Session 2793

Enhancement of Freshman Design Experience by Integration of Service Learning

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ABSTRACT
The Introduction to Engineering Design course (ENES 100) has evolved over the last decade at University of Maryland, College Park (UMCP) and integrates ideas, opinions and experiences of many faculty members who have experimented with teaching design to freshman students. The course involves freshman students in a "hands on" product realization process. The product development project is conducted by student teams of five or six. The typical product chosen, like many engineering products is synthesized from components and engineering principles that cover a spectrum of topics. Compartmentalization of knowledge within subject boundaries is avoided allowing the instructor to introduce material from several courses the students will undertake in subsequent years. During the product realization process the instructor has an opportunity to emphasize communication skills, teamwork, design process, computer aided design and drafting, software applications for document preparation, spreadsheet and presentation development.

While developing the course at University of Maryland, Eastern Shore (UMES)[1] the basic structure and content have remained unaltered from the course developed at College Park. However, suitable refinements have been incorporated such that all the four phases of "Experiential Learning Cycle" are emphasized.

The "Experiential Learning" paradigm developed has been further refined and integrated with "Service Learning" efforts. Student teams have provided valuable service to the community by presenting their design experience in the course, their perception of engineering and the engineering design process to pre-college students in local high schools as their "Service Learning" projects. The activity has not only provided "service" to pre-college students but has also enhanced communication skills of the engineering freshmen. The engineering freshmen have reflected that the activity has influenced "learning outcomes" of a richer flavor and dimension encompassing civic responsibility and life-skills over and above academic outcomes. Moreover, a survey of the pre-college students who participated in this endeavor indicates that

[1] University of Maryland, Eastern Shore (UMES) offers an ABET accredited Engineering Degree in collaboration with Clark School of Engineering at University of Maryland, College Park (UMCP) to the residents of Eastern Shores of Delmarva peninsula,

the activity has enabled them to have a better grasp of the field of engineering and has provided motivation to some, to pursue engineering as their chosen field of study in college.

Introduction

Faculty members in the Engineering Program at UMES and the Physics Department at Salisbury State University (SSU) have developed a collaborative effort under the acronym SLOPE: Service Learning Opportunities in Physics and Engineering [1]. Since it's inception in the fall of 1998 the SLOPE program has helped serve specific needs in the Eastern Shore community. Faculty supervised student projects have been identified and implemented with "learning outcomes" consistent with desired objectives of the curriculum areas.

This paper describes the integration of Experiential and Service Learning in the "Introduction to Engineering Design (ENES 100)" course offered at the University of Maryland Eastern Shore campus for the freshman engineering students enrolled in UMES and SSU campus. A significant number of these students participate in the collaborative engineering program among UMES, SSU and UMCP.

Experiential Learning Cycle [2,3] involves students through a learning process that includes concrete experiences (CE) from which students develop abstract concepts (AC) through reflective observations (RO) which are subsequently refined by further active experimentation (AE).

Service Learning [4] is a combination of academic instruction with service that addresses real community needs. The typical structure includes (i) preparation; (ii) action and (iii) reflection. A celebration event can be incorporated in the structure but is not required under the formally accepted structure. Service Learning may also be looked upon as "Experiential Learning" with a "community service" component.

Engineering is a profession in which knowledge of mathematical and natural sciences acquired by study, experience and practice is prudently applied to develop ways to utilize optimally materials and forces of nature for the benefit of mankind.

Emerging trends in engineering education facilitated by the Engineering Criteria 2000(EC2000) developed by the Accreditation Board of Engineering and Technology (ABET) [5] is encouraging integration of design throughout the engineering curriculum including the freshman and sophomore years [6]. It is also promoting a holistic integration of 'soft' and 'technical' skills encompassing academic knowledge, civic responsibilities, and life skills.

"Service-Learning" seems to be an ideal vehicle to introduce the well-documented benefits of "Experiential Learning", the community (national) need of improving/promoting engineering, mathematics, science education among middle/high school students [7], and curriculum objectives of Criteria 2000 of ABET as stated above. The integration of community service in the learning process provides a richer flavor that manifests in broader dimensions of learning outcomes. There is a growing awareness of the benefits of integrating "Service-Learning" in the curricula among the engineering educators [1, 8-11].

