

Effects of Summer Transportation Institute on Minority High School Students' Perception on STEM Learning

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Abstract

A lack of interest into science, technology, engineering and mathematics (STEM) among minority high school students can hinder the development of diverse workforce in transportation engineering. The goal of this paper was to evaluate the effect of a summer transportation institute for African American high school students in motivating their interests and career choices in engineering fields. The summer camp curriculum included senior professors' academic lectures, hands-on technical projects, field trips and recreational activities related to traffic engineering to help students increase STEM course knowledge, improve their academic awareness of transportation engineering, and enhance their abilities to create, analyze and solve practical problems. Satisfaction and MSLQ questionnaires were used to assess the effectiveness of the program. The analysis results indicate that the MSTI project is beneficial to fostering students' interest in engineering technology by successfully guiding students to choose their future STEM career and to make further education plans after graduating from high school, especially in the transportation field.

Keywords: STEM, education, transportation, summer, high school students, minority

Introduction

The United States enjoys the position of a global leader in science, technology, engineering and mathematics (STEM). According to former President Obama (2010), leadership depends on tomorrow's education in STEM. About sixteen percent of high school students in U.S. choose to pursue a STEM career and nearly half of college students in STEM fields choose to work in a related occupation. The Committee on STEM Education planned to facilitate a national strategy to reorganize STEM education programs, including increasing and sustaining public and youth engagement with STEM, and better serving groups historically underrepresented in STEM fields. Upton and Tanenbaum (2014) of American Institutes for Research reported the lack of diverse groups of individuals in STEM academic and workforce fields and the need to foster the participation among African Americans.

The program Mississippi Summer Transportation Institute (MSTI) aimed to introduce STEM to high school students and foster their interests in STEM fields to cultivate more future scientists, engineers and mathematicians. King (2015) showed that the demand for a competent transportation workforce was rising in the United States; however, the graduation rate in this area remained low. Jackson State University (JSU) was fully aware of the importance of transportation system in the country and embarked on a plan to increase the number of skilled professionals in this area. The MSTI program, which aimed at introducing a diverse group of motivated pre-college students to the transportation industry, was one of such initiatives designed to prepare the youth to meet these challenges.

This work presented the experiences gained in the residential MSTI 2017 program by using data collected to study students' perception and preferences of pursuing studies in STEM disciplines for future careers in transportation. Based on camp survey results received from participants, it demonstrated that the MSTI program is a practical, feasible, and sustainable approach to attract high school students to transportation engineering fields.

Literature Review

Arousing students' interest and recruiting more students in STEM majors were often the aims of STEM camps. For example, Sala et al. (2013) held a one-week engineering and technology summer camp, which was structured around different engineering disciplines. A total of nine instructional modules were developed and taught by engineering faculty during the camp, which were found to be successful in raising students' interest and confidence in pursuing careers in engineering and technology. Mohr-Schroeder et al. (2014) created See Blue STEM Camp to expose middle-level students to a variety of STEM fields and STEM professionals through hands-on project-based learning experiences in order to improve students' interests on STEM education after the camp experience. They reported the effectiveness of the STEM education programs in attracting students' interest in STEM. However, the research failed to identify the factors from which the students were influenced by the

programs and the processes of such influences.

Some researchers went a step further and tried to investigate how those programs foster students' interest in the STEM. Zhe et al. (2010) described their 10-week long STEM Summer Bridge Program with ten to twelve-grade high school students. By evaluating college admission data, the authors found that 100% of those students choosing to continue in college education, with 86% choosing to major in a STEM area. Participants' comments, regarding their expectations, interests, and skills, indicated that the program had promoted their interest and confidence in STEM majors, which resulted in their enhanced motivation to consider a career in STEM. However, without quantifiable data, to what extent did the Bridge Program impacted the participants remained unknown. Matthews (2011) conducted a far-post assessment on the influence of the Green Design Apprenticeship with students 2-3 years after the completion of the program. The author employed a qualitative method to explore the factors that affected students' choices of learning and working fields. Through content analysis, the researcher found that the program content had positive effects on students' decisions for study fields and daily activities. However, the project was conducted only with talented high school students who were interested in learning about academic and career options in engineering, and the result should not be applied to other students readily. Although the above research tried to explore the factors that influenced students in various STEM programs, the lack of quantitative evidence or inference made it impossible to assess the influencing factors of these programs accurately.

