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Exploration of NSF-ATE Projects Approaches in the Integration of Technology and Engineering Education at the K-12 levels

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ABSTRACT

Access to post-secondary education, specifically in the technical, two-year institution area, is a topic of growing interest in the country. Funding agencies, such as NSF, via the Advanced Technological Education Program (ATE), are supporting initiatives and research aimed at increasing the number of technicians and engineers and improving science, mathematics performance, and technological literacy among pre-college populations. This study focused on projects and programs awarded under the NSF-ATE program. It aimed to understand their approaches to K-12 engineering and technology education. Forty eight percent of the 2009 spring-summer active awards with K-12 components were identified. Through a mixed-method design, 49 NSF-ATE award representatives responded to an online survey, and five were interviewed after their online responses were analyzed. Results show that "pathways to increase the number of engineers and technicians" was the most prevalent goal, that their activities were more informational than instructional, that and their concerns concentrated primarily on their evaluations.

Keywords: NSF-ATE Program, two-year institutions, technological literacy

INTRODUCTION

American public policy has focused much attention on the lack of science and mathematics preparedness of K-12 level students.[1] It has also raised awareness about the disparity between the number of future engineers and technicians attracted to two-year and four-year colleges, as well as the number of jobs available and projected in these areas. [2, 3] Additionally, some authors have emphasized the need to improve technological literacy for all citizens through technology and engineering education at the K-12 levels. [4, 5]

Since October of 1992, the National Science Foundation's Advanced Technological Education (ATE) program has funded centers of excellence and projects devoted to "establish a national advanced technician program, utilizing the resources of the Nation's two-year associate-degree-granting colleges". [6] According to NSF's website, in the spring-summer of 2009, there were 261 active awards related to ATE. Many ATE Centers and Projects incorporate elements targeting K-12 schools. Objectives of these efforts range from enriching community college elementary education courses with technology and engineering [7] to increasing the number, quality, and diversity of teachers in the service area, especially in mathematics, science, and technology. [8] Because of the differences in the missions of ATE Centers and Projects, uniform instruments that assess their effectiveness in relation to those missions and how they integrate technology and engineering education at the K-12 levels are missing.

Every year, Western Michigan University's Evaluation Center conducts a survey that targets ATE-Principal Investigators titled "ATE Survey". [9] The survey collects program information related to background, articulation agreements, organizational practices, collaborations, materials development, professional development, and program improvement; all of these being important aspects of the ATE program. Twelve (12) of the 68 total questions in the survey are related to K-12, comprising only 17% of the survey. At the K-12 levels, the survey incorporates questions related to secondary education primarily in regards to articulation agreements, materials development, professional development, and program improvement. Additionally, K-12 level related questions are embedded and subsumed in multi-level questions. These questions and the associated results neither allow nor provide a more detailed picture of the K-12 engagement of ATE projects.

The need for collecting more granular/specific data and increasing the understanding of influences of ATE in populations related to K-12 grade levels is apparent. Capitalizing on Mendoza Diaz and Cox's [10] analysis of K-12 engineering education efforts in four-year-baccalaureate-degree-granting colleges, and the Evaluation Center's ATE Survey, this paper presents results from a research project, which used spring-summer of 2009 active award ATE (centers and projects) data to assess similar efforts in two-year associate-degree-granting colleges. Additionally, this paper provides information concerning ways the ATE community is integrating technology and engineering education into K-12 programs for the betterment of both practice and research.

Goals and Research Questions

The goals of this study are to:

(a) Construct a knowledge base of K-12 technology and engineering education efforts in ATE active awards that would serve as a foundation for further investigations.

(b) Develop a "road map" via the survey reports that would inform ATE awardees and other interested parties about implications for both practice and research.

(c) Inform ATE awardees about efforts and perceived success of other ATE awardees.

The overarching research questions of the study are:

1. How are Technology and/or Engineering Education incorporated in ATE-K-12 initiatives?
2. How is the effectiveness of these initiatives perceived by ATE representatives?
3. How are both technology and engineering education K-12 interventions and perceived effectiveness related?

LITERATURE REVIEW AND BACKGROUND

Literature about K-12 efforts in engineering and technology education is abundant. The majority of publications report K-12 activities organized by college and universities conducive to the recruitment of students into engineering and technology paths. Via an extensive literature review, Mendoza-Diaz and Cox [10] identified key aspects of K-12 engineering and technology initiatives. Table 1 presents a summary of these key aspects.

A specific review of the *Journal of STEM* education reveals the validity of this framework. In recent years, *JSTEM* has given attention to secondary and outreach activities via (a) a guideline of outreach through a primer to K-4 Education [11], (b) a paper providing information about the guidelines of Project 2061 of the American Association for the Advancement of Science (AAAS) [12], (c) one paper containing anecdotic information of Tufts University's work with Elementary audiences using the LEGO and ROBOLAB [13], (d) another paper with anecdotic information of Model-Eliciting Activities at the high school level [14], and (e) two more in-depth studies of initiatives at the high school levels for the purpose of recruiting students [15,16]

At this point it is worth noting most published materials were related to the works of four-year college institutions. Not systematically understanding career advancement at two-year college institutions, and their outreach efforts into the K-12 area, is a deep concern not only for understanding the landscape, but also sharing best practices.

About the aspect of the impact of the Advanced Technological Education (ATE) Program -with a known and mandated emphasis on two-year college institutions-, the literature reports the perspective of integration of academic and vocational education [17], the perspective of effective evaluation [18], sustainability [19], and articulation agreements.[20]

Bailey and Matsuzuka [17] engaged in a rigorous analysis of ATE integration of academic and vocational goals via a case study involving collaborating high schools and four-year institutions. They identified major activities of ten ATE awarded community colleges. Included in their activities

Overarching agenda	• **Pathways to increase the number of engineers** • **Math & Science achievement improvement** • **Technological literacy improvement**
Nature of the Engineering Education Program or Intervention	• Teacher Professional Development or Outreach activity • Engineering Design Process • Hands-on Math & Science • Engineering Disciplines
Assessment Method	Descriptive and Quasi-experimental (pre- and post-tests)
Object of Study/Unit of Analysis	• Students' attitudes and knowledge • Teachers' attitudes and knowledge • Principals' perceptions • Parents' perceptions • University students' perceptions
Population	• Students • Teachers • Parents and caregivers • Principals
Informing Theory	• Constructivism (Constructionism, Guided Inquiry, Communities of Practice) • Self-efficacy
Standards Addressed	• National and State Mathematics, Science and Technology • Massachusetts Technology/Engineering

***Table 1**: Literature Synthesis in Engineering Education at the K-12 Grade Levels (Mendoza Diaz and Cox [10]).*

were (a) curriculum development, (b) professional development, and (c) awareness and pathway development to recruit high school students.