Freshman Design Experience and Service- learning

Introduction to Engineering Design (ENES 100) is a course that has been developed at the University of Maryland, College Park in response to the paradigm shift in engineering education that enables integration of engineering design in the freshman year of the engineering curriculum. Besides introducing design it helps promote student creativity and allows faculty to introduce the broad objectives of engineering education and engineering profession.

"Engineers" play a significant role in the economic prosperity of a nation and are sometimes referred to as the " engines " of economic growth. However, students typically graduate from high schools without a good understanding of the engineering field and career options ahead of them. As such dissemination of information among high school students about the field of engineering is a valuable contribution to society.

Figure 1 illustrates how experiential and service learning was integrated in the "Introduction to Engineering Design Class (ENES 100)" in the fall semester of 1999. The course was based primarily on the Introduction to Engineering Design (ENES 100) course developed at the University of Maryland, College Park as described in reference[12] with suitable refinements to incorporate experiential and service -learning.

Students visited a local industry to witness engineering practice in the real world and reverse engineered commercially available scales to gather some *concrete experience***.** They *reflected* on their *concrete experience* and related the same to their design project and classroom lectures to form *abstract concepts* that assisted them in devising *active experiments* that led to more *concrete experiences*. The design project evolved from simple scales to more complex designs with more features as students learned and became more comfortable with physically realizing the abstract concepts. They *reflected* on their learning experience in the design report and while giving "Service-learning" presentation to high school students.

The course involved freshman-engineering students through the entire design process. Following reference [12], the students were exposed to concepts of weight and mass and their units, basics of engineering mechanics, D.C.(Direct Current) circuit analysis and electronics related to design of postal scales. Design concepts pertaining to variety of analog and digital scales including spring-based scales, strain-gaged based scales, hydraulic scales and scales based on mechanical lever arrangements were introduced. They also learned variety of software tools for document preparation, spreadsheet applications, presentation development, computer-aided design, drawing and analysis. Discussions were also held about the history of engineering and technological development through time, social and economic impact of engineering innovation, information gathering and technical writing, safety and reliability in engineering design, and, ethics, as it pertains to engineering practice in the real world.

Students were encouraged to apply all of what they learned in classroom lectures in their design project, engineering drawing, design reports and oral presentations. Students worked in teams of four or five to brainstorm over design alternatives, performed project planning using Gantt Chart, developed engineering drawings, purchased components and performed manufacturing, safety and quality assurance tasks. The students were also required to give oral presentations and develop a technical report to enhance their communication skills. Twenty-one students from UMES and SSU participated in the class in four teams in the fall 1999 class of ENES 100. Each team developed a postal scale under the same realistic constraints of space, time, and, budget. Photographs 1 through 4 show the completed scales that each team designed and manufactured. Two of the four teams built electro-mechanical postal scales, the other two built purely mechanical scales. Each scale had a capacity of up to 5 lbs.

Historically, high school students do not have a very clear idea about the field of engineering. The continued national economic growth necessitates a larger number of high school students from all cross sections of society to pursue engineering, technology and related fields. Two important factors have to be addressed to realize this goal. More effort needs to be devoted to prepare students in high schools in mathematics and science courses. Also, high school students have to be motivated and inspired to pursue engineering not only because of the financial rewards it promises but also because of their genuine interest and desire to pursue the same. To accomplish these objectives each student team was required to give a presentation of their design project to high school students. This also gave them the opportunity to describe the different fields of engineering to the high school students as well as to introduce the activities of the Junior Engineering Technical Society (JETS) [13] to them. In particular, activities under the acronyms TEAMS (Tests of Engineering Aptitude Mathematics and Science) and NEAS+ (National Engineering Aptitude Search +) were highlighted. TEAMS program enables teams of high school students to learn team development and problem solving skills. NEAS + is an academic self-assessment that helps high school students determine their strengths and weaknesses in subject areas that are critical to engineering and technology thereby enabling them to select appropriate electives while in high school as well as promote academic preparation through self-study. During the ENES 100 course that was offered in fall of 1999 at UMES the student teams gave presentations to four different high schools (Parkside High, Wicomico High, Bennett High, and Washington High) in the Wicomico and Somerset Counties in the eastern shore of the State of Maryland. It is anticipated that such activity will enable high school seniors to make more informed career choices. The activity will also directly influence the desired "outcomes" of improving presentation and communication skills of the engineering students. Photographs 5 & 6 show one of the student teams giving a presentation to high school students at Parkside High School.

