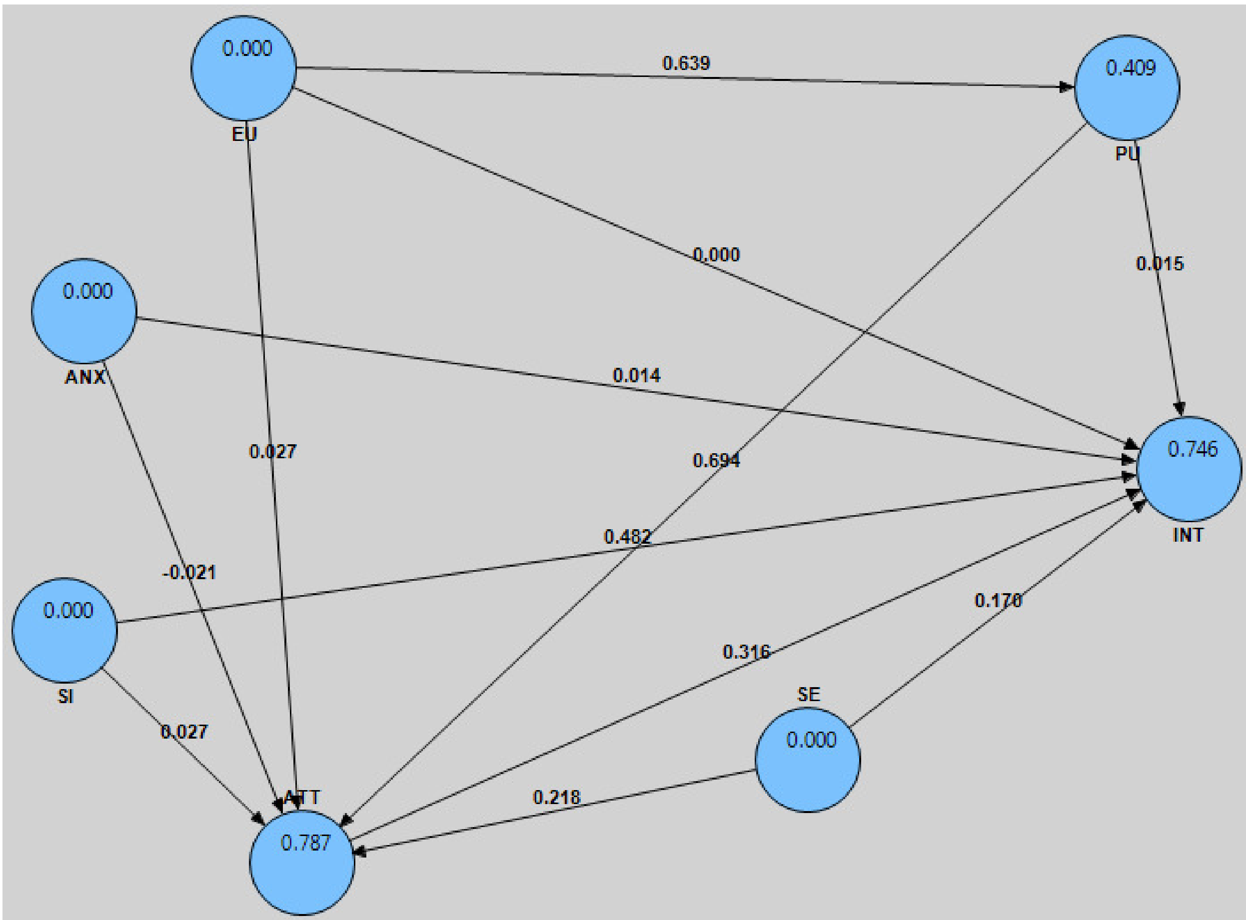

Figure 2. Path coefficient and R-square

The same software was used to evaluate the loading of each question in each construct as shown in Figure 3 and Table 2.

