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Integrating Engineering Design Into Technology Education: Georgia's Perspective

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Abstract

This descriptive research study reported on Georgia's secondary level (grades 6-12) technology education programs capability to incorporate engineering concepts and/or engineering design into their curriculum. Participants were middle school and high school teachers in the state of Georgia who currently teach technology education. Participants completed a Likert-type online-survey which reported on technology education teacher's (a) current instructional practices to teach engineering-based instruction, (b) curricular value placed on engineering-based instruction, and (c) instructional needs to teach engineering-based topics. General demographic information was collected from all participants. The results from the study aided in informing the educational community on the perspective of the values, needs, and

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instructional practices associated with an engineering design focus for technology education. A summary of the five main recommendations are reported.

Introduction

The nation's secondary level technology education teachers are experiencing a shift in curriculum focus. Pundits have lobbied for engineering design as a focus for the curriculum (Wicklein, 2006) and according to recent research teacher's attitudes are becoming more favorable to the need and value of an engineering-based curriculum for technology education (Rogers, 2005). As of 2004, over 1000 of the nation's technology education departments were including pre-engineering education in their respective programs (Rogers & Rogers, 2005). In a study conducted by Gattie and Wicklein (2007), it was determined that the overwhelming majority (93%) of technology teachers surveyed felt that engineering design was an appropriate focus for technology education.

The receptiveness of technology educators to turn to engineering as a curricular focus does come with several caveats. Gattie and Wicklein's (2007) study revealed that many teachers have substantial needs related to (a) identifying appropriate textbooks (89.7%), (b) developing engineering fundamentals for instruction (91%), and (c) inclusion of analytical predictive analysis rigor for students (86.7%) as they work to make engineering a more significant focus of technology education. In response to the increased interest in engineering as a curricular focus for technology education, Georgia's Department of Education developed an advisory committee on engineering and technology education. The goal of the committee was to determine if engineering design should become the academic focus of Technology Education in

Georgia (Advisory Committee on Engineering and Technology Education in Georgia, 2007). This study was the investigative research sanctioned by the Georgia Department of Education to evaluate a variety of issues and concerns that are impacting the capability of technology teachers in Georgia to teach engineering related topics within the state's technology education curriculum.

Purpose of Study

The purpose of this study was to report on the current status of Georgia's technology education programs inclusion of engineering design into their current curriculum. Engineering design was defined as the following:

> Engineering design demands critical thinking, the application of technical knowledge, creativity, and an appreciation of the effects of a design on society and the environment (ITEA, 2000). The engineering design process centers around four (4) representations used to describe technological problems or solutions: (1) Semantic – verbal or textual explanation of the problem, (2) Graphical – technical drawing of an object, (3) Analytical – mathematical equations utilized in predicting solutions to technological problems, (4) Physical – constructing technological artifacts or physical models for testing and analyzing (Ullman, 2003).

This study was statewide in scope and sought to collect data with regard to four primary criteria: (1) current instructional practices to teach engineering-based instruction, (2) curricular value placed on engineering-based instruction, (3) instructional needs to teach engineering-based topics, and (4) demographic make-up of middle school (MS) and high school (HS) technology education teachers in Georgia. The objective of the study was to determine the most significant issues faced by the state's technology education teachers regarding the inclusion of engineering concepts and design. The following research questions guided the study:

1. What is the demographic breakdown of Georgia's middle school and high school technology education teachers?
2. What are the current instructional practices of Georgia's middle school and high school technology education teachers with regard to teaching engineering-based topics?
3. What is the value of engineering design for technology education programs held by Georgia's middle school and high school technology education teachers ?
4. What are the instructional needs of Georgia's middle school and high school technology education teachers related to teaching engineering design?

Benefits

The results from the study aided in informing the Georgia Department of Education, technology education teachers, and the learning community within the state of Georgia on technology teacher's perspective of the curricular values, instructional needs, and instructional practices associated with teaching an engineering design focused currciculum. The results of the study are important to the field of technology education and will help provide valuable insight into the improvement of technology education by presenting an example of one state's current status of engineering design and that respective state's plan of action to implement necessary changes. By evaluating the subsequent needs and value that technology education teachers hold in regard to an engineering design focus in Georgia, Georgia's Department of Education can make informed decisions when designing professional development and engineering focused pathways and curriculum.