Learning Outcomes of ENES 100 at UMES

Significant attention was paid to make the course (ENES 100) consistent with the "outcome based" approach to Engineering education as advocated by EC2000 of ABET. Particular attention was paid towards Criterion 3 [5] that includes the desired outcomes of the engineering program.

"Service-Learning" emphasizes both "Service" and "Learning" and can be distinguished from the activities that may be labeled as "Volunteerism" or "Community Service", where the "Learning" aspect is insignificant. The students "Learn" as they "Serve" their community. Therefore, it is important to identify and encourage activities that have specific learning outcomes consistent with the course and curricula within which such activities are performed. In the process of integrating "Service Learning" with the Introduction to Engineering Design course [ENES 100] the outcomes listed below were desired. The outcomes include not only academic but also those of civic responsibility and life-skills that are consistent with the engineering profession [14]:

Academic outcomes desired

- Assimilation of "learning inputs" provided by the instructor to be able to apply the knowledge to design and manufacture a "Postal Scale" and develop presentations using modern software tools to introduce the field of engineering and the design process to high school students.
- Experience with engineering design from start to finish including project definition, planning, risk assessment, design alternative analysis, software use, prototyping, testing, deployment, evaluation and maintenance.
- Development of communication skills.
- Better appreciation of the role of customer in engineering design.
- Improved study habits and interaction with the faculty.
- Ability to integrate knowledge from many different fields.

Life Skills Outcomes Desired

- Critical thinking ability.
- Interpersonal and conflict resolution skills to successfully cooperate in a team.
- Appreciation of the role of community service in society.

Civic Responsibility Outcomes Desired

- Appreciation of "Code of Ethics"[15] for engineers and development of professional ethics.
- Desire to serve the community in the future.
- Better appreciation of engineering and its socioeconomic impact.

Assessment of academic outcomes was performed by way of product demonstration, oral presentations and quality evaluations, tests and classroom examinations. A survey was included in the final exam for a comprehensive assessment of learning outcomes from the perspective of the students (See Table -1). An award ceremony was held during the final presentation on the last day of classes and the 'Best Team Player', 'Best Team leader' and the 'Most Improved Team Member' were recognized with a certificate of achievement and a token award.

Results and Conclusion

Table -1 shows the compilation of the data from a survey of 21 students. '0'- indicates that the course did not influence the particular 'Outcome' at all, '1'- indicates it influenced very little, '2'- Indicates it influenced moderately, '3'- indicates it influenced strongly. Figures 2 through 5 indicate that the important desired outcomes were successfully achieved in the course from the perspective of the students. The results indicate that integration of Experiential and Service-learning had a favorable impact on the learning outcomes.

More needs to be done to inform and generate interest among high school students to pursue Science, Mathematics, Engineering and Technology fields to keep pace with the continued national economic growth. The feedback from the high school students and teachers with regard to the activities described in this paper have been extremely positive and have provided inspiration for expanding the scope of the effort.

Acknowledgment

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References

[1] Nagchaudhuri, A., Eydgahi, A., and Shakur, A., "SLOPE: An Effort Towards Infusing Service-Learning in Physics and Engineering Education", *Proceedings of 2000 ASEE Annual Conference*, St. Louis Missouri, June 18- 21, CD ROM.

[2] Kolb, D.A., Experiential Learning:Experience as the Source of Learning and Development, Englewood Cliffs, N.J.: Prentice Hall, 1984.