An increasing number of researchers have investigated the influencing factors of STEM programs using rigorous numerical analysis. Louisiana Tech University conducted the GEAR-UP Summer Camp, which introduced engineering to 7th and 8th graders. Bachman et al. (2008) reported their findings from the 2004, 2005 and 2006 Science Summer Camps, one-week camps which intended to serve students who were not yet determined to attend college as engineering or science majors. Pre- and post-surveys were conducted to evaluate students' STEM interests, attitudes, and self-perceptions of skills. A comparison of the mean score showed that there were only small changes in some categories, which

indicated that the camp did not have a dramatic impact on the motivational disposition of the campers. The histograms of an alumni survey indicated that students thought positively of the camp experience and viewed the experience as an important stimulus in their consideration of becoming a science major in college. However, the results of the pre-survey and follow-up interviews indicated that the campers were highly interested and motivated in engineering/science even before the camp, so the camp's impact on average students' science interests, attitudes, and self-perceptions of skills remains unknown.

There are also some studies focusing on the impacts of the camp on students' perceptions of engineering and future choice of major. Ayar et al. (2013) discussed the lived-experiences and career interests of 27 high school students who participated in a two-week robotics summer camp, in which the students in pairs designed, built, tested, and modified their robots through practical implementations. Study data indicated that the students' interests in engineering were improved in the camp, and the camp experience helped them determine specific engineering fields that they wished to study in their academic career. Hammack et al. (2015) tried to measure how participating in a week-long engineering summer camp affected middle school students' attitudes toward engineering and technology. The results indicated a positive impact on participants. However, it is not clear which components of the camp contributed to this change.

Effectiveness of STEM programs are frequently mentioned in many researches (An 2012; Kimmel et al. 2015), but the statistical analysis in the above literatures could hardly provide enough evidences to prove how to reach the aims of STEM camps. The conflicting results from previous investigations made it necessary to explore the real influence of programs that aim to arouse students' interest in STEM. Furthermore, the specific influential factors, as well as their impact on students' STEM learning achievement and future major choices, need to be identified and formulated.

Program Overview

The MSTI Program, aiming to introduce a diverse group of motivated high school students into the transportation industry, had been hosted by JSU for nine consecutive years (2009 - 2017) and supported by the Mississippi Department of Transportation (MDOT) and the Federal Highway Administration (FHWA). The Department of Civil and Environmental Engineering of JSU held the MSTI 2017, which was a three-week residential summer program, in partnership with the FHWA, MDOT, local industries, and community organizations. Jackson State University had sought a grant to support this study from FHWA and MDOT to conduct this program. JSU

donated faculty and staff-time, laboratory facilities, and classroom space as in-kind contributions and drew upon the expertise of academia, private industries, government, and the various departments to successfully execute this program.

The academic and extra-curricular activities of the MSTI 2017 were designed to help high school students improve STEM knowledge and leadership skills. Furthermore, the MSTI 2017 Program strived to 1) increase students' awareness of transportation rules, regulations and safety; 2) enhance students' understanding of transportation-related problems and solutions; 3) expose students to a variety of transportation career opportunities; 4) improve students' creative, analytical and problem-solving skills; 5) develop students' interpersonal and leadership skills; and 6) provide college and career guidance.

3.1 Student Recruitment and Selection

Conventional student recruitment strategies were employed to disseminate information about the MSTI 2017 Program, such as posters, fliers, visits to high schools, communications with school teachers, counsellors and principals, and announcements on the JSU website. Additionally, social media such as Facebook and Twitter were used to reach the students. Program application packages were sent to school principals and counsellors in all Mississippi school districts.

