[Journal of STEM Teacher Education](https://ir.library.illinoisstate.edu/jste)

Volume 42
Issue 3 *JITE Fall*

Article 2

September 2005

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Teacher attitudes toward pre-engineering education in the nation's high schools and middle schools are becoming more favorable (McVearry, 2003). This is particularly true in states that have placed a high emphasis on pre-engineering education and on increasing the number of students entering college-level engineering and engineering technology programs (McVearry). McVearry went on to note that more high schools and middle schools are forming partnerships with universities to assist in providing these career options to students. Thilmany (2003) noted that high school and middle school teachers from across the nation are realizing that schools must provide pre-engineering programs that allow students to explore their strengths and interests in engineering and engineering technology. Wicklien (2003) concurred, noting that "Engineering is viewed by most people as a valued career path" (p. 5).

Since engineering is not a recognized school discipline, pre-engineering is being infused into current technology education programs with the support of the engineering and engineering technology professions (Thomas, 2003). However, technology education suffers an image and identity crisis, both with the public and with other professions (Pearson, 2003; Wicklien, 2003). Many in the engineering profession do not even know that technology education exists. And if the public knows about technology education, what does it know about the discipline? Does the general population view technology education as a pre-engineering program? A recent Gallup poll indicated that only 36% of the respondents shared the notion of technology education as a pre-engineering program and over two-thirds of the respondents viewed technology as "only computers"

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(Rose & Dugger, 2002, p. 1). According to Wicklien, the general public holds engineering in much higher regard than technology education. However, "in contrast to engineering, technology education is embedded in the k-12 classroom" (Pearson, 2003, p. 3).

According to McVearry (2003), Project Lead The Way (PLTW) is the nation's premier program in providing high schools and middle schools with pre-engineering curriculum and linkage to college-level engineering and engineering technology programs. PLTW has grown from 11 high schools in 1997, mostly in upstate New York, to a current total of over 1250 schools in 44 states, plus Great Britain, serving over 160,000 students (McVearry, 2003; PLTW, 2005). The growth of PLTW schools in Indiana has reached 135 schools while serving over 15,000 high school and middle-level students. The Indiana Department of Education has placed this pre-engineering curriculum (PLTW) in the technology education discipline, both for course registration and teacher licensure.

Technological Literacy

Technological literacy, the core concept and content of technology education, is based on the *Standards for Technological Literacy: Content for the Study of Technology* (International Technology Education Association, 2000). Schroll (2002) raised the concern about pre-engineering education's influence on technological literacy. Schroll asked "What happens to technological literacy if we modify our curriculum" to incorporate pre-engineering concepts (p. 4)? If pre-engineering is placed in the technology education curriculum, can teachers prepare students that are both technologically literate and possess engineering skills? Grimsley (2002) stated yes, noting that "Engineering content and concepts are intertwined in every aspect of the *Standards for Technological Literacy: Content for the Study of Technology*" (p. 2). Wicklien (2003) concurred, observing that engineering and engineering design provide an appropriate platform to deliver technology education.

Pearson (2003) indicated that the International Technology Education Association (ITEA) sought input from engineering societies, such as the National Academy of

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Engineering, for assistance with the *Standards for Technological Literacy*. Engineering and engineering design are both key components of the standards, and nowhere do the standards indicate that engineering and technological literacy are mutually exclusive. Additionally, engineering societies were generous supporters and contributors to the development of these standards (Thomas, 2003). Dearing and Daugherty (2004) noted that "the standards have provided an opportunity to move technology education and pre-engineering closer together and have helped illustrate the mutual relationships and benefits of technologically literate secondary students to the engineering profession" (p. 8).

However, a well-grounded pre-engineering program teaches students more than just technological literacy; it also teaches students scientific inquiry, engineering concepts, and career basics (Grimsley, 2002). Schroll (2002) concurred noting that "pre-engineering courses at the middle and high school levels hold the promise of a curriculum that truly acts as a platform for applying and integrating skills" (p. 4). Thilmany (2003) noted that pre-engineering curriculum focuses on expanding problem-solving in students' cognitive development. Pearson (2003) agreed that problem-solving is a focal point of pre-engineering curriculum.