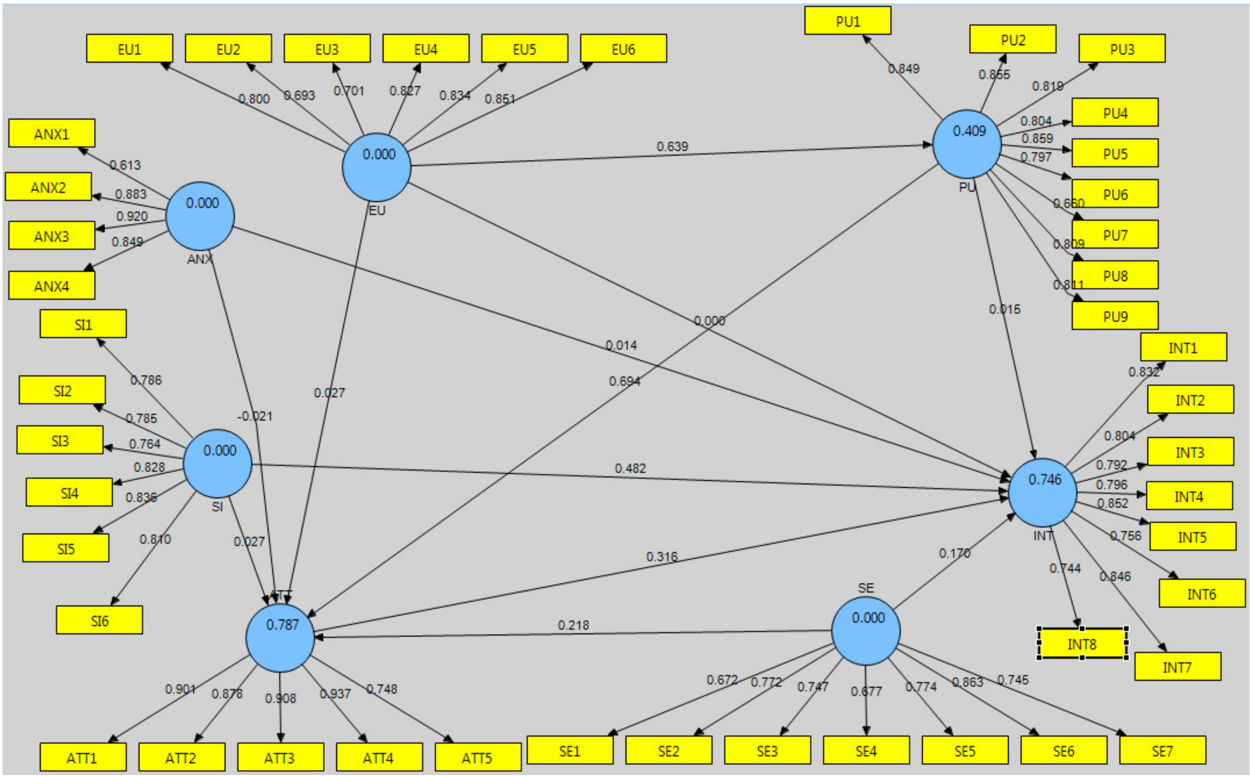

Figure 3. Analysis of the proposed model

In order to examine the designed hypotheses, the t-values for all paths and hypotheses were calculated as illustrated in Table 3. The hypotheses with a t-value above 1.96 were accepted.

According to the analysis of hypotheses in Figure 3, the H1, H2, H3, H5, H8, H9, H11, and H12 hypotheses have been confirmed. In other words, the individual's perception of the EU of robotic projects has a positive relationship with ATT and their PU; PU has a positive and direct relationship with students' ATT and IN toward using robotic projects and enrolling in more STEM classes. SI has a direct and positive relationship with ATT toward using robotic projects, and SE has a direct and positive relationship with ATT and IN toward enrolling for more STEM-oriented courses.

On the other hand, the hypotheses of H4, H6, H7, and H10 show t-values smaller than 1.96 and thus have been rejected. This conveys that this study could not confirm the positive relationship between SI and changing ATT toward using robotic projects, any positive or negative effect of ANX toward using robotic projects in the classroom and ATT and IN of using robotic projects in the future and/or enrolling in more STEM-related courses, and no positive relationship between perceived EU and ATT toward using robotic projects.

Table 3. Results of hypothesis testing

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

Conclusions

This paper attempted to address the underlying factors that impact students' attitudes and intentions toward enrolling for more STEM-related courses through a research model that uses several theoretical frameworks that explain human behavior. Twelve hypotheses were developed for the model, and only four were rejected; the rest were confirmed. This study showed that PU, SI, SE, and ATT have direct and positive relationships with students' intention toward enrolling in more STEM courses and using robotic projects. It also was found that there is no positive relationship between SI and ATT, ANX and ATT, ANX and IN, and EU and IN to enroll in more STEM-related courses.

In this study, the social influences were limited to family members, friends, peers, and instructors. Future studies could focus on the effect of the job market, mass media, and other electronic media on student attitudes and intentions about working with robotic projects and enrolling in more STEM courses. Also, the data collections were done only in a period of two consecutive semesters for the same course, which makes it impossible to determine the actual behavior of the students and whether their intention had actually led to more registration in STEM-related courses. Thus, further studies are needed to determine whether the behavior of enrolling in more STEM courses is a function of individual intentions.

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Biographies

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ALI EYDGAHI started his career in higher education as a faculty member at Rensselaer Polytechnic Institute in 1985. Since then, he has been with the State University of New York, University of Maryland Eastern Shore, and Eastern Michigan University. During 2006-2010, he was chair of the Department of Engineering and Aviation Sciences, founder and director of the Center for 3-D Visualization and Virtual Reality Applications, and technical director of the NASA funded MIST Space Vehicle Mission Planning Laboratory at the University of Maryland Eastern Shore. In 2010, he joined Eastern Michigan University as an associate dean in the College of Technology and currently is a professor in the School of Engineering Technology. He has extensive experience in curriculum and laboratory design and development. Dr. Eydgahi has served as a member of the Board of Directors for Tau Alpha Pi, as a member of advisory and editorial boards for many international journals in engineering and technology, as a member of review panel for NASA and Department of Education, as a regional and chapter chairman of IEEE, SME, and ASEE, and as a session chair and as a member of scientific and international committees for many international conferences. Dr. Eydgahi can be reached at aeydgahi@emich.edu