Twenty-two rising 9th-12th grade African American students, ten female and twelve male, were selected to participate in the program by the Inter-modal Advisory Committee (IAC). The recruitment criteria were as follows: (1) Be a dedicated rising 9th-12th grade student; (2) Have completed at least one high school algebra course; (3) Have a cumulative grade point average of 2.8; (4) Be recommended by a teacher or counselor; (5) Have expressed interest in STEM and especially transportation careers; (6) Have submitted a copy of current transcripts; (7) Be committed to completing the entire program; (8) Have provided a written statement regarding his/her reasons to participate this program. During the program, students were required to reside in student dormitories on JSU campus from Sunday afternoon through Friday afternoon. An evening coordinator organized in-class scientific projects. All participants received a scholarship to attend this three-week residential summer program.

3.2 STEM-Focused Program Curriculum

This residential MSTI 2017 program provided a well-balanced curriculum and an environment that was conducive to students' academic and personal development, cultivating interpersonal skills and exposing students to real-world transportation issues through a series of classroom activities, field trips and recreational activities.

3.2.1 Academic

The MSTI curriculum included presentations on design, construction, operation, maintenance and management of transportation facilities, various modes of transportation, people and cargo in transportation, transportation laws, emergency evacuation management and preparedness, as well as transportation-related environmental issues. Students were exposed to traffic simulations to learn about traffic engineering concepts, highway capacity, levels of service, Microstation software to design highway facilities, computer-based simulations to analyze roadway intersections, the design of city streets, and Geographic Information System (GIS) programs to visualize and manage transportation facilities.

Participants were taken on field trips to various transportation facilities in the area to learn the available transportation modes and inter-modal facilities, and to meet related transportation industry, builders, and stakeholders. Students experienced various transportation careers and functions from experts at these sites. Additionally, there were presentations by a MDOT materials engineer, rail division project manager, traffic engineer, state planner and law enforcement supervisor. Besides, JSU Civil and Environmental Engineering faculty and graduate students presented lectures and demonstrated lab activities during tours to the Civil Engineering Laboratories. The curriculum employed events such as presentations, group discussions, and assignments to help improve students' STEM capabilities.

3.2.2 Enhancement

The enhancement program provided some college preparatory activities. These activities, such as traffic-control robot competition, bridge competition and so on, were designed to expose students to college and career planning, and to enhance their design ability and teamwork skills. Students' knowledge of computer safety and usage, communication skills, resume building, and SAT/ACT preparations were also enhanced. Further, students were exposed to activities that help improve STEM capabilities, study habits, time management, and personality development skills.

3.2.3 Sports and Recreation

The recreation program exposed students to games and recreation rules and regulations. Emphasis was placed on developing leadership skills, good sportsmanship, and a healthy and competitive attitude. Activities included swimming, basketball and a variety of competitive games. A campus scavenger hunt and ice cream night brought students much fun and the opportunity to get to know each other. An evening coordinator organized in-class scientific projects, including Eiffel tower construction, hanging in duct tape, balsa bridge glider, egg drop, and paper tower competition. An ice cream night, root bear competition, and surprise water balloon fight entertained

students while providing a break from the extensive daytime activities.

The MSTI program culminated in a closing luncheon where the knowledge and skills gained by students were demonstrated to parents and guests. Each student was awarded a certificate for participation, and professional staff received certificates of appreciation to recognize their service in the MSTI program. Weekly evaluations were conducted, and overall program evaluations were held at the end of the MSTI program.

4. Survey Results and Data Analysis

A comprehensive survey was used to assess the MSTI Program achievements, focusing on career and academic decisions made by senior year participants and containing questions about participant demographic status, the changes of career planning, subject choices, schools attended, and specialization field before and after MSTI. Additionally, a database of MSTI participants created by JSU contained summaries of surveys and was utilized to establish an alumnus of MSTI participants at JSU.

To find out the influence of the MSTI program, researchers looked into students' satisfaction through the survey to see the general influence, and then further investigated student's learning disposition changes over the program to examine the specific influence. The satisfactory survey showed that, after attending the activities in the program, the majority of students thought the MSTI program influenced them to choose JSU University. A higher percentage of students selected STEM as their future majors in college. Most importantly, all the responding students acknowledged that the program effectively helped them to understand engineering and transportation. The investigation of students' learning disposition further revealed the influence of the program.