PLTW Implementation

This study examined the infusion of the PLTW pre-engineering curriculum into the well-established technology education programs of the middle schools and high schools in the state of Indiana. Indiana has long been at the forefront of technology education, but recently has seen a shift to pre-engineering education. The state is second only to New York in the number of schools offering pre-engineering education and the number of technology education teachers involved (PLTW, 2005).

Teacher Acceptance

In the past, the acceptance of new curricula by technology education teachers has not met with overwhelming success (Rogers, 1996; Rogers, 1995; Rogers & Mahler, 1994; Smallwood, 1989). Rogers (1996) indicated that an externally developed curriculum in which the teachers were not involved in the development was not accepted by technology education teachers. Bussey, Dormody, and VanLeeuwen (2000) noted that barriers to successful implementation of new curriculum in technology education included inadequate funding and lack of teacher preparation, while successful adoption could occur given adequate funding, professional development, and positive influence from fellow teachers (Boling, 2003).

The PLTW pre-engineering curriculum was presented to Indiana's technology education teachers through a from-the-ground-up dissemination. Teacher leaders provided hands-on workshops to fellow technology education teachers regarding the pre-engineering curriculum. These teacher leaders were excited about the new curriculum. Thomas (2003) noted that Utah teachers and engineers were also very enthusiastic about introducing secondary students to engineering concepts and content.

Professional Development

According to Burkhouse, Loftus, Sadowski, and Buzad (2003), "Recent academic publications have viewed effective professional development as critical to the existence of self-renewing, learning institutions" (p. 7). The authors' research went on to indicate that "a focused professional development experience led by qualified teachers, mentors, and colleagues is the indispensable foundation for competence and high-quality teaching" (p. 7).

Willis (2002) noted that "people believe that professional development should be targeted and directly related to teachers' practice" (p. 6). He went on to note that professional development "should be curriculum-based, to the extent possible, so that it helps teachers help students master the curriculum at a higher level" (p. 6).

A critical component of the PLTW program is a comprehensive teacher training model (PLTW, 2005). For each of the past three summers, Purdue University has offered technology education teachers intensive two-week professional development on the implementation of the PLTW pre-engineering curriculum. These workshops are team-taught by a faculty member from each engineering area of the PLTW curriculum and

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by an experienced PLTW teacher, thus providing relevant insight for participants. Grimsley (2002) noted that to effectively teach engineering content and concepts, teachers need to engage in comprehensive professional development. "Professional development should reinforce the engineering concepts the teacher is expected to teach "(Grimsley, p. 8). These summer workshops provided this type of experience for these pre-engineering teachers.

As noted by Bybee and Loucks-Horsley (2000), "Long term professional development programs, not just events, are required for the technological literacy standards to touch all students" (p. 32). Follow-up to the summer training institutes was also provided by both PLTW and the university.

Administrative Support and Funding

An administrative structure was established within the state of Indiana that included state agencies, universities, and industry. Through this partnership, teachers and school corporations could see the cooperation and support offered by all entities.

In order to facilitate a positive implementation of the PLTW pre-engineering curriculum across the state, funding opportunities were made readily available to schools and teachers. This funding was in the form of grants from the Indiana Department of Education and the Indiana Department of Workforce Development. Through this process, teachers who chose to be involved could demonstrate their commitment and then have their pre-engineering program funded. Once in place, the pre-engineering curriculum received on-going funding via federal career and technical education funding through the Indiana Department of Workforce Development.

Research Questions

The following research questions were addressed by this study:

1. To what extent are Indiana technology education teachers embracing pre-engineering education?

2. Is there a difference between technology education teachers from different demographic groups with respect to the value they place on pre-engineering education?
3. Do Indiana technology education teachers perceive that pre-engineering education activities contribute to their students' achieving technological literacy?

