Analytical Survey and Assessment for a Cross-Training Program In Construction Project Management

Gholam Omidi , Ph.D., Bill. W. Oldham, Farouk G. Attia, Ph.D
University of Houston, Houston, Texas 77204-4083

Abstract

As a result of technology advancements moving at speeds that were never envisioned, it has become mandatory for Project Management to be proficient in the major areas that support and quantify the activities that result in project completions being "on-time and within budget." Project Control provides the data and metric interface used to develop the information needed to manage a project based on the interrelationships of cost and value. The problem addressed in this study was to identify the need for a training program specifically addressing cost engineering, planning/scheduling and estimating and to develop and evaluate a single module of a basic project control curriculum overview and outline. A commercial model to support the development of a cross-training program for project control personnel was also outlined. Questionnaires were distributed to 20 senior construction Project Management personnel to perform a needs assessment for this training program, to cross-train personnel with skills and information between elements of project control. Descriptive statistics were used to analyze the information received from the sample population. Results of these Questionnaires were as follows.
- A composite attitude of project control personnel was revealed by the review and survey showing that control personnel were considered as specialists by their peers.
- There is a need to enhance the skills of project control personnel with cross-training to assist them in dealing with corporate problems solving.
- Areas of skills and knowledge enhancement, use of computer software and improved math skills were identified as desired contents for training programs. Specifically addressed were undergraduate computer abilities which are currently considered basic computer skills, however, not included in the typical Construction Engineering/ Technology Educational programs.
- Elements from the curriculum overview identified for inclusion in a cross-training program were (1) Types of contractual relationships, (2) Construction Contract types, and (3) Basic contract documents, but there was no total uniform consensus for use of the module presented.
- Responses from the survey identified specific areas that should be addressed by the Educational system in the areas of basic engineering and technology real world skills.

Computer programs identified in the survey covered general areas that provided a broad basic format for all Engineering/Technology applications in the workplace. Currently, most Educational programs are not addressing these basic computer skills needed for employers. This covers the development of the basic analytical and project management

tools which provide the required computer skills to college graduates. A better scholastically trained graduate would be more effective and can be trained sooner in company specific needs

Survey responses also indicated that new program management personnel with BS degrees in most Construction Engineering/Technology programs have large learning curves to grasp the basic analyses needed for project management. The College arena was sited as the most appropriate place for providing the basic learning process of management tools in project control.

Significance of this study showed that a need was identified for the continued study and development of formal cross-training programs in Engineering/Construction specifically addressing project controls, estimating, cost engineering, planning/scheduling and project analysis.

1.0 Introduction

Project Management can be defined, within the context of the real world, as the process of managing the development of a complex product[1]. The product can be a refinery, a housing project, a space station module or a single wood structure. The process usually includes some or all of the following phases: conceptual work, architectural work, engineering work and construction activity. These phases use project controls in all stages of development from initial planning through the final evaluation of determining completion cost.

In an engineering and construction environment the level and need of training for personnel performing project controls (estimating, cost engineering, scheduling, and analytical support), has made a leap forward from simple to complex. Ten or 20 years ago, performing a rough estimate for a project consisted of using the best "guess" and the telephone to call your suppliers to find out what they are charging for various types of materials. Some of that still occurs, but it is quickly being replaced by computers and databases.

Formerly creating and maintaining a schedule was done by hand. Cost control functions were performed by an accountant who knew little about estimating or scheduling, and analytical support consisted of a few experienced managers getting together and exchanging information to a few "what if" questions.

In more recent times, with the information explosion brought on by the use of computers in the marketplace during the 80's and 90's, managers began to rely on well-trained project control personnel. However, educational institutions that trained the engineers

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[1] In the text by Kavanagh, Muller & O'Brien entitled <u>Construction Management</u> (1978) it is stated that a dictionary definition of *project* is " an undertaking requiring concerted effort." More informed definitions tend to add conditions such as: projects are complex efforts to achieve specified results within a schedule and budget; projects typically cut across organizational and functional lines; projects are unique and not completely repetitious of some previous effort.

lagged in providing their graduates with updated skills in computer analysis to meet the needs of industry. This factor contributed to specialization within companies.