4.1 Program Characteristics and Satisfaction

To find out students' satisfaction of the program, this research investigated the following aspects through questionnaire: the most attractive characteristics of this program to students (Figure 1), clarification of program expectations (Table 1), guidance from program instructors (Table 1), which shows why the students are attracted to the program and whether they are willing to share their experience to others after the program.

The most attractive characteristics are shown in Figure 1. More than 60% of students were attracted to the MSTI program because of the valuable educational experience, which was three times greater than the second highest reason: the opportunity for hands-on training. The second highest percent of students thought that the chance of hands-on training related to transformational engineering was the most attractive point. The research result proved that the function of this program had been well acknowledged by students who believed that this

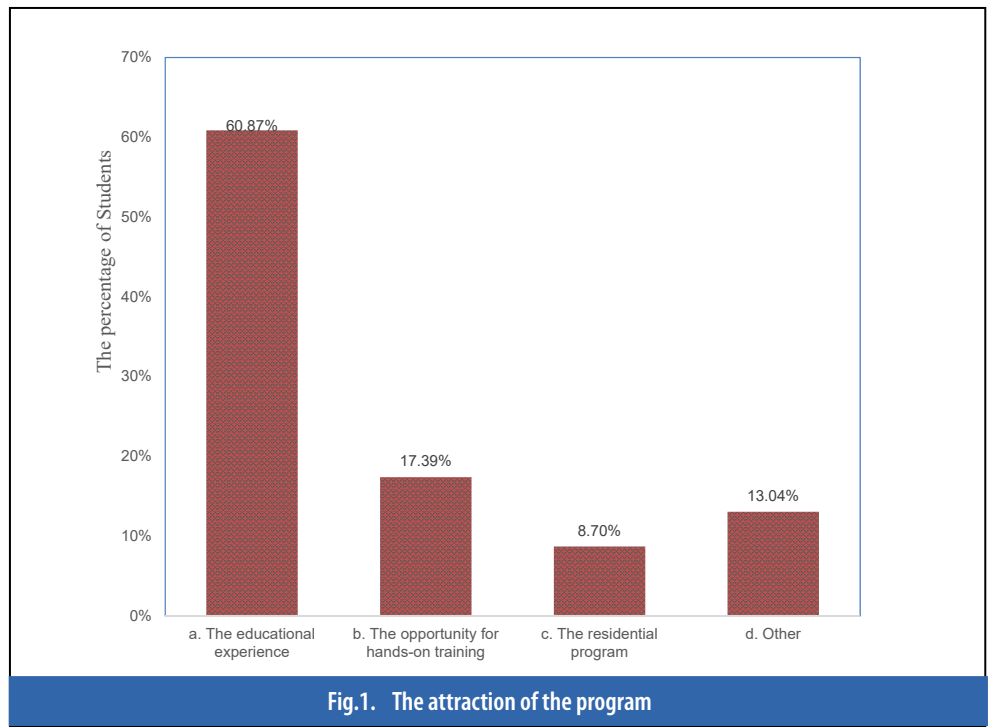


Fig.1. The attraction of the program

program provided excellent transformational engineering education opportunities and STEM training.

In the satisfaction questionnaire, there were three questions that contributed to find out students' satisfaction with the STEM camp—whether students had reached the aims and finished tasks of the project, whether faculty provided clear instructions, and whether they would share their experience to others after MSTI program. The questionnaire was rated on a 5-point Likert scale ranging from “strongly disagree” to “strongly agree” that measured how the participants think about the administrative process of MSTI. Table 1 listed the means, and standard deviations of three related questions, in which the means of all three items were far more than 3.0 with a standard deviation (SD) value around 0.83, indicating that the students were quite satisfied with the program arrangements and students received excellent instructions in transportation fields. Their satisfactions on the camp were very high and they were willing to share their experiences in MSTI with their peers and friends.

