AC 2012-4627: ASSESSING TECHNOLOGICAL LITERACY OF MIDDLE SCHOOL STUDENTS

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Abstract

Project Lead the Way (PLTW) is a rigorous and relevant pre-engineering curriculum implemented in middle schools and high schools throughout the United States. PLTW has a hands-on approach using activities and project-based learning. The College of Engineering at Wichita State University has partnered with three local school districts to implement the PLTW program to increase interest in Science, Technology, Engineering and Mathematics (STEM). This study begins to assess the impact of the PLTW program on student perceptions and attitudes toward engineering and technology as part of an ongoing three-year assessment.

A pre- and post-assessment were administered to middle school students (*N*=1063 and *N*=800, respectively) at the beginning and end of the 2010-2011 academic school year. The assessment consisted of 67-questions addressing students' attitudes toward engineering and technology. This assessment was a combination of subscales from the Pupils' Attitude Toward Technology (PATT-USA) and the Middle School Attitudes to Engineering, Science & Mathematics survey. Dependent variables of interest included attitude differences between PLTW students and non-PLTW students, gender differences, and differences attributed to length of involvement in the PLTW program. Results indicated PLTW students have a greater interest in technology, however there were notable gender differences and differences attributed to length of involvement in the program. Males had a greater interest in technology and longer involvement (0-3 years) in the program resulting in more positive attitudes. Females tended to have more negative opinions about technology at both pre- and post-assessment.

Introduction

Project Lead the Way (PLTW) is targeted toward educating middle and high school students about engineering and technology to encourage the study of engineering post high school graduation.[1] PLTW was established in 1997 to address the shortage of domestic engineers. There are currently 4,500 program implementations in every state with more than 18,000 teachers trained to teach PLTW courses.[2] Approximately 70% of students involved in the PLTW program report intentions of obtaining a college degree in an engineering/technology related field after graduating high school; PLTW students are 5 to 10 times more likely to enter into an engineering/technology related field than other high school graduates.[2] In 2000, this program was successfully implemented in middle schools throughout the United States.[2]

The College of Engineering at Wichita State University has partnered with three local school districts to increase interest and awareness in Science, Technology, Engineering and Mathematics (STEM) by implementing the Project Lead The Way (PLTW) program. The middle school curriculum offered within the three school districts consists of a combination of seven units of the Gateway to Technology (GTT) courses (e.g., Automation and Robotics is one of the foundation units). Students learn about engineering graphics, engineering science, and engineering careers. This allows students to grasp how technology works, not just how to use it. This hands-on learning approach provides opportunities for students in areas they may not normally pursue.

This paper reports the results of a pre/post assessment of student attitudes toward engineering and technology during the 2010-2011 academic school year in middle schools implementing the PLTW curriculum and comparable schools not involved in the program (control group). The online assessment administered was a combination of the Pupils' Attitude Toward Technology (PATT-USA) and the Middle School Attitudes to Engineering, Science & Mathematics survey.[3, 4] This was the first assessment of a three-year project.

The following research questions were of primary interest:

1. Is there a difference in attitude toward technology/engineering for PLTW students after one year of the program compared to those in the control group?
2. Is there a difference in attitudes based on gender collapsed across groups?
3. Is there a difference in attitudes based on the number of years enrolled in the various GTT courses?

Methods

Participants

A pre-assessment was administered at the beginning of the academic year to middle school students (i.e., grades 6th through 8th) from three Wichita, KS school districts. This served as a baseline of students' attitudes before engaging in the PLTW program and included students enrolled in PLTW courses (n = 731) and a control group (n = 332). A post-assessment was administered at the end of the academic year to the same students; 800 of the original students completed the post-assessment (PLTW n = 650; Control n = 150).

Materials

The 67-question survey consisted of demographic information (e.g., age, grade, number of years taking GTT courses), the PATT-USA and the Middle School Attitudes to Engineering, Science & Mathematics surveys. These two surveys were chosen because they were designed specifically for the age group of interest (6th through 8th grade) and had been previously validated by other researchers. Items in the online survey consisted of likert-scale questions.

Marc de Vries originally developed PATT in the Netherlands in the early 1980s. In 1989, the PATT-USA version was developed and administered to over 10,000 junior high school students in 7 states to validate the assessment.[5] The sample consisted of 6th through 8th grade students, of which a majority (approximately 2/3) had taken a technology-related course. The PATT has since been translated and used in over 25 countries. Only 3 of the 6 subscales of the PATT-USA were used in the current assessment to eliminate overlap with the Middle School Attitudes to Engineering, Science & Mathematics survey and to decrease the time necessary to complete the online survey. The three PATT-USA subscales consist of the 1) General Interest in Technology, 2) Consequences of Technology and the 3) Technology is Difficult subscale.