Methodology

In order to address each of these research questions, this study used a survey technique to ascertain the perceptions of Indiana's technology education teachers. These teachers were divided into two groups; technology education teachers that have completed the PLTW pre-engineering professional development and currently teach PLTW courses (PLTW teachers), and technology education teachers that do not currently teach pre-engineering technology education courses (non-PLTW teachers).

Instrument

Both PLTW teachers and non-PLTW teachers were first asked to provide demographic data; highest degree, age group, and professional association membership. All technology education teachers were also asked if, overall, they felt that pre-engineering education was a valuable component of technology education. An instrument was developed that listed 14 pre-engineering learning activities (PLTW, 2005). These 14 activities represented two learning activities for each PLTW course. The activities were selected by a team of PLTW affiliate professors and master teachers. All respondents were asked to rate their perception of the effectiveness of each activity in contributing to the development of technological literacy (ITEA, 2000). The ratings were on a four-point Likert-type scale, plus a no opinion option, as indicated by Boling (2003) and Zargari (1996): very effective (4), somewhat effective (3), somewhat ineffective (2), not effective (1) or (0) no opinion. "The 0 = No Opinion option was used to reflect the opinions of those participants who might not be familiar with the content of a particular statement" (Zargari, p. 60). As suggested by Hewitt (2000) "No opinion was coded as missing data" (p. 158).

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The Likert-type scale was suggested for this type of study by both Zargari (1996) and McCall (2001). McCall noted that "the words of the Likert scale are converted in meaningful way to an interval scale that gives the researcher the ability to use totals or to calculate numerical averages" (p. 2). Construct validity was determined by three pre-engineering education professionals (Borg & Gall, 1983).

Population and Sample

The population for this study consisted of the 1,043 technology education teachers listed with the Indiana Department of Education. From this population, two samples were selected. The first, group consisted of teachers who had completed the PLTW professional development institute at Purdue University and were currently teaching PLTW courses; 76 teachers comprised this sample group. An equal number (n = 76) of non-PLTW teachers were randomly selected from the Indiana Department of Education list of technology education teachers. Thus this study utilized two sample groups, one PLTW teachers and the other non-PLTW teachers.

The response rate was 44.7% (n = 34) for the PLTW teachers and 36.8% (n = 28) for the non-PLTW teachers or an overall response rate of 40.8% (n = 62). The demographic description of the respondents can be viewed in Table 1.

Findings

Overall the respondents indicated that pre-engineering education was a valuable component of technology education. Of the respondents, 69.4% (n = 43) indicated that pre-engineering education was a "very valuable" component of technology education, and 25.8% of the respondents (n = 16) noted it was a "somewhat valuable" component (see Table 2). None of the technology education teachers noted that pre-engineering education was not of value or that it did not belong in technology education. Only three respondents (4.8%) did not have an opinion on pre-engineering education.

Of the PLTW teachers, 88.2% (n = 30) noted that pre-engineering education was a "very valuable" component of

Table 1
Demographic Descriptions of Respondents

	PLTW teachers $N = 34$		Non-PLTW teachers $N = 28$	
	n	%	*n*	%
Highest degree earned:				
Bachelor's	13	38.2	5	17.9
Master's	21	61.8	23	82.1
Years of age:				
Less than 31	6	17.6	5	17.9
31-40	7	20.6	3	10.7
41-50	9	26.5	12	42.8
Over 50	12	35.3	8	28.6
Professional association membership:				
ITEA	21	61.8	21	75.0
ACTE	2	5.9	0	0
ASEE	1	2.9	0	0

technology education, while 13 non-PLTW teachers (46.4%) responded that pre-engineering education was a "very valuable" part of technology education. For this study's analyses, if a respondent noted "no opinion" on the questionnaire, his/her response was not included in the statistical analysis; this was based on the fact that a "no opinion" response did not indicate a mid-point on the Likert-type scale, but rather that the respondent was not familiar with pre-engineering (Polit & Hungler, 1991). As noted in Table 3, the mean rating for PLTW teachers was 3.88 (SD = 0.327), while the mean of the rating for non-PLTW teachers

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was 3.52 (*SD* = 0.510), thus indicating that the PLTW teachers viewed pre-engineering education as a slightly more valuable component of technology education than the non-PLTW teachers.