4.2 Academic Plan Changes Before and After MSTI

This study investigated the changes of students' attitudes towards future education, the choices of

universities and majors after the participated MSTI program, as well as the obstacles that would prevent them from attending colleges.

Figure 2 gave the changes in students' opinions on degree program before and after MSTI program. Before participating MSTI, about 59.09% of students had decided to pursue a degree, and the percentage increased to 81.82% after the program. The undecided student percentage dropped from 40.91% to 18.81%, showing that the students had a much clearer mind about a future degree program plan after attending the MSTI program. The results indicated that the MSTI program had a positive effect on high school students' decisions on future education and guided them to pursue a further degree after graduation.

In Figure 3, the participating students changed their future choices of universities. Before MSTI program, about 18.18% of students chose JSU to be their university after high school graduation. After MSTI, the percentage of students increased to 40.09%. Initially, as many as 81.82% students chose other schools, and after the summer camp experience, the number dropped to 59.10%, indicating that the program gave the students an excellent chance to know about JSU and helped them to decide the choice of future universities.

	Mean	SD*
Clear about the project expectations.	3.57	0.81
Faculty provides clear instructions.	3.90	0.83
Share MSTI experience with peers	3.90	0.83

*SD is short for Std. Deviation.

Table 1. Students' satisfaction on MSTI program

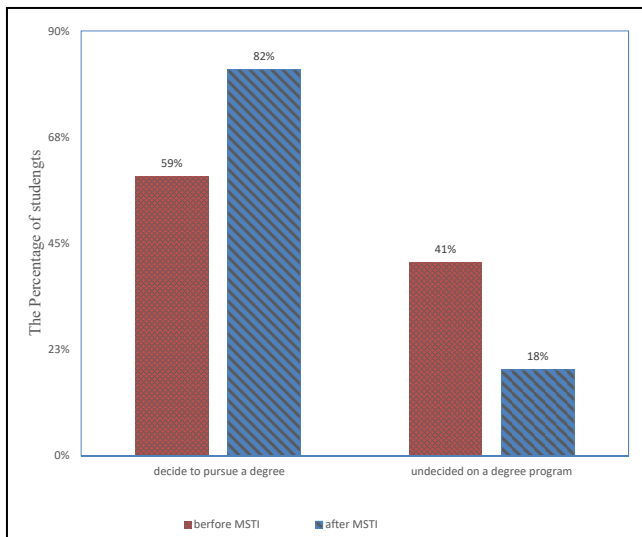


Fig. 2. Changes of Decision on a Degree Program

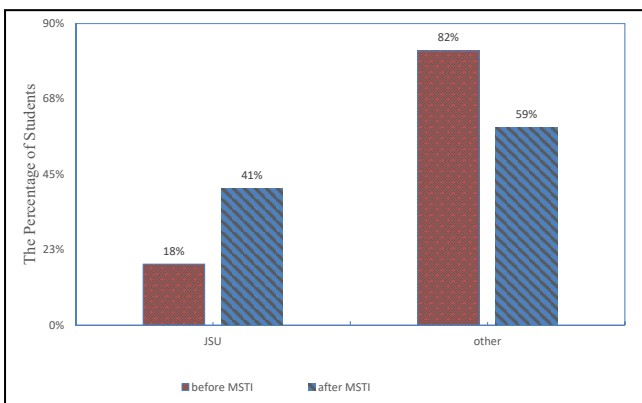


Fig. 3. Change in Choices of Schools

There were also changes in decisions on majors before and after MSTI program in Figure 4. The decision on major of engineering increased from 22.73% to 50.00%, while the math decision increased slightly from 4.55% to 9.09%. This result indicated that the MSTI program had a distinct influence on students' decisions about their future majors in universities. The program