It is the presenters view, based on a continuing experience with project controls, that before the widespread use of computers and sophisticated software, an experienced engineer would have been assigned a few new tasks in one of the areas of project controls. The current trend is for experienced personnel to be hired and trained to specialize through hands-on experience within the company, using software that is company specific.

Personnel continue to specialize in an area of expertise in spite of the increased level of complexity and the amount of reliable information needed by current managers for making decisions[2].

New developments in commercial software have resulted in databases that integrate information from more than one area of project controls. Examples are Parade® a cost software package that converts data from Primavera Schedule®, or Monte Carlo®, a software package that converts scheduling information from a Primavera® database to perform probabilistic risk analysis. In many engineering and construction companies, personnel who are knowledgeable in the use of high-tech software can provide a manager with information from an integrated database and create relational reports that provide analytical and meaningful information.

Based on the presenter's 25 years of experience, that supports a view that a need exists and identified in the engineering, construction and aerospace environment, for improving training programs to update the skills of personnel. The current practice followed in many companies for upgrading their source of decision-making data is to buy computer software. The cost engineer, estimator or scheduler usually tries it out, creating more databases explicit to their area of project controls. This results in a continuation of specialization.

In the current era of company downsizing that results in restructuring and trimming staff and expense to maintain a competitive edge in the marketplace, it is important for employees to be armed with additional skills. In recent years we have seen many individuals, young and old, "laid off' from their job. With the emphasis on "cost effectiveness," most employers must then distribute the workload among fewer employees. In recent discussions of developments in engineering and construction, Barrie and Paulson state that recent trends in construction are increasing technological complexity and more complex interdependencies. In addition they state, "There are now, and will continue to be, shortages of resources, including … skilled workers, and technical and supervisory staff." (Barrie & Paulson 1992)

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[2] In the text Control & Management of Capital Projects (1991) by J. W. Hackney, he states that: "..function (of project controls) is impeded by the increasing tendency toward specialization and organizational segregation of operations…" This adds to the concept that specialization of this type could fall into the category of habit.

A factor that will enable a company to maintain a broad base of skills is the cross-training of employees. Cross-training offered in three basic areas of estimating, planning / scheduling, cost engineering would enable the employee to be productive in multiple positions. Therefore, when tasks in a single area do not require all of an employee's time, he/she will be able to support tasks in other areas.

It is also important for personnel supporting management to have an in-depth overview of project controls. The curriculum outline for project controls incorporates the concepts that support the analytical and decision making process of management and allows control personnel to see the relationships between the various areas of project controls.

1.1 Statement of the Problem

The problem addressed in this work is to identify the need for a training program in project controls, resulting in an evaluation and assessment in support of a cross-training development program.

Upon defining the problem, a critical analysis of the problem was discussed with several individuals representing different industrial backgrounds to determine the validity of the problem in the workplace. It was then determined that an appropriate needs assessment would require a survey (questionnaire) of a typical population. The survey would require the population to be working in the realm of project controls. This would impact the results of the survey, but not sufficiently to skew normal distribution.

The purpose of this study was to survey a sample population of project managers employed by Engineering/Construction and Aerospace companies in order to assess the needs for a company-administered training program. Responses to the questionnaire that surveyed the needs of project control personnel provided measurable data which assured the need for such programs.

2.0 Analysis of Survey Results

Eighteen (18) of the 20 questionnaires returned for analysis resulted in a 90% return ratio from the population of project control personnel.

The following sections of the survey instrument are analyzed by the use of Descriptive Statistics.

2.1 General Survey Questions

Question number one asks, "Does your company cross-train any employees using a formal program?"

Twenty eight percent (28%) or 5 out of 18 responded that their company offered a formal program for cross-training in some areas. Seventy two percent (72%) responded that

their company did not offer any formal training for cross-training personnel in any area. This question was to make the respondent consider any type of formalized training program and relate the use of a training module as a cross-training vehicle.

The results indicate that 28% of the population surveyed worked for companies that used a formal training program for cross-training. If reliance on the fact that formal cross-training is an effective way of training employees, one must assume that the effective use of cross- training programs is approximately 28% utilized.

Question No. 2 asks, "Is there a formal training program to update skills in project controls (Estimating, Cost and Scheduling)?

This question was designed to identify the population that used formal training in project controls. The results indicated that 78% or 14 out of 18 of the population had no formal training programs available for cross-training in project controls. In addition, all of responses that identified cross-training programs available in their companies, only four responses identified a program available for cross-training personnel in project controls.