Table 2
Pre-engineering as a Valuable Component of Technology Education by PLTW and Non-PLTW Teachers

	PLTW Teachers *N* = 34		Non-PLTW Teachers *N* = 28	
	%	*n*	%	*n*
Very valuable	88.2	30	46.4	13
Somewhat valuable	11.8	4	42.8	12
No opinion	0.0	0	10.7	3
Not valuable	0.0	0	0.0	0
No place in tech ed	0.0	0	0.0	0

Table 3
Pre-engineering as a Valuable Component of Technology Education Mean Ratings for PLTW Teachers and Non-PLTW Teachers

PLTW teachers		Non-PLTW teachers			
M	*SD*	*M*	*SD*	*df*	*N*
3.88	.327	3.52	.510	57	59

Examining the technology education teachers' perceptions of pre-engineering by professional association membership indicted that non-members of ITEA valued pre-engineering education more favorably than ITEA members. ITEA members had a mean rating of 3.62 (*SD* = 0.493) and non-ITEA members mean rating was 3.94 (*SD* = 0.236) (see Table 4). Comparison of teachers' perceptions by educational degree earned noted that teachers whose highest degree was a bachelor's had a mean rating of 3.65 (*SD* = 0.493) compared to teachers with a master's degree or higher whose mean rating was 3.75 (*SD* = 0.439), thus indicating the teachers with a higher level of education had a more positive view of pre-engineering education (see Table 5). Dividing the sample by age-level indicted that 85.0% of teachers over the age of 50 years rated pre-engineering as a "very valuable" component of technology education (see Table 6). Mean rating by age group noted teachers 40 years of age and younger had a mean of 3.61 (*SD* = 0.502), teachers between 40 and 50 years of age had a mean rating of 3.68 (*SD* = 0.478), while teachers older that 50 years noted a mean rating of 3.85 (*SD* = 0.366).

Table 4
Pre-engineering as a Valuable Component of Technology Education by ITEA and Non-ITEA Teachers

	ITEA Teachers *N* = 39		Non-ITEA Teachers *N* =*18*	
	%	*n*	%	*n*
Very valuable	61.5	24	94.4	17
Somewhat valuable	38.5	15	5.6	1
	M	*SD*	*M*	*SD*
	3.62	.493	3.94	.236

The results of the survey instrument provided mean scores for the 14 pre-engineering activities listed, related to the activity's effectiveness in teaching technological literacy. The overall mean ratings can be viewed in Table 7. The pre-engineering activities of applying the engineering design process (*M* = 3.57, *SD* = 0.523), designing and prototyping solutions (*M* = 3.55, *SD* = 0.582), designing automated manufacturing systems (*M* = 3.55, *SD* = 0.559), and applying geometric constraints

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Table 5
Pre-engineering as a Valuable Component of Technology Education by Degree Status

	BS degree $N = 17$		MS degree $N = 40$	
	%	*n*	%	*n*
Very valuable	64.7	11	75.0	30
Somewhat valuable	35.3	6	25.0	10
	M	*SD*	*M*	*SD*
	3.65	.493	3.75	.439

Table 6
Pre-engineering as a Valuable Component of Technology Education by Age Group

	≤ 40 $N = 18$		41-50 $N = 19$		≥51 $N = 20$	
	%	*n*	%	*n*	%	*n*
Very valuable	61.1	11	68.4	13	85.0	17
Somewhat valuable	38.9	7	31.6	6	15.0	3
	M	*SD*	*M*	*SD*	*M*	*SD*
	3.61	.502	3.68	.478	3.85	.366

(M = 3.53, SD = 0.537) were rated the highest overall by these technology education teachers in developing technological literacy in their students. All four of these activities were rated as “very effective" by the respondents. Even the lowest-rated activity, designing commercial structures (*M* = 3.22, *SD* = 0.810), was rated above the "effective" level for teaching technological literacy by these technology education teachers.