Zinser and Hanssen [20], from the Evaluation Center, used data from the annual 2004 and 2005 surveys (covering 97% and 98% of all ATE awardees of each year) to identify how articulation between two and four-year colleges was taking place. Benefits of these articulations included (a) transferability, (b) improvement in student services, and (c) improvement of relationships among institutions.

Lawrenz, Keiser, and Lavoie [19] focused on the sustainability of ATE awards. Results of the Evaluation Center's 2000 National Survey served as a point of entry. Thirteen projects were selected for site visits. Collaboration, program improvement, and professional development were the areas identified as critical and substantive in the sustainability of ATE awards. Newer versions of the National Survey reflect these results by incorporating questions related to them in the Evaluation of ATE projects and centers. In a follow-up study, Lawrenz, Gullickson, and Toal [18] report the evaluation of the ATE program encompassing the 1999-2006 time period. Different dissemination avenues are mentioned such as brochures, videoconferences, and presentation in ATE Principal Investigators Conferences (with associated proceedings). How the evaluation has evolved over the years, and how different stakeholders have afforded opportunities to refine the Evaluation Centers' Survey, are both the focal points in this study.

In the fall of 2000, the *Journal of Technology Education* featured an article of NSF funded projects. [21] The article reported on a study conducted during a special conference organized after the 1998 Advanced Technological Education (ATE) conference. The post-conference study had the purpose of finding strategies for obtaining funds and involved PIs of NSF funded projects. With a survey of 18 questions and observations, the authors explored (a) suggestions that were most helpful in obtaining initial NSF funding, (b) hurdles encountered during proposal development, (c) barriers that discourage technology education-related grant writers from developing NSF proposals, and (d) reasons to write NSF proposals. They concluded that among other issues, "The synergy generated across disciplinary boundaries should be encouraged…the problem of low self-confidence in grant writing needs to be addressed…and NSF requires the involvement of elementary and/or secondary teachers in Instructional Materials Development and Advanced Technological Education projects." [22]

Revisiting the key aspects of the Evaluation Center's ATE Survey [9], this study took the following aspects into consideration:

- Background
- Articulation Agreements
- Organizational Practices
- Collaborations
- Materials Development
- Professional Development
- Program Improvement

THEORETICAL BACKGROUND

In addition to the aforementioned frameworks, this study considered the concerns of leaders of ATE projects. For the purpose of generating a better informed investigation, the researchers used the theoretical framework known as Concerns-Based Adoption Model (CBAM). In CBAM, *Concern* is defined as, "the composite representation of feelings, preoccupation, thought, and consideration given to a particular issue or task." [23] CBAM was developed originally by the Research and

Development Center for Teacher Education at the University of Texas-Austin [24] and was conceived specifically for school settings using terminology as relevant to audiences such as teachers and principals.

The CBAM model is composed of six elements, (1) Change Facilitator, (2) Resource System, (3) Stages of Concern, (4) Levels of Use, (5) Innovation Configuration, and (6) User System Culture and Environment. The stages of concern element, on which the emphasis of this study is placed, is a dimension of CBAM that, "addresses how teachers and others perceive an innovation and how they feel about it."[25] The seven stages of concern of CBAM are *awareness, informational, personal, management, consequence, collaboration*, and *refocusing*. Table 2 describes these stages.

In summary, within this panoramic view of ATE literature, the importance of K-12 audiences and activities has been discussed particularly in terms of attracting pre-college audiences and integrating ATE activities in pre-college settings. A content analysis of active ATE awards (conducted by the authors of this study) revealed that approximately half of the active ATE awards have incorporated K-12 components, yet reported literature on K-12 activities and integration is thin. Therefore, it is clearly necessary to explore how the NSF-ATE program is addressing activities aimed at pre-college audiences.

METHODOLOGY

We recruited representatives of active-awarded NSF ATE centers and projects, one per grant, including program coordinators, outreach coordinators, and principal investigators through convenience sampling. Recruitment involved contacting them via e-mail messages and phone calls "drawing samples that are both easily accessible and willing to participate in a study." [26] We sent an initial e-mail invitation to all active-award principal investigators (approximately 260). We followed-up with personalized e-mail messages sent to specific principal investigators who have used K-12 related keywords in their projects abstracts. We sent approximately 125 personalized e-mail messages inviting investigators to participate. Of these 125 messages, 49 principal investigators or other project representatives (designated by the principal investigators), one per grant, completed the online survey (39% response rate).

Our research design followed a sequential-integrated mixed method approach. A diagram of the design is shown in Figure 1. Phase 1 corresponds to the quantitative part of the research and phase 2 corresponds to the qualitative portion. The analysis of phase 1 informed phase 2 in order "to best understand and explain the research problem." [27]

Awareness	Indicates small concern or relationship with the innovation
Informational	Denotes a concern at a level of general understanding, but personally detached from the innovation.
Personal	Represents stakeholder's uncertainties as related to how adequate he/she feels about achieving the demands of the innovation.
Management	Indicates the notice given to the process of applying the innovation in issues related to "efficiency, organizing, managing, scheduling, and time demands". [23]
Consequence	Refers to the notice given to how stakeholders are impacted by the innovation.
Collaboration	Denotes how stakeholders coordinate and cooperate with other constituencies in the utilization of the innovation.
Refocusing	Indicates the possibility of more widely applicable advantages of the innovation for the purpose of adaptation or replacement with a better option.

Table 2: Stages of Concern in CBAM.