Question No. 3 asks, "Would cross-training control personnel be beneficial to your organization in time of downsizing?" This question was written to elicit a response based on the personal judgment of the population working in project controls that would indicate a positive or negative benefit from the corporate perspective.

Eighty nine percent (89%) or 16 of 18 responded affirmatively. It is evident from this response that the majority of the population considered cross-training project controls personnel would be beneficial in times of downsizing. This is supported in the literature review when the Editors of the Project Management Institute Standards Committee state that training should include activities designed to enhance the skills, knowledge, and capabilities of the project team. (PMIS 1996)

Question No. 4 asks, "In the recent history of your organization have managers cross-trained personnel to other positions where they were required to use new skills?" This question was positioned at this point in the questionnaire to force the respondent to identify if fellow employees were cross-trained to acquire new skills. Earlier in question No. 1, only 28% of the population sampled responded that a formal training program was used in their company in any area. Question No. 4 was designed to identify if cross-training to acquire new skills, was utilized in any area instead of a formal program.

Thirty nine percent (39%) or 7 of 18 of the population responded positively that cross-training was used to develop new skills. Sixty one percent of the population (61%) did not have cross-training available in any form. Project Management Institute Standards Committee criticizes this in the literature review, when it states "Improvements in either individual skills or team capabilities facilitate identifying and developing betters ways of doing project work". (PMIS 1996)

With a 61% or 11 of 18 with a majority responding, it leads us to the possible conclusion that cross-training is not generally thought of as a source of acquiring new skills, but also not thought of as a process of establishing new skills in a project controls environment.

Question No. 5 asks, " When a project control employee in your company was required to perform the tasks of their peers (cost, scheduling, estimating), was the on-the-job training received adequate for the transition to be successful?"

This question was designed to determine if the cross-training that was used in the area of project controls was successful. The respondents to the questionnaire   with 44% (8 of 18) responding positively and 56% responding negatively. The results of this survey element were not conclusive. The results did show that some of the population did have some success with on-the-job training when used as an alternative or adjunct to a formal training program.

Question No.6 asks, "Do you think that a formal training program in project controls (cost engineering, scheduling, estimating) could be utilized to enhance the skills of the current project control personnel of your company?" In the cover letter the population sample was requested to review the overview, curriculum outline and description of the commercial model found in an appendix prior to responding to the questionnaire. After examining the material the population felt that within their organization a formal training program in project controls would be an effective method to cross-train personnel for project management. Ninety four percent of the population answered (17 out of 18) positively.   The results were also supported by question No. 3. This resounding support is also supported by the literature review.

Question No. 7 asks, "Are the project controls personnel in your organization considered specialist with little interface in related areas?"

This question concludes part I of the survey with a look at how the specific control personnel interact and relate with their work in relation to the work of other control personnel. In addition it inquires about the company attitude that exists toward the various project control personnel. If the company considered them specialists, their hiring practices would also support this by
hiring, for example, estimators who can only estimate and schedulers who can only schedule.

This represents an older corporate culture, where specialization was important. This finding is supported by the literature review by O'Brien in CPM in Construction Management, (4th Ed.) when he states "Scheduling systems have made up a cadre of specialists.." (O'Brien 1993)

Twenty two percent (22%) or 4 of 18 of the polled group do not consider their peers in project controls as specialists. However, because of the wording of the question, the results do not necessarily indicate the population considers their peers as capable well-

trained generalists in the integrated area of project controls. The response may indicate they did not consider their peers as having enough skill to be considered specialists.

This would also indicate that most corporations have a stereo-typical view point of project controls and the skill types that generally occupy those areas of project management.

2.2 Specific Project Control Content Survey Questions

Part II of the survey instrument relates to elements and techniques of project controls that would be included in a project control cross-training program. This approach was intended to guide the population from the larger, more general overview, toward a focus on the elements of project control training.

Question No. 8 asks the question, "In project control reports, is cost/scheduling data integrated in the cost control reporting system (It is assumed to be computer based)?"

This question addresses the issue of integration of the various reporting functions of project controls. The integration of these functions indicates that certain basic methods and practices have been put in place.   These functions include the following: the development of a common work breakdown structure (both in the estimate and schedule), recognition of similar events and activities between cost, scheduling and estimating for progress determination, check estimates, and a functional project execution guide.