The Middle School Attitudes to Engineering, Science & Mathematics survey has also been psychometrically tested. A principal component analysis identified 7 factors including 1) Interest: Stereotypic Aspects, 2) Interest: Non-Stereotypic Aspects, 3) Positive Opinions,

4) Negative Opinions, 5) Problem Solving, 6) Technical Skills, 7) Engineer, and finally two additional items regarding girls' abilities in math and science, and the student's intent on attending college.[4] Cronbach's alpha for the assessment was .85 indicating good internal consistency between items.

Procedure

Consent and assent forms were distributed to students and their guardians. After all forms were returned, teachers at their respective schools administered a 67-question online survey to students. The pre-test was administered at the beginning of the Fall 2010 semester and a post-test was administered at the end of the Spring 2011 semester to the same students. Participation took approximately 30 minutes for each administration.

Results

The following analyses were run as between-subject design because identifying information was not collected from students (i.e., names). Therefore, there was no way to match students' pre-test scores with their post-test scores.

Group Differences

A series of independent sample t-tests were conducted to determine the difference between groups at pre- and post-test. Type I errors were controlled using a Bonferroni procedure.

Table 1. Mean (*SD*) of Pupil's Attitude Toward Technology (PATT-USA) subscales by group at pre- and post-test.

	Control (pre)	PLTW (pre)	Control (post)	PLTW (post)
General Interest	2.09 (0.70)	2.34 (0.76)[1]	1.98 (0.71)	2.24 (0.74)[1]
Consequences	2.70 (0.73)	2.80 (0.76)	2.51 (0.81)	2.69 (0.74)
Technical Difficulty	1.35 (0.81)	1.54 (0.88)[1]	1.47 (0.85)	1.58 (0.91)

Note: 1 – Disagree, 5 – Agree; Higher mean values indicate greater interest, more positive consequences, and greater difficulty.
[1] Significant at the .05 alpha level

Students involved in PLTW reported a greater interest in technology (i.e., "I would enjoy a job in technology") at pre-test and post-test. PLTW students perceived technology to be more difficult to understand and use (i.e., "Technology is only for smart people") at pre-test but not at post-test.

Table 2. Mean (*SD*) of Attitude toward Mathematics, Science and Engineering subscales by group at pre- and post-test.

	Control (pre)	PLTW (pre)	Control (post)	PLTW (post)
Stereotypic	1.68 (0.88)[1]	1.48 (0.91)	1.67 (0.86)	1.48 (0.92)
Non-Stereotypic	1.58 (0.93)	1.50 (0.96)	1.49 (0.92)	1.52 (0.97)
Positive subscale	1.78 (0.70)	1.77 (0.79)	1.88 (0.66)	1.74 (0.75)
Negative subscale[2]	2.23 (0.75)	2.19 (0.76)	2.13 (0.74)	2.10 (0.87)
Problem Solving	1.63 (0.83)	1.50 (0.79)	1.61 (0.80)	1.55 (0.77)
Technical Skills	1.19 (0.87)	1.04 (0.92)	1.23 (0.84)	1.15 (0.94)
Engineer	1.57 (0.76)	1.48 (0.74)	1.70 (0.69)	1.53 (0.78)
Attend College	1.11 (1.57)	1.02 (1.33)	1.00 (1.20)	1.14 (1.32)
Girls good as boys	0.98 (1.33)	1.03 (1.32)	1.25 (1.18)	1.25 (1.33)

Note: 1 – Strongly Disagree, 5 – Strongly Agree; Higher mean values are more preferred; "I don't know" responses are not included in the mean.
[1] Significant at the .05 alpha level
[2] Phrased negatively, lower mean is more desired.

Students within the control group were more interested in the stereotypical aspects of technology (i.e., "I would like a job where I could invent things") at pre-test but not at post-test. Although the means between pre- and post-test were similar for the two groups, those students in the control group were more significantly likely to give an "I Don't Know" response to the two additional questions (i.e., "attend college" and "girls good as boys") at pre- and post-test for both groups.

Gender Differences

A series of independent sample t-tests were conducted to determine the difference at pre- and post-test for gender collapsed across groups. Type I errors were controlled using a Bonferroni procedure.

Table 3. Mean (*SD*) of Pupil's Attitude Toward Technology (PATT-USA) subscales by gender at pre- and post-test.

	Female (pre)	Male (pre)	Female (post)	Male (post)
General Interest	2.01 (0.72)	2.47 (0.72)[1]	1.99 (0.71)	2.35 (0.73)[1]
Consequences	2.67 (0.77)	2.85 (0.73)[1]	2.55 (0.74)	2.73 (0.76)[1]
Technical Difficulty	1.31 (0.82)	1.62 (0.87)[1]	1.40 (0.90)	1.69 (0.87)[1]

Note: 1 – Disagree, 5 – Agree; Higher values indicate greater interest, more positive consequences, and greater difficulty.
[1] Significant at the .05 alpha level

Males reported a greater interest in technology, perceived more positive consequences associated with technology, but still considered technology to be more difficult to understand and use than females at both pre-test and post-test assessment. There was a trend observed that the perceived difficulty associated with technology increased from pre- to post-test regardless of gender.