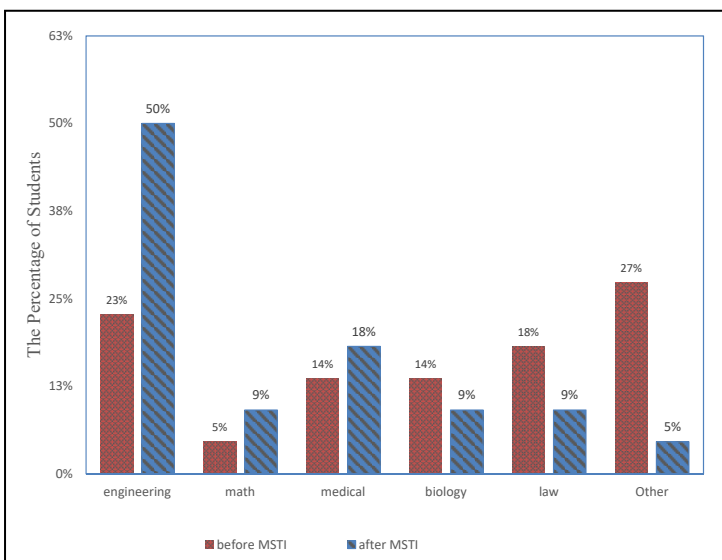


Fig. 4. Changes of Decision on Major

provided them with valuable direct contact and observation of the major they like as well as gave them a clear understanding about its applications in future careers. The result further illustrated that the carryout of the program met expectations and achieved the original aims of the program.

Figure 5 showed how students perceived the possible obstacles to pursuing a degree in the future after attending the MSTI program. The students indicated on their surveys that more than half of them thought nothing could stop them from pursuing degree studies after graduating from high school, which also indicated that the MSTI project itself had a positive impact on students' attitudes towards continuing education. About 23% of the students thought financial difficulties would be their obstacles because most of the students who participated in the survey were on relatively lower economic level, whose family economic reality determines their thoughts that the economy was a big difficulty. The majority of students believed that there was no obstacle in the university's preparatory course,

geographical location and family support.

Table 2 showed the mathematical statistics of the impact of MSTI program on students' future academic plans and careers, mainly including: after participating MSTI, had they undergone a positive change on science and engineering awareness and viewpoints? Had the project improve confidence in their future career plans?

Was there any useful information in the project that would help them to make future career choices? As can be found from the table, the averages of the latter two questions were above 4, and the mean of the first question was 3.48, indicating that the students' answers were positive towards the summer camp program. The development of the project would help them to plan their careers. In particular, the change of viewpoints in the field of engineering would help

them in the procedure of choosing a future profession in the area of engineering technology, in which US has a more significant talent demand, especially transportation engineering.

4.3 Enhancement of Skills

The project made surveys after students' participation of the STEM camp to investigate the effect of MSTI in improving student's skills, such as the knowledge of writing skills, teamwork skills, oral presentation and documentation, combined with other answers on their acquired skills. As shown in Figure 6, the MSTI program improved students' many social and academic skills. About half of all students mentioned that their teamwork skills were significantly improved. Nearly 22.73% students believed that their oral presentation skills were improved, and the second highest improved skill was the documentation skill. The MSTI program provided students with many opportunities to cooperate and solve problems together and encouraged them to express opinions and make oral presentations.

To further evaluate the effectiveness of MSTI programs, the following questions were asked through questionnaires: Does participation of MSTI improve skills? Can enhanced skills be applied to future academic practice? Does MSTI teamwork help to develop skills? As can be seen from Table 3, the means of three questions were all above 4 out of a full score 5, which showed that the MSTI project greatly enhanced students' engineering and technical skills, especially their teamwork skills.

4.4 Changes of Learning Disposition in MSTI

To further investigate students' attitudes towards the program, the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1991) was applied in the program, and data was collected in the pretest and post-test to investigate the influence of the MSTI program on students' learning disposition. MSLQ was a widely used questionnaire, designed and developed by a team of researchers from the National Center for Research to Improve Postsecondary Teaching and Learning (NCRIPAL) and the School of Education at the University of Michigan. The researchers chose 44 items in the questionnaire to test students on five scales: self-efficacy, intrinsic value, test anxiety, cognitive strategy use and self-regulation. Students rate themselves on a 7-point Likert scale from "strongly disagree" to "strongly agree".