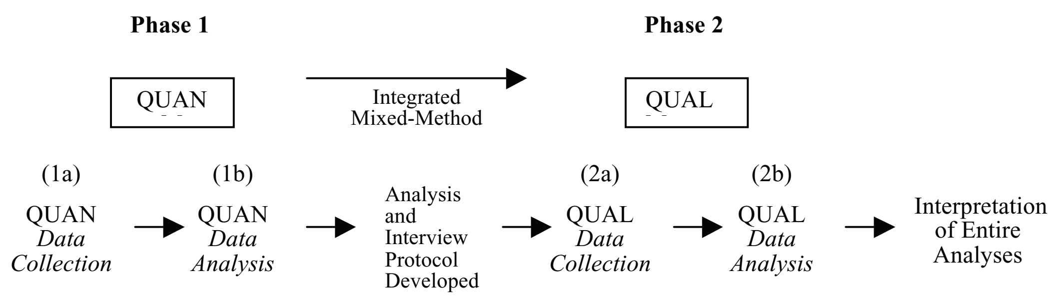

Figure 1. Sequential-integrated mixed-method design.

Instruments

We developed an online survey, the "Census of K-12 ATE Efforts and ATE Principles of Good Practice-Effectiveness Evaluation", which included 16 question sets. The first group of questions consisted of demographic information. Subsequent question sets asked for information concerning(a) the main goals of the ATE activities (question 2), (b) the major activity areas in ATE projects (question 3 to question 6), (c) the specific student activities (question 7), (d) the audiences ATE activities were aiming for (question 8), (e) the standards addressed by ATE efforts (question 9), (f) their pedagogical perspectives (question 10), (g) their learning objectives (question 11), (h) the assessment approaches (question 12 to question 15), and (i) the concerns of ATE project leaders (question 16). A number of questions were arranged in ranked order so respondents could select items and assign importance at the same time. Question two, for example, asked, "What are the most important goals of your activities targeted towards K-12 individuals or K-12 institutions?" The answer options consisted of a matrix, with six items on the rows and six levels of importance in the columns (from most important to least important), where respondents could only select one level of importance within the matrix. In addition, most question sets included open-ended sections for the case of options not included in the multiple-choice format.

Confidentiality was maintained and all participants provided informed consent allowing us to use their responses for research. Five participants were selected for interviews via a telephone conversation. Follow-up interviews served the purpose of expounding on the diverse responses provided to the online survey.

GOALS AND RESEARCH QUESTIONS

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FINDINGS

Quantitative analysis took place via (a) descriptive analysis of responses and (b) via correlations of survey results.

Quantitative Analysis- Descriptive Analysis

The question related to main goals of ATE activities yielded the results shown in Figure 2. The top two most important goals reported by ATE project/program leaders are related to providing pathways to increase the number of technicians and engineers for their own specific recruitment,

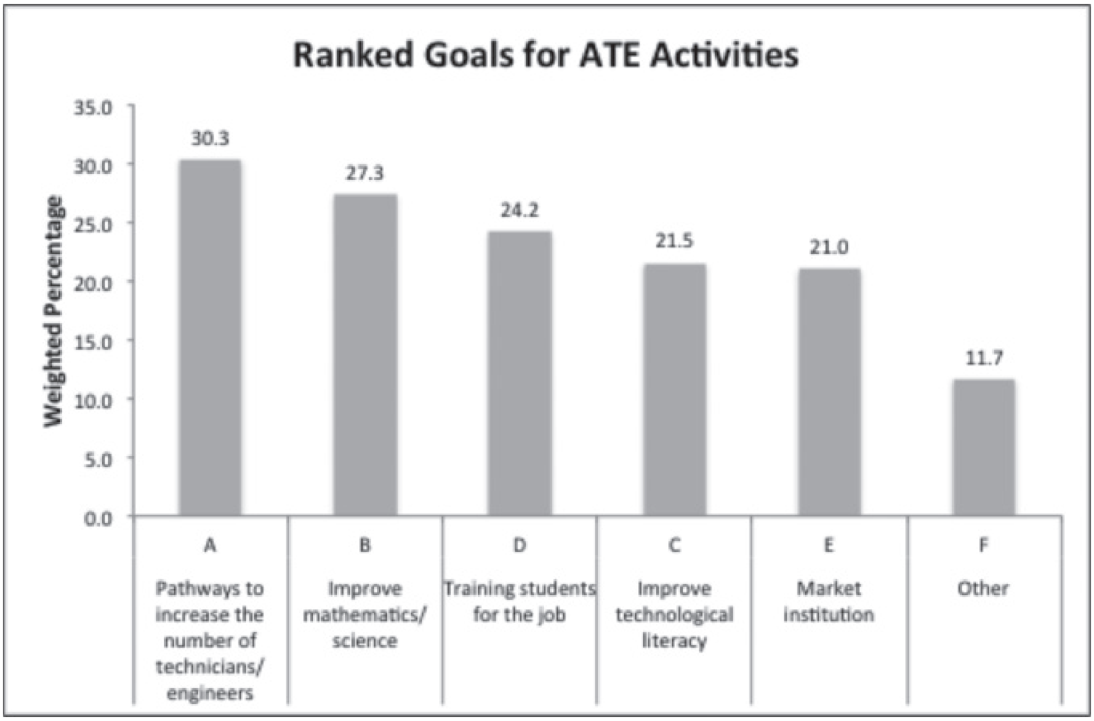

Figure 2. Ranked goals for ATE Activities.

and the improvement of mathematics and science achievement of students. The open-ended section of the question gave opportunity to 13 participants to describe goals they thought were not provided in the choices. The majority of them were more specific in relation to content (e.g., "to better inform and train teachers, counselors and students about *careers in biotechnology*"). Two respondents provided different approaches to the question that had not been considered, one emphasizing the importance of increasing the diversity of the engineering professionals, and the other to "make people aware of technical jobs in our immediate area."