Methodology

This study was descriptive in design with clearly defined independent and dependent variables. Descriptive research studies inquire about the nature, frequency, or distribution of variables and /or relationships among variables. According to Ary, Jacobs, & Razavieh (1990), descriptive studies make no attempt to manipulate variables but serve to provide descriptions of variables and/or the relationships among these variables. A descriptive study seeks to describe a construct the way it is as it naturally occurs (Huck, Cormier, & Bounds, 1974). Descriptive studies can help educators understand frequent curriculum implementation problems and other issues in current teaching practices (Gersten, n.d.).

Descriptive statistics was the primary source of data collected in this study. The independent variables for the proposed study included demographic criteria for Georgia's middle school and high school technology education teachers including (a) years of experience, (b) grade level at which they teach, (c) gender, (d) age, (e) college degree attained, and (f) college major. The dependent variables were perspectives held by Georgia's secondary level technology education teachers for the curricular values, instructional needs, and instructional practices associated with teaching an engineering design focus for the field of technology.

Participants

For the purpose of this study, the researchers intended to survey all middle school and high school technology education teachers in the state of Georgia as identified by the

State of Georgia's educational database. A census approach to sampling is very effective for small populations and eliminates sampling error while attempting to provide data on all individuals in a population. In the case of small populations, it is recommended that researchers sample the entire population in order to achieve desireable results (Israel, 1992). Permission to utilize Georgia's database was granted by the Georgia Department of Education under the authority of the Freedom of Information Act. The total population for middle school and high school teachers teaching technology education in the state of Georgia was 605 (Georgia Department of Education, 2007). From this population the researchers collected data from 252 teachers of which 214 was usable data. According to the survey results, 38 teachers started the survey and did not complete it for one reason or another. The study was able to collect data from 35% of the total population of technology education teachers in the state of Georgia.

An e-mail cover letter was meticulously developed to include a statement of confidentiality, a description of the sudy, statement of rationale for partipant's assistance, purpose of the study, and its relevance to the field of technology education. University of Georgia's Internal Review Board (IRB) procedures were carefully followed when drafting the initial letter of solicitation for participants. Initial letters of participation were e-mailed to all respective technology education teachers in Georgia, followed by a follow-up letter which was e-mailed out 2-weeks after the initial e-mail message was sent. This follow-up procedure is commonly endorsed by expert educational researchers when attempting to solicit participation from non-responders (Gall, Gall & Borg, 2007).

Survey Instrument

The researchers designed and developed a survey instrument to primarily collect quantitative data with additional items that collected narrative qualitative data. The survey was developed using standard instrument protocol culminating in content validation prior to sending the survey out for data collection. A 4-point Likert-type scale was used primarily to ascertain the perspectives of participating teachers where 4 = Extremely Satisfied, 3 = Satisfied, 2 = Dissatisfied, and 1= Extremely Dissatisfied. The survey utilized a web-based format where teachers accessed the instrument on-line and data was collected using an electronic data retrieval system. The service of Hosted Survey Company was used to construct, house, and maintain the on-line survey website where participants were prompted to complete the survey. The proposed survey instrument built upon the existing instrument utilized in the Gattie & Wicklein (2007) study. Content and construct validity were established through face validity verification performed by the Advisory Committee. Committee members were instructed to identify any items that were deemed confusing and those not addressing the intended construct. Moreover, the newly developed instrument reflected revisions suggested by the Georgia Advisory Committee on Engineering and Technology Education (2007).

Participants were prompted from an initial e-mail on August 15, 2007 to log-on and complete the survey. The e-mail message included instructions for completing the survey, as well as a specified deadline for returning the survey. Follow-up communications were sent to non-responders requesting their completion of the survey. After answering all questions on the survey, the participants electronically submitted their completed survey for computation and analysis. A follow-up e-mail was sent on August 29, 2007 to all non-responders. On September 15, 2007, data collection ceased and data files were developed based on returned survey results.