The researchers collected 22 pairs of valid pretest and posttest MSLQ surveys. Paired-sample T-Test was used to investigate the change in students' learning disposition before and after the MSTI program. As shown in Table 4, students experienced significant growth in the variable of "Self-Efficacy" ($p=0.03$) and "Cognitive Strategy Use" ($p=0.020$) after participating MSTI program. The mean of self-efficacy was increased by 0.26 (from 5.31 to 5.57) with an effect size value 0.31, indicating that students

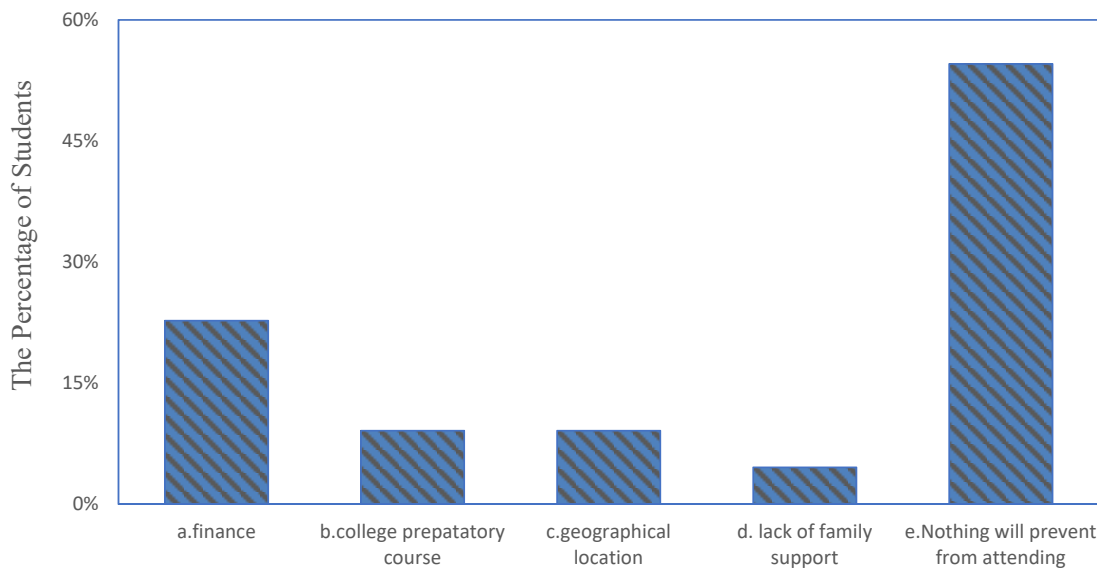


Fig. 5. Obstacles during Degree Pursuing

	Mean	SD
Opinion has changed towards engineering.	3.48	1.12
Increased confidence in choosing major.	4.15	0.99
Get useful information on career choice.	4.00	0.77