Table 7
Overall Pre-engineering Effectiveness for Technological Literacy

Activity	*M*	*SD*
Applying the engineering design process	3.57	.532
Designing and prototyping solutions	3.55	.582
Designing automated manufacturing systems	3.55	.559
Applying geometric constraints	3.53	.537
Designing CIM processes	3.49	.621
Performing parametric modeling	3.45	.581
Constructing automated manufacturing systems	3.43	.654
Performing materials testing	3.43	.680
Performing CIM processes	3.33	.738
Conducting structural analyses	3.33	.686
Designing logic gates	3.30	.716
Constructing electronic circuits	3.27	.659
Designing electronic circuits	3.24	.611
Designing commercial structures	3.22	.810

Table 8 provides an overview of the effectiveness ratings between the PLTW teachers and the non-PLTW teachers. PLTW teachers rated applying geometric constants (*M* = 3.70, *SD* = 0.529) as the most effective pre-engineering activity in teaching technological literacy. While non-PLTW teachers noted that design and prototyping solution was the most effective teaching activity (*M* = 3.54, *SD* = 0.588).

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Table 8
Pre-engineering Effectiveness for Technological Literacy by Groups

Activity	PLTW teachers *M*	PLTW teachers *SD*	Non-PLTW teachers *M*	Non-PLTW teachers *SD*	*df*	*N*
Applying the engineering design process	3.64	.549	3.48	.510	56	58
Applying geometric constraints	3.70	.529	3.25	.550	51	53
Designing and prototyping solutions	3.56	.577	3.54	.588	49	51
Performing CIM processes	3.28	.895	3.36	.581	38	40
Designing electronic circuits	3.59	.507	2.95	.686	35	37
Constructing electronic circuits	3.53	.624	3.05	.686	35	37
Designing commercial structures	3.38	.921	3.00	.632	35	37
Designing logic gates	3.57	.646	3.06	.772	28	30
Performing materials testing	3.50	.618	3.36	.727	38	40
Designing automated manufacturing systems	3.62	.619	3.50	.512	36	38
Constructing automated manufacturing systems	3.50	.730	3.38	.590	35	37
Designing CIM processes	3.47	.640	3.50	.607	33	35
Performing parametric modeling	3.52	.570	3.31	.602	45	47
Conducting structural analyses	3.38	.805	3.27	.550	41	43

Conclusions

The results of this study indicated that Indiana technology education teachers have embraced pre-engineering education as a very valuable component of technology education.

This study's findings indicate that both PLTW teachers and non-PLTW teachers view pre-engineering education as a valuable component of technology education. However, PLTW teachers are nearly twice as likely to rate pre-engineering as a very valuable component than are non-PLTW teachers. Non-ITEA members were also more likely to rate pre-engineering as a very valuable component of technology education than were ITEA members. A higher percentage of older technology education teachers (50 years and older) rated pre-engineering as a very valuable component than did younger technology education teachers (less than 40 years old). Since older teachers are less likely to accept change unless they perceive the change as valuable for the profession, these older technology education teachers must perceive pre-engineering education as being of value to technology education (Rogers, 1996).

Indiana technology education teachers viewed all 14 pre-engineering activities listed as valuable in developing technological literacy in their students. The respondents noted that the four most valuable pre-engineering activities were applying the engineering design process, designing and prototyping solutions, designing automated manufacturing systems, and applying geometric constraints.

The very positive perceptions of Indiana technology education teachers toward pre-engineering education can be traced back to its implementation process. This implementation was a cooperative venture between the Indiana Department of Education (administrative support), the Indiana Department of Workforce Development (funding), and the Technology Teacher Education Program at Purdue University (professional development). The results of this study indicated that Indiana technology education teacher perceive pre-engineering education is an embedded component of the state's technology education curriculum.

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