[3] Svinicki, M.D. and Dixon, N.M. "The Kolb model modified for classroom activities", *College Teaching*, Vol. 35, No: 4, 1987.

[4] Schine, J.S., Service Learning: 96th Yearbook of the National Society for the Study of Education, Part 1, NSSE, 1997

[5] Paterson, D.G., "Engineering Criteria 2000: A Bold New Change Agent", *ASEE PRISM*, September 1997.

[6] Meade, J., "Change is in the Wind", *ASEE PRISM*, May 1993.

[7] Brown, S.E., "Making a Difference in Science and Engineering Education", *Mechanical Engineering*, May 1999

[8] Tsang, E., Johnson, B., Litchfield, B., Newman, J., Ramage, C., and Dubose, L., "Integrating Service Learning into Introduction to Mechanical Engineering, *Proceedings of 1995 ASEE Annual Conference*, Washington, D.C., June 26-29, 1996, CD-ROM.

[9] Tsang, E., Martin, C.D., and Decker, R., "Service-Learning as a Strategy for Engineering Education for the 21st. Century, " *Proceedings of 1997 ASEE Annual Conference*, Milwaukee, WI, 1997.

[10] Coyle, E.J., Jamieson, L.H., and Sommers, L.S., "EPICS: A Model for Integrating Service-Learning in to Engineering Curriculum", *Michigan Journal of Community Service Learning*, Vol. 4, 1997.

[11] Nagchaudhuri, A., and Conway, H.M.,"Teaching Tools for Teachers"- An Engineering Design Project to Enhance Science and Mathematics Education for Middle/High School Students, DE-Vol. 102, *Mechanical Engineering Design Education: Issues and Case Studies*, ASME 1999, pp. 37-42.
[12] Dally, J.W. and Rocheleau, D.N., Introduction to Engineering Design, Book 3 (Postal Scales), 1998, College House Enterprises, LLC, Knoxville, Tennessee.
[13] JETS : Junior Engineering Technical Society , [Online], Available : http://www.jets.org [May, 2000].
[14] Astin, W.A., and Sax, L.J., " How Undergraduates are Affected by Service Participation", *Journal of College Student Development*, Vol. 39, No: 3, May/June, 1998.
[15] NSPE Code of Ethics For Engineers, [Online], Available:http://www.nspe.org/eh1-code.asp [June, 1999].

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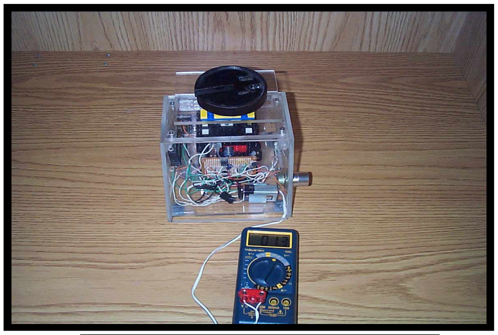
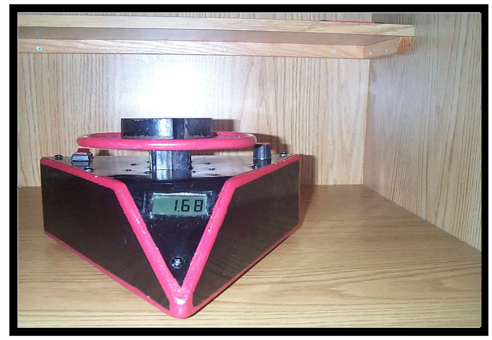


PHOTOGRAPH 1 :
Team 1



PHOTOGRAPH 2 :
Team 2

PHOTOGRAPH 3:

PHOTOGRAPH 4 :
Team 4

PHOTOGRAPH 5: ENES 100 team giving presentation to high school students at Park Side