Sixty one percent (61%) or 11 of 18 of the population responded positively and 39% responded negatively to this question. This indicates that 61% of the population have computer integrated systems. The need for this is supported by the literature review when the Editing body of The American Association of Cost Engineers (1992) states that a comprehensive (*integrated)* project control system is needed to guide work through both planning and execution.

Question No. 9 asks, "Is the same work breakdown structure that is used to develop an estimate also used in the development of cost reports and schedules for the same project?" This question quizzes the respondent on the internal organizational structure used in the estimating, cost and scheduling systems of their respective companies. This lays the ground work to identify the basic structure that is used. This basic structure is normally found throughout most corporate reporting systems. Also, the question was designed to determine if a relational database was used by the population with their respective companies.

Sixty one percent (61%), 11 of 18 of the population stated that a WBS is used in development of an estimate and also in the development of cost reports and schedules for the same project. Thirty nine percent (39%) of the population did not use the same WBS for development of the reports and schedules. This leads us to the possible conclusion that an integrated basic structuring of project control reports is not done in some companies.

Question No. 10 was a re-statement of question No. 9 and was done as a check question. The results were virtually the same, but it gave the option of excluding reports and schedules from the question.

The remaining questions all requested the population sample subjectively rank the responses in accordance to the professional experience of the respondents.

Value weighting was used for evaluation of the final four questions. The results were shown in tabular format.   The results of Question No. 11 are shown in Table 2.1.

Table 2.1 - Rank of Mathematical Skills

Question No. 11	Weighted Value
A. Calculus	61
B. Trigonometry	61
C. Algebra	44
D. Statistics	36
E. Other	26

Question No. 11 required the respondent to subjectively rank the mathematical skills needed by project control personnel, in order of importance. Elements included Calculus, Trigonometry, Algebra, Statistics and other. Other was a fill in-the- blank response with whatever the individual felt appropriate. The purpose of the question was to identify the necessary mathematical skill level of project control personnel.

Using the weighted values from Table 2.1, the ranking of the mathematical skills follow in sequence beginning with the highest priority: (a) Calculus, (b) Trigonometry, (c) Algebra, (d) Statistics (e) Other (Accounting, Finite Math). This is supported in the literature review by Steward, Wyskida, & Johannes, in their text entitled Cost Estimators Reference Manual, (1995) when they state, "…the skills needed.. include business and finance skills, mathematical and statistical skills…"

Question No. 12 asks, "What basics would you include in a cross-training program for project controls personnel?" This question presented a group of six items and requests the population sample to rank in the order they would include them in a cross-training program. The six items were: (a) statistical computations, (b) computer software programs and data bases, (c) concepts related to scope and technical content, (d) detailed skills training for estimating, cost and scheduling, (e) task relationships between project controls, and (f) math skills.   Since the test module dealt essentially with conceptual data, it was important to recognize how the respondents reacted to additional areas not fully developed in the test module, but could be expanded or excluded, depending on the response.

Table 2.2 - Cross-Training Basics

Question No. 12	Weighted Value
A. Statistics	96
B. Software	67
C. Concepts	32
D. Skill Areas	46
E. Task Relationships	54
F. Math Skills	83

By using the weighted value scoring from Table 2.2, we find that the population prioritized the following data: (a) Statistical Computations, (f) Math Skills, (b) Computer Software, Program and Data Bases, (e) Inter-relationships of tasks, (d) Detailed Understanding of related skill areas, and (c) Concepts. The top two choices from the population were Statistical Computations and Math Skills. The population selected the two areas they would specifically include in a cross-training program.

Question No. 13, requests the respondent to rank a list of six elements of project management that they would include in a training program for project control personnel. This question was a step away from the prior questions that focus on specifics of project control areas, to look a some general aspects in project management which relate to project controls. This was posed to inquire as to how the population looked from a project controls perspective at project management . The choices were (a) Basic phases of project management, (b) Organizational approaches, (c) Types of contractual relationships, (d) Contract types, (e) Elements of a contract, and (f) Basic contract documents.