Question three to six focused on core activities of ATE projects. Results fell in three major activity areas: (a) professional development, (b) materials development, and (c) program improvement. The most populated area was professional development ranging from 100% to 25% of the project's activities (n=44). The second most populated area was materials development (n=43). The least populated area was program improvement (n=38). Question four was an open ended-question that requested information about the professional development activities and the target population. The majority of the responses fell in the category of in-service teachers with 34 respondents providing detailed information about their in-service professional development activities. Sixteen respondents

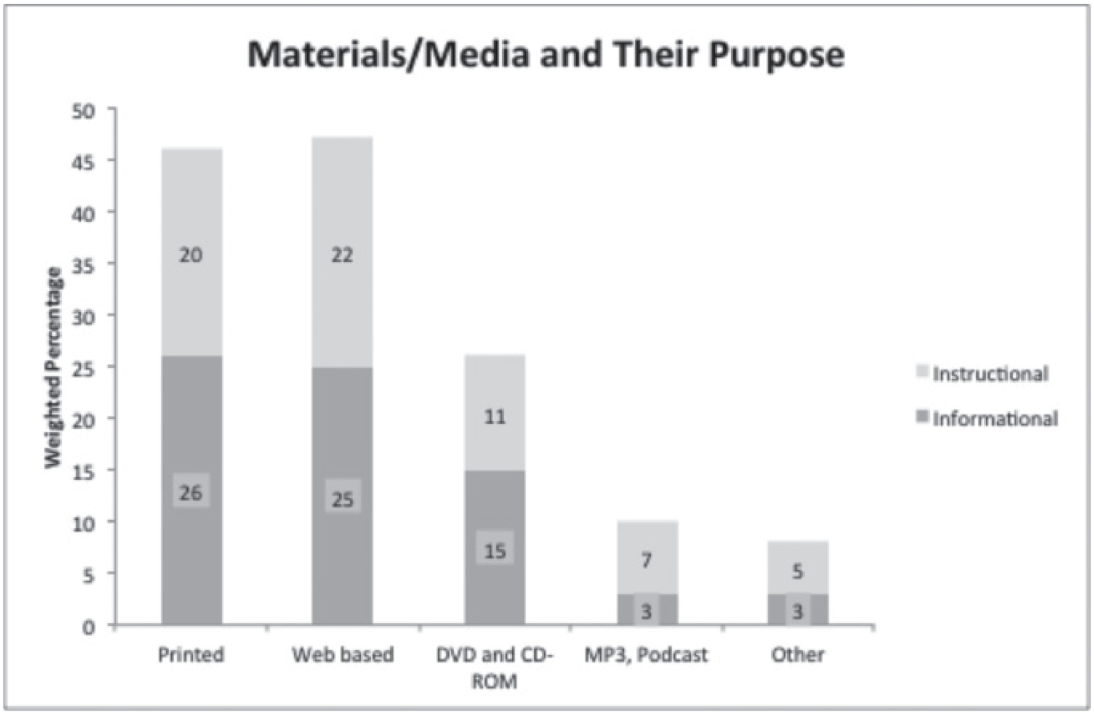

Table 3. Materials/Media and Their Purpose.

reported administrator professional development, while 21 described professional development activities for other audiences such as pre-service teachers.

Table 3 provides detailed information about the types of materials developed and their purpose, either informational or instructional (question 5). Most of materials selected were printed or web-based for informational purposes primarily. Other materials not included in the options referred to E-books, Blogs, or Twitter applications. It is important to note that although these materials could fall into the web-based category, respondents judged differentiation between them to be important.

Program improvement activities (question 6) were related to dual-credit activities (n = 25), internships or co-op (n = 9), pre-service training (n = 14), and others (n = 23). Most reported activities fell into the category of dual-credit activities, and "other," in which many respondents included student activities.

Question 7 specifically asked to have the student activities ranked in order (see Figure 3). Presentations/Booths, Informational Campaigns, Workshops and Competitions were the most populated options whereas mostly experiential options such as visits to either College or Industry and Service Learning were mentioned least.

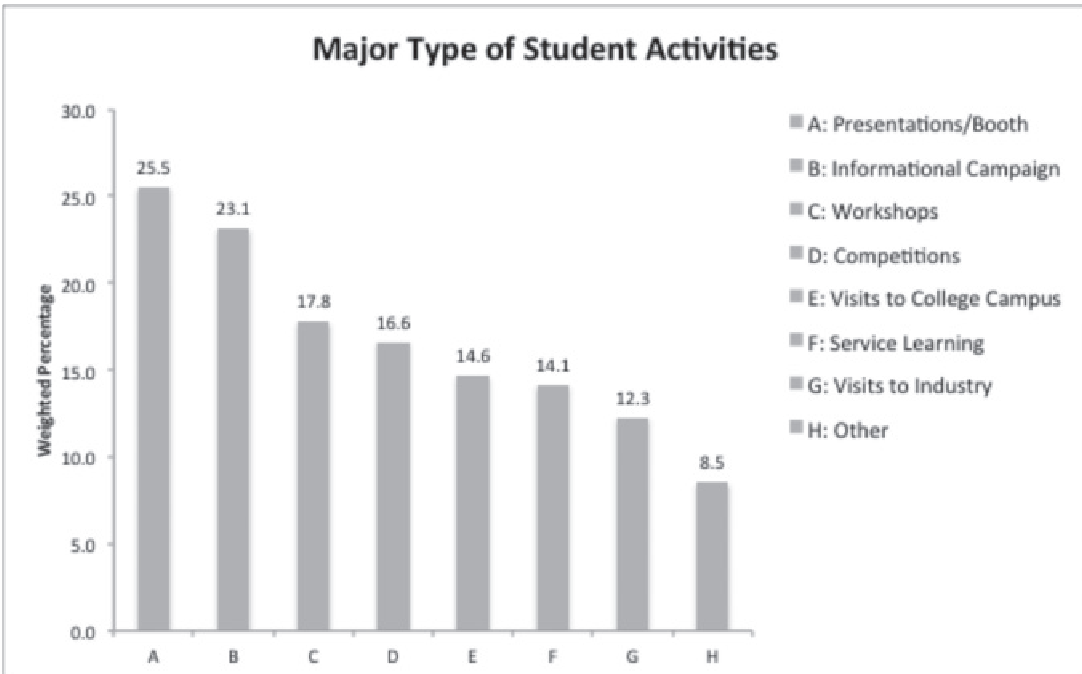

Figure 3. Major types of Student Activities.

Question 8 focused on the audiences of the ATE activities and their rank (see Figure 4). As shown, students and teachers by far are the most ranked audiences. The least mentioned population was "other" (open-ended section of the question), which included community partners and business partners.