Data Analysis

Non-parametric data analysis was used to compare the varying levels of instructional practices and instructional needs with specific demographic data. Data was recorded and analyzed using SPSS (Statistical Package for the Social Services). Descriptive statistics were computed including mean, median, and standard deviation to describe group results. Specific qualitative data was reviewed, organized, and reported based on major themes that emerged from the research. Final reporting of data reflected the suggestions of the advisory committee to include a statistical breakdown of high school and middle school technology education teachers in the state of Georgia.

Findings

Personal Demographic

The total population for middle school and high school teachers teaching technology education in the state of Georgia was identified at 605 by Georgia Department of Education (Barker, personal communcation, Septemer 26, 2007). From this population, the researchers collected data from 252 teachers of which 214 was usable data (n = 214). According to the results of the survey, 38 teachers dropped out of the survey without completing the questionnaire. More than 28% of all technology teachers participating in the survey from Georgia were female (see Table 1). This is a promising statistic for an under represented population when one considers the national average is about 18% for female technology educators (Gattie & Wicklein, 2007). With 65% of the teachers with 15 years or less experience in the field, the study reveals a relatively young demographic of technology educators in the state of Georgia (see Table 2).

Table 1. Gender of Georgia's Technology Educators

Answer	Quantity	% of Total
Male	152	71.02%
Female	62	28.97%
Total	214	100.00%

Table 2. Years Experience Teaching Technology Education as of August 2007

Answer	Quantity	% of Total
Less than 1 year	16	7.47%
1-5 years	39	18.22%
6-10 years	51	23.83%
11-15 years	32	14.95%
16-20 years	24	11.22%
21-25 years	22	10.28%
26+ years	30	14.01%
Total	214	100.00%

Status of Engineering Design in Georgia's Classrooms

In comparison to a national survey (Gattie and Wicklein, 2007) which reported that 90% of technology educators in the country believed that they were currently teaching engineering design, a lower response of 76% of technology education teachers in Georgia reported that they were currently teaching content related to engineering and/or engineering design. These findings clearly represent a shift in the focus of many of the state's technology curriculums. However, only 37% of all teachers surveyed in the state of Georgia were aware of any engineering-based curriculum. This begs the question; if teachers are teaching engineering content and principles in their classroom, what curriculum and materials are they using? Table 3 represents the breakdown of high school and middle school technology teachers in the state of Georgia who identified that they do currently teach topics/courses related to engineering or engineering design. Table 4 provides a statistical breakdown of technology teacher's awareness of any local or state approved course(s) or curriculum that has a focus on engineering or engineering design.

Table 3. Do you currently teach topics/courses related to engineering or engineering design?

Answer	Quantity	% of Total
Yes	93 HS/ 78 MS = 171	80.00%
No	14 HS/ 29 MS = 43	20.00%
Total	214	100.00%

* Note HS= high school teachers, MS=middle school teachers

Table 4. Are you aware of any local or state approved course(s) or curriculum that has a focus on engineering or engineering design?

Answer	Quantity	% of Total
Yes	63HS/ 16MS = 79	36.92%
No	67HS/ 68MS = 135	63.08%
Total	214	100.00%

Needs of Technology Teachers in Georgia

In assessing the needs of middle school and high school technology teachers in Georgia regarding the teaching of engineering design content, the study revealed that 88% of the teachers surveyed identified needs in the area of integrating the appropriate levels of mathematics and science into the instructional content (See Table 10). Table 5 provides a breakdown of the instructional needs identified by the Georgia teachers.

Table 5. My instructional needs to teach engineering design include:

Instructional Need	Mean	SD
integrating the appropriate levels of mathematics and science into the instructional content	3.07	1.036
having the appropriate types of tools and test equipment to teach engineering design	3.20	1.122
identifying appropriate instructional content	2.99	1.077
having the appropriate type of laboratory layout and space to teach engineering design	3.15	1.122
developing additional analytical (math) skills to be able to predict engineering results	3.01	1.085

Administrative Support for Engineering Design Based Curriculums

The study determined that approximately 93% of technology teachers surveyed felt there were no administrative (local or state) constraints to limit/exclude engineering design content in their curriculum. Table 6 provides a summary of perceived constraints and/or limitations to implement an engineering designed based curriculum for secondary level technology teachers. Budgetary restrictions were not identified as an overwhelming hindrance in relation to the inclusion of engineering or engineering design content in the technology curriculums. The survey revealed that 42% of technology teachers in Georgia believed that they were under budgetary restrictions while 55% of the teachers felt that there were no budgetary restrictions that would limit the inclusion of engineering content into the technology education curriculum. Table 7 provides a statistical breakdown of the teacher's perceived budgetary restrictions.