Table 2.3 - Rank of Project Management

Question No. 13	Weighted Value
A. Phases of P.M.	34
B. Organizations	66
C. Contract Relations	87
D. Contract Types	71
E. Contract Elements	56
F. Contract Documents	64

The weighted values from Table 2.3 show that the population ranked the choices in the following manner:
1.   (c) Types of contractual relationships,
2.   (d) Contract types
3.   (f) Basic contract documents
4.   (b) Organizational approaches
5.   (e) Elements of a contract
6.   (a) Phases of project management.

Question No. 14 requests the respondent to review the curriculum overview and outline, and rank the three major elements of project controls (Estimating, Planning/Scheduling

and Cost Engineering) in order of priority that should be incorporated in a training program. This question identified the most significant element of project controls by the population. This was not to exclude any specific element, but to highlight what the population considered the most relevant.

Table 2.4 - Rank of Project Control Elements

Question No. 14	Weighted Value
A. Estimating	53
B. Planning/Scheduling	30
C. Cost Engineering	25

The weighted values from Table 2.4 show that the population made the following determination in priorities of the three elements listed. This question was ranked slightly different from the previous questions, in that the lowest value obtained is the first priority. First choice was (a) Estimating, the Second choice was (b) Planning/ Scheduling and the Third choice was (c) Cost Engineering. The result of this question is not surprising in that the literature review generally supported this subtle finding. The following is a graphical representation of the choices.

3.0 Conclusions and Recommendations

The development of techniques used for project controls from 1956 to 1990 evolved from the use of simple arithmetic and use of bar graphs to the wide spread use of some variation of the Critical Path Method. After 1990 more sophisticated methods of tracking projects were developed, as a result of the strides made in computer technology.

Authors reviewed in recent literature advocate current methods that integrate cost, estimates, schedule and materials into a comprehensive project control system using sophisticated computer software.

Many project control personnel are considered as specialists by their peers and managers. In order to understand the more comprehensive control systems training is necessary. Training would also result in development of an enhanced company culture and improved skills and knowledge for project personnel.

For project management, benefits from cross-training project control personnel would include improved communication and sharing of information between departments. These elements would lead to developing better ways of doing project work. Improvements suggested by the authors included integrating the primary elements of project controls as cost engineering, scheduling, estimating and value analysis.

After reviewing the literature, a rationale was established that project management would benefit from training Project Control personnel with an overview of the related functions and tasks performed by their peers and team members. A further review was conducted and it was found that most authors felt there were healthy trends toward integrating information in the areas of project controls. In addition many authors presented critical

elements necessary to a program for success in project management. However, no consistency in curriculum, training content or identified need existed, thus the reason for the study.

3.1 Summary of Survey Results

The results of the survey showed the majority of the population responded that their company does not offer any type of formal Cross-Training in any area. The statistics indicate that formal programs are not fully utilized to enhance skills in the area of project controls.

However, 89% of the population considered cross-training in project controls would be beneficial during time of downsizing. Also 94% of the population felt that formal training could be utilized to enhance the skills of project personnel in their company.   In spite of this wide spread recognition that training would enhance project management only 39% of the population responded that cross-training was actually used to develop new skills. Just one company had a formal cross-training program for project controls.

When asked if the cross-training that was offered in the area of project controls was successful for personnel to perform the tasks of their peers when necessary the response from the population was split 50%. This may indicate that formal training would be more successful than informal cross-training. This result is interesting considering that the population polled are employed by companies that are considered the leaders in their respective industry.

The survey showed the majority (78%) of the population considered project control personnel to be specialists rather than generalists with a broad knowledge base of their field.

Sixty one percent (61%) of the population surveyed integrate cost scheduling data in the cost control reporting system. The integration of these functions indicates that certain basic systems, such as logic, programming and databases, are being utilized. This indicates that 39% of the population work in companies that do not integrate basic project control reporting.

This survey also identified primary elements of project controls that were considered relevant to the development of a curriculum overview and outline, using a commercial model as an example in a cross-training program.

Results showed that when selecting content, the relevant mathematical skills included Calculus, Trigonometry, and Algebra.

The top three basic concepts to be included in a formal cross-training program were statistical computations, math skills, and knowledge of computer software and databases.

The top three elements of project management selected that were considered most important for personnel to be familiar with were types of contractual relationships, contract types and knowledge of the basic contract documents.

The three major elements of project controls that were selected for incorporation in a cross-training program were estimating, planning / scheduling and cost engineering, listed in sequence of priority selected by the respondents.