Table 2. Changes in Students' future education and career choices

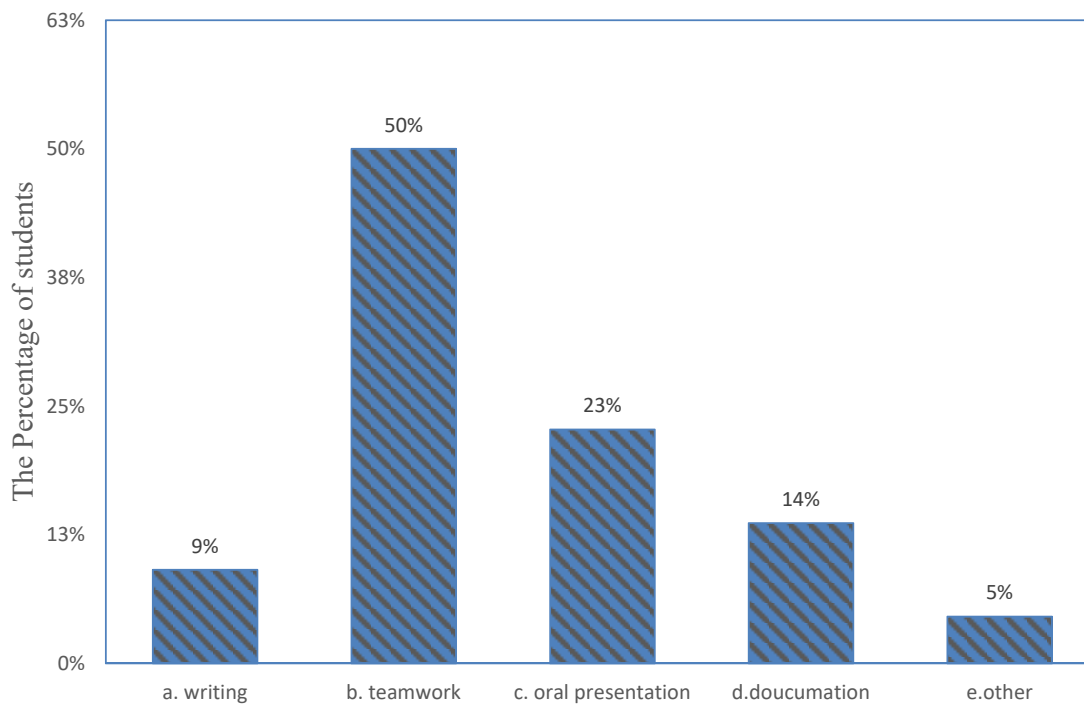


Fig. 6. Acquired Skills After MSTI

achieved great confidence in fulfilling academic tasks during MSTI program, which had a positive influence on students' skills in finishing tasks.

The mean of cognitive strategy use was also increased by 0.26 (from 5.20 to 5.46) with an effect size value 0.36, indicating that students developed a passion for

learning engineering-related majors after participating MSTI, and would actively take the initiative to utilize various strategies. Although the pretest and the posttest of intrinsic value, test anxiety and self-regulation were not statistically different, the means of those scales were slightly increased, showing that the MSTI program had increased students' learning motivations. The results indicated that the program fostered students' development of self-efficacy and cognitive strategy use. The activities, especially the bridge program and the robot program did arouse their interests in engineering and encouraged them to use their cognitive strategies.

Conclusion

The MSTI project applied a variety of summer camp activities to increase students' knowledge in STEM courses—which could guide high school students to make good future career plans—by arousing their interests in science and technology engineering, especially transportation engineering, and enhancing their engineering skills through the form of teamwork. The results of the MSTI program were evaluated by questionnaires, showing that the participating students highly praised the STEM-based transportation program and were quite satisfied with the implementation of the entire program. The MSTI program had a positive impact on the future education and career planning of participating students and increased their interests in engineering. The MSTI program significantly increased the probability that students would choose engineering as their future career, which was beneficial to meeting national or regional demands for transportation engineering talents. The MSTI program enhanced students' cooperative and leading abilities and cultivated their skills in design, writing, presentation and documentation during teamwork. It is believed that the MSTI project will continue to guide more high school students toward an interest in STEM study and toward a career in engineering, especially in the field of transportation.

Scales	Pre-Test		Post-Test		Growth				Effect Size
	Mean	SD	Mean	SD	Mean	SD	T	P	
Self-Efficacy	5.31	0.94	5.57	0.84	0.26	0.61	2.23	0.03*	0.31
Intrinsic Value	5.40	0.88	5.65	0.74	0.25	0.70	1.93	0.06	0.34
Test Anxiety	4.76	0.97	4.91	0.75	0.15	0.79	1.06	0.30	0.20
Cognitive Strategy Use	5.20	0.68	5.46	0.72	0.26	0.58	2.47	0.02*	0.36
Self-Regulation	4.57	0.72	4.68	0.88	0.11	0.91	0.63	0.53	0.12

*P is significant at the 0.05 level. Effect Size= difference between means of post-test and pre-test divided by the Std. Deviation of post-test. Effect size=0.2 be considered a 'small' effect size, 0.5 represents a 'medium' effect size and 0.8 a 'large' effect size.

Table 4. The improvement of learning disposition after intervention (n=22)

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