Table 6. Are you under any administrative (local or state) constraints to limit/exclude engineering or engineering design instructional content in your technology education curriculum?

Answer	Quantity	% of Total
Yes	12HS/ 4MS = 16	7.48%
No	118HS/ 80MS = 198	92.52%
Total	214	100.00%

Table 7. Are you under any budgetary restrictions that limit/exclude engineering or engineering design instructional content in your technology education curriculum?

Answer	Quantity	% of Total
Yes	52HS/ 37MS = 89	41.59%
No	73HS/ 45MS = 118	55.14%
Other	5HS/ 2MS = 7	3.27%

Answered	214	100.00%

Value of an Engineering Design Curriculum

In calculating group mean scores, collected data was collapsed using the category Value of an Engineering Design Curriculum revealing that teachers indicated that infusing engineering design into curriculum would elevate the status of their program, the profession, and standing among faculty while providing a platform for math and science integration (Group Mean 2.97, Group SD 1.08). Table 8 provides a statistical breakdown of the participants' responses to the Value of an Engineering Design Curriculum listing the mean and standard deviation for each portion of the stem. According to the data, the only value that did not produce a mean score approaching 3 on a 4-point Likert-type scale was the stem; elevate the technology teacher as a more valued member of the faculty. In reporting this data, the Georgia Advisory Committee on Engineering and Technology Education (2007) suggested that the low score on this particular stem can be attributed to an already high value that technology educators feel they have among faculty; however, this is an unproven theory. With that being said, the survey does seems to suggest to researchers that technology teachers in Georgia believe that an engineering design focused curriculum would elevate their program beyond its current status and that there is autonomy within their curriculum to facilitate such a shift in paradigm without many administrative constraints.

Table 8. An engineering design curriculum would:

Curricula Value	Mean	SD
elevate technology education to higher academic levels	3.10	1.06
elevate the technology teacher as a more valued member of the faculty	2.75	1.21
increase student interest and appreciation for mathematics and science	2.93	1.10
provide a platform for integration with other school subjects	3.03	0.99
elevate technology education to higher academic levels	3.09	1.06

Discussion

Teachers in the state of Georgia are becoming more favorable to a focused engineering-design based curriculum as evident by the study which revealed that 70% (see Table 9) of the teachers believed that infusing engineering design into technology education curriculum would elevate the status of their program, the profession, and standing among faculty while providing a platform for mathematics and science integration (Group Mean 2.97, Group SD 1.08). Teachers in the state of Georgia indicated that they are currently teaching engineering related content in their classrooms with 76% of teachers surveyed identifying that they are already teaching content related to engineering and/or engineering design. However, many Georgia technology teachers indicated they were having problems locating appropriate engineering-based curriculum material with 63% of teachers in the state of Georgia reporting that they are unaware of any engineering-based curriculum. This lack of awareness is important to consider when creating professional development workshops designed to produce curriculum material. In regards to professional development, teachers identified that there is need for instruction in the area of subject integration with 88% of the teachers surveyed revealing their need to locate appropriate levels of mathematics and science into the instructional content (see Table 10). In relation to administrative support, 93% of teachers felt there were no administrative (local or state) constraints to limit/exclude engineering instructional content in their curriculum.