National and State Standards addressed in the ATE Project/Program Activities were asked in question 9. Not surprisingly, both National and State Standards in Science, Technology, Engineering, and Mathematics (STEM) were the most populated options.

Question 10 requested information about pedagogical considerations. It is important to note that due to the varied approaches to K-12 efforts, the lexicon presented in these pedagogical considerations was taken directly from the award abstracts as published in the National Science Foundation website. Since National Science Foundation organizes a conference of ATE awardees each year, it was assumed that ATE representatives understood these concepts and were at least familiar with the definitions of the terminology. Figure 5 shows the results in which Hands-on and Project Based Learning options have the highest frequencies. Answers in "other" consisted predominately of variations of project-based learning.

Specific learning objectives of learning activities were requested in question 11 via checkboxes that allowed respondents to select as many objectives as they deemed applicable (see Figure 6).

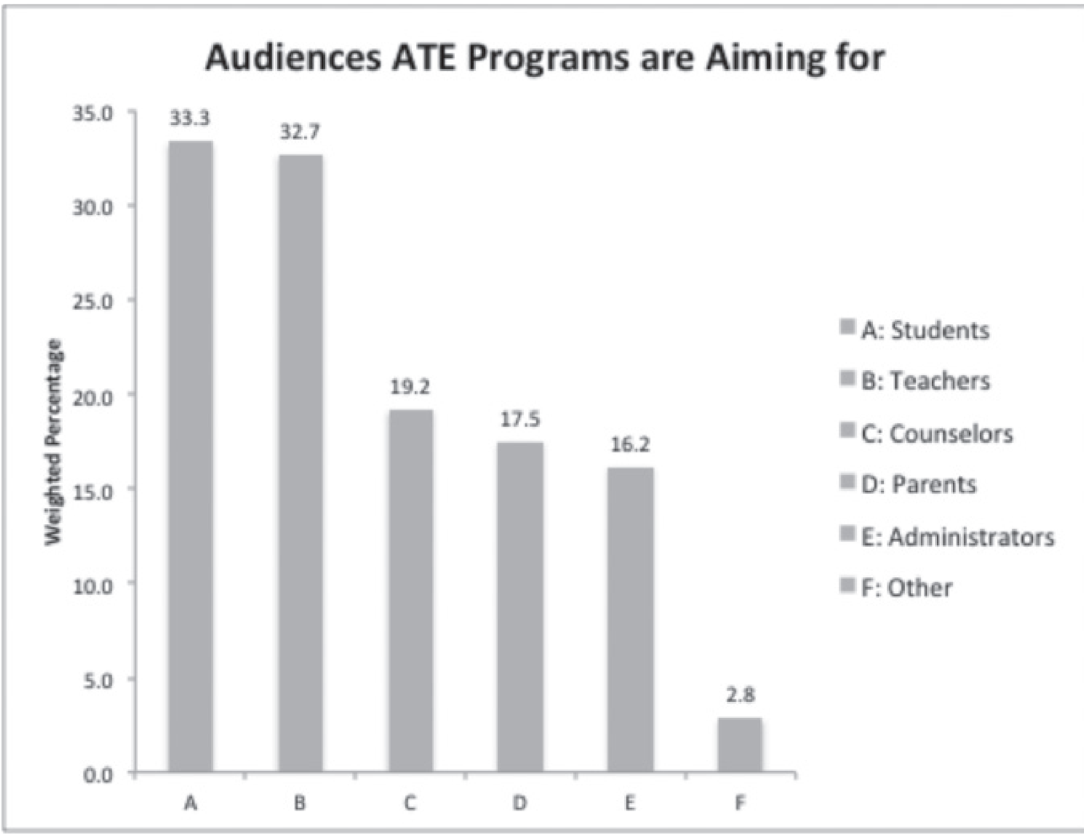

Figure 4. Audiences ATE Activities are Aiming for.

The most frequently mentioned learning objective was to improve the understanding of careers. However, all options were highly considered (with more than 15 respondents).

Questions 12 to 15 were related to assessment. Question 12 focused on the audiences assessed. Students (n=27) and teachers (n=25) at the K-12 levels were the center of assessment, leaving college populations (n=10) and administrators (n=2) as the minimum. The type of outcomes assessed (question 13) resulted in attitudes (n=25) and knowledge (n=26) as the main areas and performance (n=14) as the least. The type of assessment is presented in Figure 7, which shows that Pre-Posttests, Posttest only, and Teacher Interviews were the types of assessment most selected. The instruments most used by ATE projects/programs were (a) external evaluator selected instrument (n=8), (b) instruments developed by own ATE personnel (n=16), and (c) standardized instruments or instruments developed by other projects (n=20).

In the areas of concern and based on the Concerns Based Adoption Model[23], twelve items were explored. The items inquired as to what extent participants agreed with the Table 4 statements.