Table 4. Mean (*SD*) of Attitude toward Mathematics, Science and Engineering Subscales by gender at pre- and post-test.

	Female (pre)	Male (pre)	Female (post)	Male (post)
Stereotypic	1.87 (0.80) [1]	1.26 (0.89)	1.82 (0.87)[1]	1.26 (0.86)
Non-Stereotypic	1.57 (0.98)	1.49 (0.93)	1.61 (0.99)	1.44 (0.93)
Positive subscale	1.88 (0.75) [1]	1.69 (0.76)	1.82 (0.70)	1.72 (0.77)
Negative subscale[2]	2.32 (0.72)	2.10 (0.78)[1]	2.21 (0.78)	2.02 (0.89)[1]
Problem Solving subscale	1.62 (0.84) [1]	1.47 (0.77)	1.61 (0.83)	1.52 (0.73)
Technical Skills	1.28 (0.90) [1]	0.92 (0.89)	1.36 (0.95)[1]	0.99 (0.87)
Engineer	1.63 (0.75) [1]	1.40 (0.73)	1.67 (0.71)[1]	1.47 (0.80)
Attend College	1.13 (1.50)	0.99 (1.34)	1.07 (1.19)	1.15 (1.39)
Girls good as boys	0.94 (1.34)	1.06 (1.31)	1.33 (1.27)	1.20 (1.33)

Note: 1 – Strongly Disagree, 5 – Strongly Agree; Higher mean values are more preferred; "I don't know" responses are not included in the mean.

[1] Significant at the .05 alpha level

[2] Phrased negatively, lower mean is more desired.

Females were more interested in the stereotypical aspects of engineering (i.e., "I would like a job where I could invent things"), had more positive opinions regarding engineering (i.e., "I would like a job that lets me do a lot of math & science"), and had greater technical skills, and agreed more with items within the Engineering subscale (i.e., "Engineers help make people's lives better"). Males had fewer negative opinions of technology, greater interest in technology, associated more positive consequences with technology, and perceived technology to be more difficult than females at pre-test and post-test. At pre-test, females believed themselves to have greater problem solving skills.

Differences in Experience Level

A series of one-way between-subject ANOVAs were conducted to determine the difference at pre- and post-test. Type I errors were controlled using a Bonferroni procedure.

Table 5. Mean (*SD*) of Pupil's Attitude Toward Technology (PATT-USA) subscales by number of years of GTT courses taken at pre- and post-test.

	None (pre)	None (post)	1 year (pre)	1 year (post)	2 years (pre)	2 years (post)	3 years (pre)	3 years (post)
General Interest	2.09 (0.70)[1]	1.98 (0.71)[1,2]	2.32 (0.76)	2.21 (0.75)[2]	2.43 (0.73)	2.30 (0.69)	2.18 (1.15)	2.77 (0.70)
Consequences	2.07 (0.73)	2.51 (0.81)	2.81 (0.74)	2.67 (0.74)	2.81 (0.78)	2.79 (0.71)	2.35 (1.36)	2.73 (0.71)

Technical Difficulty	1.35 (0.81)	1.47 (0.85)	1.55 (0.89)	1.58 (0.92)	1.47 (0.82)	1.63 (0.80)	1.62 (1.00)	1.74 (0.97)

Note: 1 – Disagree, 5 – Agree; Higher mean values indicate greater interest, more positive consequences, and greater difficulty.

[1] Significant at the .05 alpha level.

[2] Marginally significant.

Students who have not taken GTT courses were less interested in technology than those who have taken 1 to 2 years at pre- and post-test. At post-test, those who did not take GTT courses or took only 1 year were less interested in technology than those who had taken 3 years of GTT courses.

Table 6. Mean (*SD*) of Attitude toward Mathematics, Science and Engineering Subscales by number of years of GTT courses taken at pre- and post-test.