Table 9. An engineering design curriculum would:

elevate the technology teacher as a more valued member of the faculty

Answer	Quantity	% of Total	Mean	SD
No Opinion	11HS/ 1MS=12	10.28%	2.75	1.21
Strongly Disagree	4HS/ MS=8	3.74%		
Disagree	23HS/ 11MS=34	15.89%		
Agree	47HS/ 40MS=87	40.65%*		
Strongly Agree	45HS/ 18MS=63	29.44%*		
Answered	214	100.00%		

* 70% of participants Agree or Strongly Agree

Table 10. My instructional needs to teach engineering design include:

integrating the appropriate levels of mathematics and science into the instructional content				
Answer	Quantity	% of Total	Mean	SD
No Opinion	7HS/ 9MS=16	7.48%	3.07	1.04
Strongly Disagree	0HS/ 1MS=1	0.47%		
Disagree	5HS/ MS=8	3.74%		
Agree	66HS/ 49MS=115	53.74%*		
Strongly Agree	52HS/ 22MS=74	34.58%*		
Answered	214	100.00%		

* 88% of participants Agree of Strongly Agree

Lack of proper training, resources, and curriculum awareness has seemingly precluded technology educators in the state of Georgia from infusing engineering design and content into their technology education curriculums. Professional development will help address many issues of curriculum awareness and consensus among technology teachers. However, a more concerted effort to develop technology teachers with the capacity to teach engineering design in their classroom while integrating math and science principles within their instructional content should be a key focus of professional development according to the research results.

The lack of appropriate text and materials coupled with limited awareness of adequate engineering focused curriculum by the teachers seems to suggest a lack of curriculum resources and professional development support for teachers in the state of Georgia. Statewide there seems to be support from administrators for infusing engineering-design into technology education curriculums; however, the engineering design initiative will have to come from technology educators at the local level to facilitate such a shift. The lack of consensus for a statewide curriculum endorsing the inclusion of engineering content seems culpable for the lack of curriculum awareness on the part of technology teachers.

Recommendations

Based on the findings from the research and other qualitative data collected, a list of recommendations was provided to the Georgia Department of Education. These recommendations were presented as a response to the growing challenges that have become inherent when attempting to infuse engineering education into Georgia's traditional technology education curriculum. The following recommendations are based on the findings from this research study.

1) State program specialists from Engineering and Technology Education and other Career, Technical and Agricultural Education (CTAE) program areas should review course content of all courses within current pathways and those in varying stages of development. This is a result of an overwhelming percent of the teachers who identified that they were

not aware of any state approved courses or curriculum with a focus on engineering design (see table 4).

2) Professional development opportunities for current Engineering and Technology Education instructors should be provided. This came as a result of eighty-eight percent of the teachers identifying instructional needs in the area of math and science in order to effectively integrate engineering design into their classrooms (see table 10).
3) Georgia State Department of Education staff (program specialists and personnel designated by CTAE state director) should work closely with Professional Standards Commission and teacher educator institution personnel to review certification issues related to Engineering and Technology Education. As recommended by the Advisory Committee, it was suggested that the Georgia State Department of Education work collaboratively with identified personnel in order to develop a plan of action that would allow for teachers to receive certification for the integration of Engineering into the curriculums.
4) Comprehensive marketing plans for Engineering and Technology Education should be developed. (Georgia Advisory Committee, 2007, pp. 10-11). As suggested by the Advisory Committee and based on data collected in addition to this study, it was recommended that a marketing plan be developed that would clearly articulate the purpose and merit of infusing Engineering Design into current Technology Education curriculum.

Moreover, it was recommended that the state of Georgia's Engineering and Technology Program specialist, with support of the state CTAE Director, convene a team (including instructors, university faculty and administrators) to design/plan and write the curriculum for all Engineering and Technology Education pathways and courses. This plan would include course descriptions, outlines, guides, and lesson plans for middle and high school as well as recommendations for lab facilities applicable for both middle and high school Engineering and Technology Education programs. Members of Georgia's advisory committee should carefully assess procedures utilized by previous state developed curriculum projects in order to retain effective procedures and to identify methods that were ineffective in the past. Budgets should be provided by State Department of Education, CTAE Division, for activities and stipends related to this task (Georgia Advisory Committee on Engineering and Technology Education in Georgia, 2007).

It is imperative to develop a plan of action to address concerns and challenges facing teacher practitioners when seeking to incorporate an engineering-designed focus into technology education programs. The research presented here is an example of using practice to inform research and in turn it is the hope of the researchers that these findings, results, and conclusions will further inform the practice of technology teachers. In closing, the results of this study will likely have its greatest impact upon future professional development endeavors designed and implemented by teachers and teacher educators as they continue to clearly identify specific teacher's needs in the area of infusing engineering design into technology education programs.

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