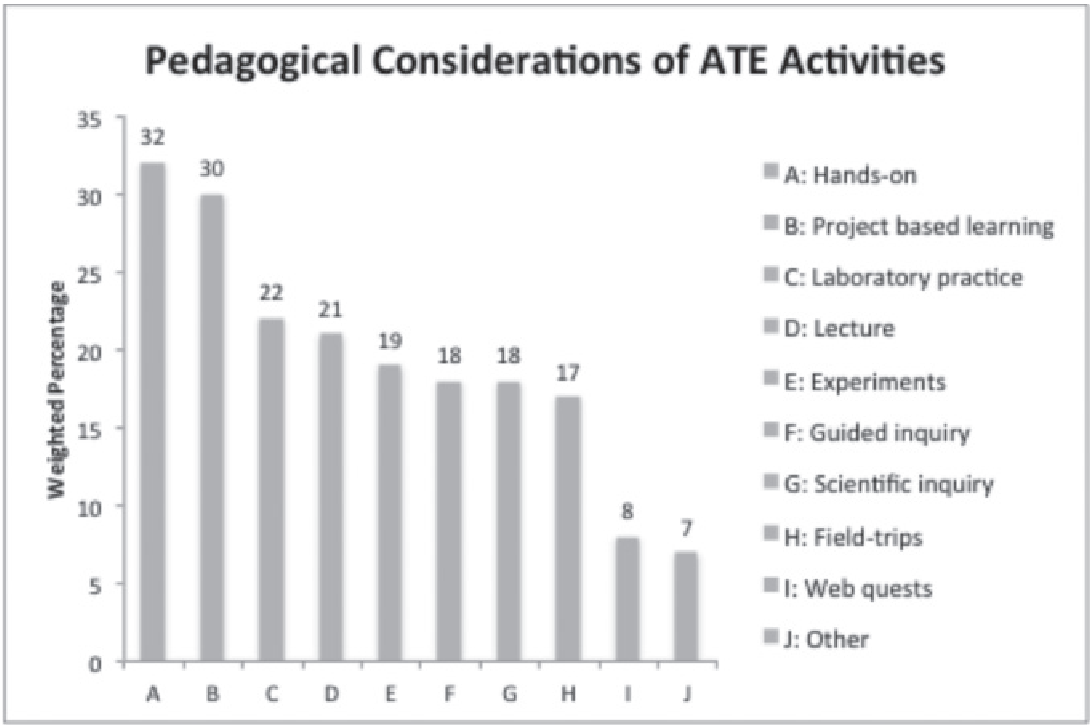

Figure 5. Pedagogical Considerations.

Table 4 shows that the concerns were concentrated on "supplement, enhance or replace K-12 activities", "coordination of efforts with others", and "evaluation."

Quantitative Analysis-Correlation Analysis

In order to find simple relationships between K-12 interventions and perceived success we focused on correlations. Since the survey questions involved ranked values, we were able to use the Spearman rho (ρ) correlation coefficient, which is special case of the Pearson *r*"[28]. We paid special attention to the resulting significant correlations between goals of the ATE activities (question 2) and selected variables. The selected variables included ATE student activities (question 7), pedagogical considerations (question 10), and concerns (question 16). Goals unfortunately (significantly) correlated little with the rest of the variables, including these three (student activities, pedagogical considerations, and concerns). Only the third goal (to improve technological literacy in the general public) significantly correlated with two student activities (after hours-college visits and informational campaigns at the 0.05 p-value) and with four pedagogical considerations (hands-on, field trips, lecture, and experiments at the 0.05 p-value). All correlations were positive, meaning

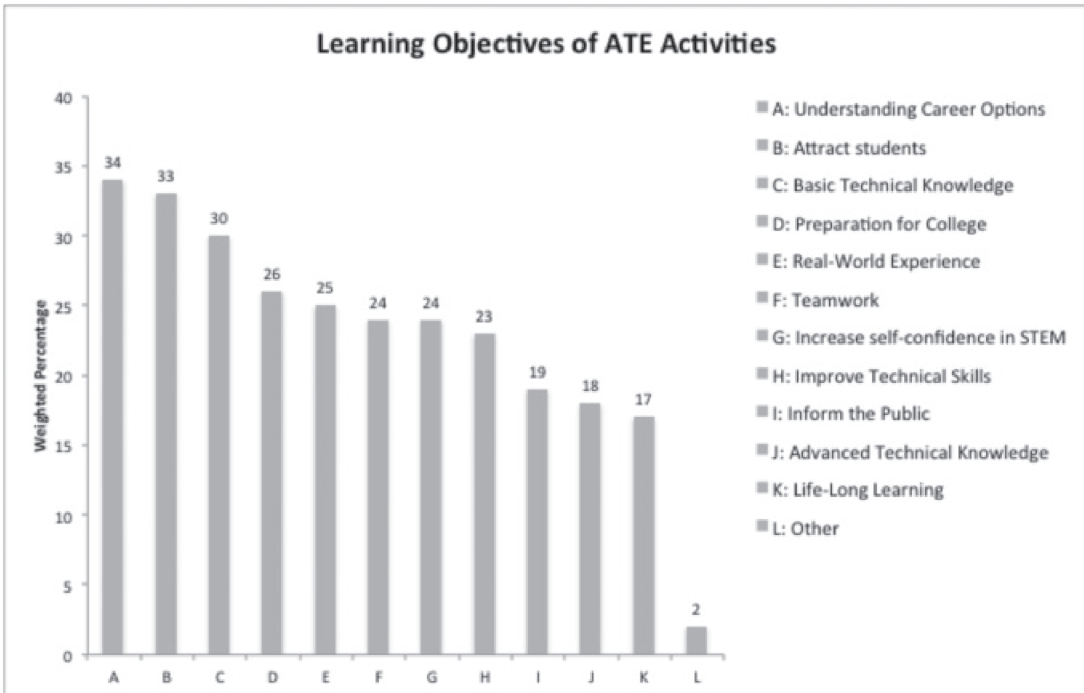

Figure 6. Learning Objectives of ATE Learning Activities.

that the importance given to improve technological literacy in the general public was positively related (varying on the same direction, or in other words, increasing/decreasing together) with the importance given to after-hours college visits and informational campaigns. The same can be said of the pedagogical considerations; the importance provided to technological literacy was also positively related to the pedagogical considerations used when planning activities (hands-on, field trips, lecture, and experiments).

Among the mentioned four (goals, student activities, pedagogical considerations, and concerns), the variables most correlated were Concerns and ATE student activities. The corresponding correlation table is as follows (Table 5). As seen below, at the p-values of 0.01 and 0.05, respondents tended to assign higher values to their concerns in alignment with their ranking of student activities (emphasizing student workshops and information campaigns). These correlations are also positive.

On the other hand, almost all ATE student activities significantly correlated, again positively, with specific audiences; teachers, parents, and counselors at both p-values of 0.01 and 0.05. This can be interpreted as activities gaining rank similarly to selected audiences (teachers, parents, and counselors). In addition, many ATE student activities significantly correlated (positively) with learning objectives such as (a) inform the public, (b) improve self-confidence in STEM, (c) improve the