	None (pre)	None (post)	1 year (pre)	1 year (post)	2 years (pre)	2 years (post)	3 years (pre)	3 years (post)
Stereotypic	1.68 (0.88)[2]	1.67 (0.86)	1.50 (0.92)	1.52 (0.92)	1.36 (0.82)	1.35 (0.85)	1.38 (1.10)	1.03 (0.99)
Non-Stereotypic	1.58 (0.93)	1.49 (0.92)	1.52 (0.96)	1.56 (1.00)	1.41 (0.96)	1.37 (0.78)	1.29 (1.21)	1.35 (1.07)
Positive subscale	1.78 (0.70)	1.88 (0.66)	1.78 (0.81)	1.75 (0.76)	1.79 (0.71)	1.70 (0.74)	1.38 (0.58)	1.50 (0.62)
Negative subscale[3]	2.23 (0.75)	2.13 (0.74)	2.19 (2.78)	2.09 (0.88)	2.25 (0.66)	2.10 (0.83)	2.03 (0.94)	2.26 (0.83)
Problem Solving	1.63 (0.83)	1.61 (0.80)	1.53 (0.79)	1.58 (0.78)	1.34 (0.78)	1.40 (0.66)	1.58 (0.78)	1.46 (0.87)
Technical Skills	1.19 (0.87)[1]	1.23 (0.84)	1.07 (0.91)	1.20 (0.96)	0.81 (0.93)	0.93 (0.76)	1.59 (1.35)	0.81 (1.11)
Engineer	1.57 (0.76)	1.70 (0.69)	1.49 (0.75)	1.56 (0.78)	1.40 (0.68)	1.42 (0.75)	1.63 (0.83)	1.16 (0.66)
Attend College	1.11 (1.57)	1.00 (1.20)	1.02 (1.38)	1.24 (1.36)	0.93 (1.00)	0.62 (0.95)	1.40 (1.14)	0.86 (1.21)
Girls good as boys	0.98 (1.33)	1.25 (1.18)	1.07 (1.34)	1.25 (1.35)	0.64 (1.03)	1.13 (1.29)	2.50 (1.73)	1.62 (1.06)

Note: 1 – Strongly Disagree, 5 – Strongly Agree; Higher mean values are more preferred; "I don't know" responses are not included in the mean.

[1] Significant at the .05 alpha level

[2] Marginally significant.

[3] Phrased negatively, lower mean is more desired.

At pre-test, the interest in technology for those students who had not taken GTT courses were more inline with the stereotypical aspects of technology (i.e., "I would like a job where I could invent things") than those who had taken 2 years of GTT courses. Additionally, those students who had not taken GTT courses perceived themselves to have greater technical skills than those who had taken 2 years of GTT courses. This could be explained as those students with longer involvement in the program having a greater appreciation for the skill level involved with technology. There were no significant differences noted at post-test.

Discussion

Results indicated that students enrolled in PLTW courses had greater interest in technology (i.e., "I would enjoy a job in technology") at pre- and post-assessment. This is not surprising considering students voluntarily participate in the PLTW program. However, the combination of students' personal interest and the hands-on (extrinsic) experience provided by the program are vital to a student's further pursuit of a STEM related-degree post high school graduation.

At pre-assessment, PLTW students were less interested in stereotypical aspects of engineering (e.g., inventing things) than the control group but no differences were noted at post-assessment. As for gender differences, male students had a greater interest in technology, perceived more positive consequences associated with technology, but still considered technology to be more difficult to understand and use than females at both pre- and post-assessment. This assessment is consistent with gender difference reported in the literature regarding interest in STEM. The current analysis collapses gender across groups. Inspection of the mean break down of gender by groups shows a trend of male and female students involved in the PLTW program (Males: M=2.60, SD=0.72; Females: M=2.99, SD=0.72) having a greater interest in technology compared to their respective genders in the control group (Males: M=2.94, SD=0.75; Females: M=3.07, SD=0.69).

Females were more interested in the stereotypical aspects of engineering (i.e., inventing things), believed themselves to have greater technical skills, and agreed more with items within the Engineering subscale (i.e., "Engineers help make people's lives better") at pre- and post-assessment. At pre-assessment, females had both more positive opinions regarding engineering (i.e., "I would like a job that lets me do a lot of math & science") and negative opinions (i.e., "Only nerds spend a lot of time doing math and science"), and believed themselves to have greater problem solving skills than males. At post-assessment, females and males did not differ in positive opinions or their perceived problem solving skills. However, females still had more negative opinions than males. One of the objectives of PLTW is to decrease this discrepancy between genders and encourage minorities to pursue careers in STEM-related fields.

Summary and Future Work

Overall, students who enroll in PLTW courses are students who seem to have a pre-existing interest in technology. Interest in technology did not increase based on involvement in the program but the perceived difficulty did increase. Possibly, after gaining knowledge about technology, students became aware of the skill level involved. This curriculum provides these students with the necessary knowledge to proceed with a career in technology and engineering. Future assessments will allow us to see the impact of multiple years of this curriculum on student attitudes toward engineering.

Currently data is being collected to assess the impact of PLTW courses on high school students' interest in technology and engineering. Pre-test data has been collected for the Fall 2011 semester and post-test data will be collected at the end of Spring 2012 semester.

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