A further review was polled upon receipt of the questionnaire and it was found that most of the population felt that the quality of the entry level personnel had limited abilities both in project management and computer skills. Most of the population preferred to hire college graduates with extensive experience to avoid training. In the review, inquiry was made as to whom the population felt had the greatest responsibility in training, the employer or the university? All of the population sited the university of having the responsibility of providing basic skills to the students.

Two methods to accomplish this were mentioned during the review. The first being the requirement that most junior and senior level work should be required to be completed in the appropriate computer software. For example, most junior and senior level work should not only require substance, correct technical data and techniques, but should require the proper computer graphics and the proper use of computer processing.

The other method recommended was to offer the computer skill course as a pre-requisite to senior level work, thus developing proficiency by requiring the use of these basic computer skills in upper level undergraduate courses.

3.2 Discussion of Survey Results

The literature review and survey had several areas of direct comparisons. The first was in the area of attitude toward project control personnel. The composite attitude from both the review and the survey, which apparently stems from an older corporate culture, is that project control personnel are specialists.

The review and the survey supported the need for enhanced skills and training, in project controls. The literature review, with the exception of one article, was reasonably silent in its commentary on cross-training for specific conditions, such as downsizing. However, the survey population felt training was a definite boon to deal with corporate problems of this nature.

Also the literature review and the survey turned up a variety of topics that both authors and respondents felt that are important in developing a training curriculum overview and outline for a formal program. This is indicated by a comparison of the sub-topics covered in the literature and the various ways the population ranked skills, topics and concepts related to training in project management. However, it would appear that the test module presented, that was derived from programs found in literature, covers the

majority of the topics the population sample felt important in a formal cross-training program.

3.3 Recommendations

Recommendations for further study include the following:

1. Two areas of skills/concepts that were defined as important for inclusion in curriculum content, included computer software and math skills.
2. The population felt that the responsibility of basic skills belonged to the university and specifically to the various engineering departments application of curriculum requirements related to computer skills and not the employer or the employers' training program. A thorough study specifically addressing this topic needs to be completed.
3. The study was conducted using a relatively small population sample. The study should be continued using a larger sample.
4. The study addressed only curriculum content and a need for cross-training in project controls using a formal program. Other topics related to curriculum content, project controls and management could be included in a new study.
5. The population was drawn from two different industries and due to the varying cultures between Aerospace and Engineering / Construction, independent surveys should be conducted.

Bibliography

1. Kavanagh, T. C., Muller, F. & O'Brien, J. J. (1978). Construction, Management - A Professional Approach. New York: McGraw-Hill.

2. Hackney, J. W. & Humphreys, K. K. (1991). Control & Management of Capital Projects. (2nd ed.). New York, NY, McGraw-Hill.

3. Barrie, D. S. & Paulson, B. C. (1992). Professional Construction Management. New York, NY, McGraw-Hill.

4. O'Brien, J. J. (1993). CPM in Construction Management. (4th ed.). New York, NY, McGraw-Hill.

5. Editors of AACE, (1992). Skills & Knowledge of Cost Engineering, (3rd ed.). The American Association of Cost Engineering, Morgantown, West Virginia.

6. Steward, R. D., Wyskida, R. M. & Johannes, J. D. (Eds). (1995). Cost Estimator's Reference Manual. (2nd ed.). New York; John Wiley &Sons, Inc.

GHOLAM H. OMIDI, Ph.D.
Gholam H. Omidi is an Assistant Professor of Construction Management at the University of Houston, College of Technology in Houston, Texas. He is actively involved with the Construction industry in the Houston area. Dr. Omidi received his B.S and M.S degrees in Civil Engineering from the University of Southwestern Louisiana and a Ph.D. from the Civil and Environmental Engineering department at Texas A&M University in 1993.

FAROUK G. ATTIA, Ph.D.
Professor Farouk G. Attia is the coordinator of the Computer Aided Manufacturing Programs at the University of Houston, College of Technology in Houston, Texas. He has over 28 years of educational and industrial experience in the fields of Manufacturing Systems, Automation, Mechanical Systems Design and Computer Assisted Engineering. Dr. Attia is an active member of the American Society for Engineering Education (ASEE), the Society of Manufacturing Engineers (SME), and the American Society of Mechanical Engineers (ASME).