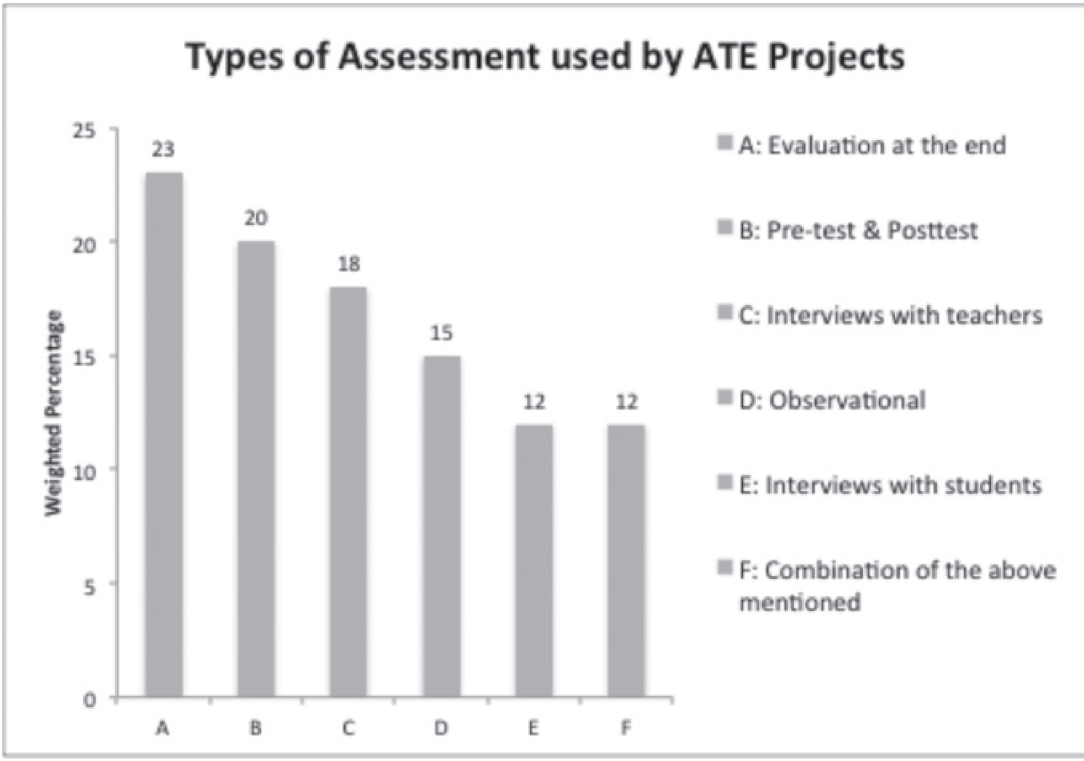

Figure 7. Types of Assessments.

understanding of career options in technological fields, (d) attract students to technology related careers, and (e) expose to real-world environments (again at p-values of 0.01 and 0.05). This means that activities such as after school hours, informational campaigns, and service learning were selected in a manner similar to the mentioned learning objectives.

Pedagogical considerations showed significant positive correlation with specific learning objectives such as (a) improve the understanding of career options in technological fields, (b) improve life-long learning skills, (c) expose real-world environments, and (d) preparation for community college/college. This indicates that respondents selected project based learning, hands-on, lecture, and experiments in a manner similar to the way they selected the aforementioned learning objectives.

Qualitative Analysis

Five participants were interviewed for the purpose of expounding upon the responses provided to the survey. Invitations to participate in interviews were sent to 15 survey respondents. The 15 respondents were selected based on their answers (or lack thereof) to the survey; meaning that the

Concern	Percentage
I am concerned about determining how to supplement, enhance, or replace the K-12 activities	12.5%
I am concerned about coordinating my efforts with others to maximize the K-12 activities' effects	12%
I am concerned about the evaluation of the impact of the K-12 activities	11%
I am more concerned about other ATE activities in our project	9%
I am concerned about the coordination of K-12 tasks and people since it is taking too much of my time	7.5%
I am concerned about my inability to manage all that the K-12 activities require	7.5%
I am concerned about knowing who will make the decision in the new system once getting involved with K-12 activities	7%
I am not concerned about K-12 activities	5.5%
I am concerned I have very limited knowledge of K-12 activities	5.5%
I am concerned about discussing the possibility of getting involved in K-12 activities	5.5%
I am concerned about knowing the effect of getting involved in K-12 activities in my professional status	4%
I am concerned because I now know of other K-12 approaches that might work better	2.5%

Table 4: Concerns of ATE Representatives.

49 survey respondents were classified in two groups (strata), respondents who answered to all or the majority of survey questions and respondents who answered very few survey questions. Therefore the sampling technique for this part of the study can be considered "stratified sampling"[26], done on the basis of their varied approaches to the survey. The interviews' duration was 27 minutes in average and the interview protocol consisted of asking the reasons that motivated the original survey responses. The interviews were transcribed and analyzed using open coding[29] as the research analysis technique. Since these approaches were varied, it was interesting to find common themes among them.

Community College Population

Participant 1 and Participant 4 stressed the idea that community colleges serve disadvantaged populations or populations that are perceived as disadvantaged. In the words of Participant 4, "Our students typically don't come from families with a lot of money, and they are having to multitask and be very innovative in how they get their education." Participant 2 mentioned the importance of articulation with four-year institutions since the community colleges "have a very different approach and otherwise (without the articulation component) our students are at a dead-end field."

	A. Student Workshops	B. Student Competitions	C. After hours or weekends to College	D. After hours or weekends to Industry	E. Information Campaigns	F. Presentations and booths	G. Service Learning
1. Not concerned about K-12 activities Correlation Coefficient	.508**	.367**	.406**	.445**	.459**	317*	.365**
2. More concerned about other ATE activities Correlation Coefficient	.496**	.268	.455**	.443**	.469**	.294*	.436**
3. Concerned about very limited knowledge Correlation Coefficient	.534**	.348*	.333*	.300*	.587**	.460**	.385**
4. Concerned about getting involved in K-12 activities Correlation Coefficient	.454**	.296*	.316*	.389**	.418**	.233	.354*
5. Concerned about the effect in my professional status Correlation Coefficient	.489**	.333*	.296*	.415**	.446**	.213	.388**
6. Concerned about knowing who will make decisions Correlation Coefficient	.567**	.377**	.314*	.327*	.316*	.229	.288*
7. Concerned about inability to manage all that K12 requires Correlation Coefficient	.537**	.259	.319*	.358*	.447**	.234	.457**
8. Concerned of the time that K12 activities are taking from me Correlation Coefficient	.515**	.331*	.371**	.330*	.386**	.254	.408**
9. Concerned about the evaluation of the impact Correlation Coefficient	.552**	.395**	.400**	.351*	.530**	.373**	.410**
10. Concerned about coordinating my efforts with others Correlation Coefficient	.553**	.376**	.363*	.276	.357*	.280	.277
11. Concerned about knowing other approaches that might work better Correlation Coefficient	.596**	.419**	.419**	.448**	.421**	.264	.376**
12. Concerned about how to supplement, enhance, or replace activities Correlation Coefficient	.456**	.310*	.195	.269	.374**	.176	.231

**. Correlation is significant at the 0.01 level.
*. Correlation is significant at the 0.05 level.

Table 5: Concerns and ATE Student Activities Correlation Table.

Pathways to increase the number of Engineers and Technicians.

The five interviewees, including the two participants who had not responded to the majority of the online survey questions, focused on the goal of providing pathways to increase the number of technicians and engineers as the force behind their funded activities. As Participant 5 stressed, "We don't have enough people in the pipeline, so we made the case that we believe in starting at middle school to get students interested in those types of pathways."

Concerns in Evaluation.

As in the case of the online survey, concerns were centered in the evaluation aspect of the ATE projects/programs. Participant 4 voiced his concerns in the following manner:

We're working with community colleges primarily all over the United States and then I think it's hard for us to measure the impact we're having because we're so spread out and we're kind of pretty low level for a mature center now; we're at a pretty low level of funding from the NSF so we don't have a lot of money to spend, you know, paying evaluators to go out and look at these things.

DISCUSSION

This research study demonstrates that, as presented in the introduction and as in the case of the majority of K-12 initiatives of the literature review, community colleges funded under the NSF ATE program are engaged in a variety of K-12 outreach activities focused mainly on providing pathways to increase the number of STEM workers. In a similar trend, the second and third most important goals of these activities are (a) to improve science and mathematics, and (b) to improve technological literacy.

Expounding on the ATE-Survey, [9] the majority of ATE activities fall into the category of professional development focused on in-service teachers. This is followed by the category of materials development, specifically printed and web-based (table 3), for information purposes (above instructional purposes). This reveals that a large proportion of the materials developed by ATE awardees have been created for information rather than instruction. The K-12 program improvement activities also align with the ATE Survey and reveal that most of them are concentrated on dual-credit courses, internships or co-op, and pre-service training.

The ATE student activities, which are almost as prevalent as the ATE teacher activities (figure 4), concentrate on workshops, competitions, visits to industry, and service learning (figure 3) informed by STEM national and state standards, as the majority of other K-12 initiatives.

Pertaining to the issue of pedagogical considerations, it was notable that most ATE project representatives have interest and knowledge in new approaches to technology and engineering education, namely, "hands-on" activities, project based learning, or even guided inquiry (figure 5).

The issue of assessment focuses primarily on students and teachers, by concentrating on attitudes and knowledge rather than performance. The most important instrument of assessment is standardized instruments or instruments developed by other projects. Moreover, less than 45% of projects utilized validated instruments, either self-validated or provided by other projects and external evaluators. These findings prove the need to increase the emphasis on research that ATE-NSF program policies have been recently highlighting.

The findings on concerns, where evaluation, coordination with others, and supplement, enhancement or replacement K-12 activities are the most highly expressed concerns (table 4), indicate that ATE leaders are at stages of "refocusing", "management" and "consequence" in the stages of concern model (table 2). They also indicate that further research is necessary in order to explore the reasons for dissatisfaction/concern.

Analyses of relationships among variables show that, although the student activities align or are consistent with audiences, learning objectives, and concerns; the expressed goals are not. As mentioned before, these goals involve (a) the pathways to increase the number of technicians/engineers, (b) improvement of mathematics and science achievement, (d) training students for prospective jobs, and (d) improvement of technological literacy, among others. The implication is that although activities, targeted audiences, learning objectives, and concerns are related, ATE projects seem not to "connect" with the overarching goals. In this sense, the conceptual framework that informed the goals, taken from an extensive literature review in the K-12 technology and engineering education areas for four-year colleges, seem not to have been recognized by ATE . Custer, Loepp, and Martin[21] show that PIs lack confidence in their abilities to write proposals. A lack of knowledge about K-12 literature might be one source of this lack of confidence, which might reflect the gap of knowledge in goals and the correlation results.

LIMITATIONS/CONCLUSIONS

This research study addressed questions on how National Science Foundation funded ATE projects engage with the K-12 educational system. The stratified sampling strategy employed asked each ATE project to identify a representative to answer the questions of the survey and interview protocol. The lack of representation by different stakeholders of the same project can be seen as a limitation, although the researchers trust to have received an authoritative or at least representative answer from participants. A second limitation can be seen in the use of pedagogical or instructional terminology, which the survey itself did not define. Since we borrowed the lexicon from NSF, which used the exact same terms in annual PI meetings and reporting requirements, we presume ATE personnel is at least familiar with the terminology.

The Advanced Technological Education Program at the National Science Foundation is a well-established program that reflects the need to prepare a work-force ready to take on national challenges. Results show a lack of leaders' and projects' preparedness to engage in state-of-the-art K-12 education and education evaluation. Although innovate approaches such as project based learning or guided inquiry are part of the pedagogical approaches of a selected group of awardees, evidence of consistent literature search, assessments (of populations and aspects), and comprehensive summative evaluations are missing. As the case of four-year institutions, these relevant aspects show disconnection with the investment and interest the nation is providing to K-12 engineering and technology education.

Clear directions for improved K-12 outreach involve broadening the populations of interest, mainly administrators and parents, with activities and research conducive to engage these groups and show impact. It also involves development of more instructional materials and instructional activities (instead of informational), utilizing the pedagogical consideration that principal investigators are clearly familiar with. The assessment of these materials and activities could lead to a much stronger involvement of P-12 students and teachers and a deeper understanding of how community colleges are influencing the engineering and technician pipeline.

The results about concerns of ATE awardees show a clear direction for improvement. The need of principal investigators more "research- capable" is evident and the ATE program as well as ATE applicants could greatly benefit from an investment in this direction. More research in the area of ATE projects could lead the community to improved evaluation and enhanced K-12 outreach. Therefore, as the objective of the current study states, authors expect that this report would inform ATE awardees and other interested parties about implications for practice and research.

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