PHOTOGRAPH 6 : The team in Photograph 1 demonstrating the scale

LEARNING OUTCOMES	0	1	2	3
Academic Outcomes Desired				
Assimilation of "learning inputs" provided by the instructor to be able to apply the theory to design an engineering product (Postal Scale) within specifications and constraints arising due to size, capacity and budget.	0	0	5	16
Experience with engineering design from start to finish including project definition, planning, risk assessment, design alternative analysis,software use, prototyping , testing, evaluation etc.	0	0	5	16
Development of communication skills.	0	0	7	14
Better appreciation of the role of customer in engg. design	0	2	11	8
Improved study habits and interaction with faculty	1	9	5	6
Ability to integrate knowledge from many different fields.	2	7	8	4
Life Skills Outcome Desired				
Critical thinking ability	1	6	9	5
Interpersonal and conflict resolution skills to successfully cooperate in a team.	2	3	7	9
Appreciation of role of community service in society.	1	3	13	4
Civic Responsibility Outcomes Desired				
Appreciation of "Code of Ethics" for engineers and development of professional ethics.	0	5	8	8
Desire to serve the community in the future.	1	7	6	7
Better appreication of engineering and its socioeconomic impact.	0	2	8	10

TABLE:1 Outcome Assessment for fall 2000 class of ENES 100 at UMES

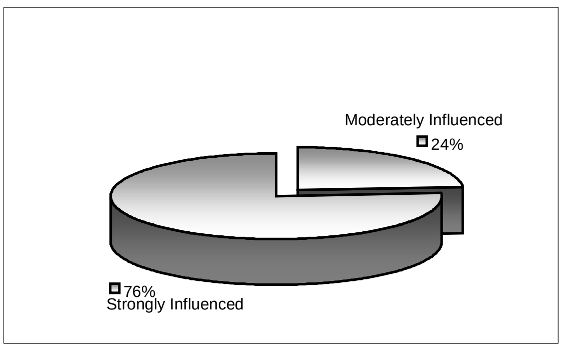


FIGURE 2 : Survey result for an 'Academic' Outcome (*Experience with engineering design from start to finish*)

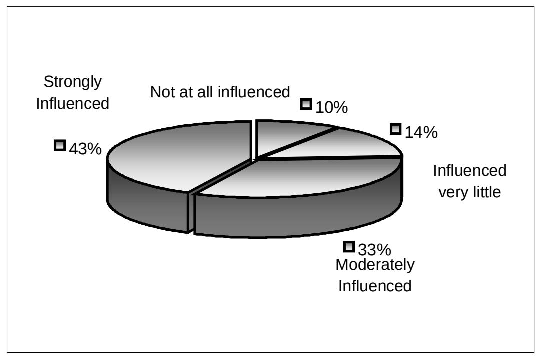


FIGURE 3 : Survey result for a 'Life-skill' Outcome (*Interpersonal and conflict resolution skill to successfully cooperate in a team*)

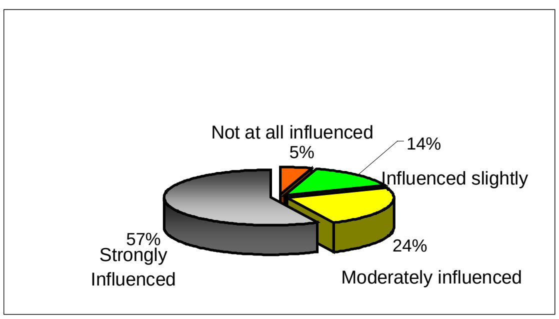


FIGURE 4: Survey result for a 'Civic-responsibility' Outcome (*Appreciation of role of*

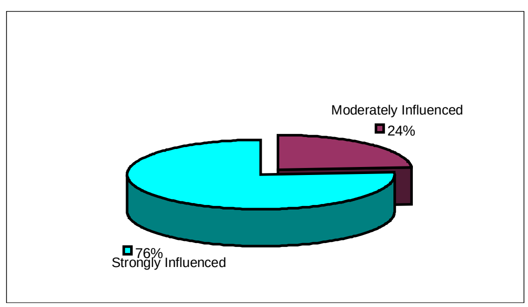


FIGURE 5 : Survey result for *'Communication-Skill'* development (Academic)

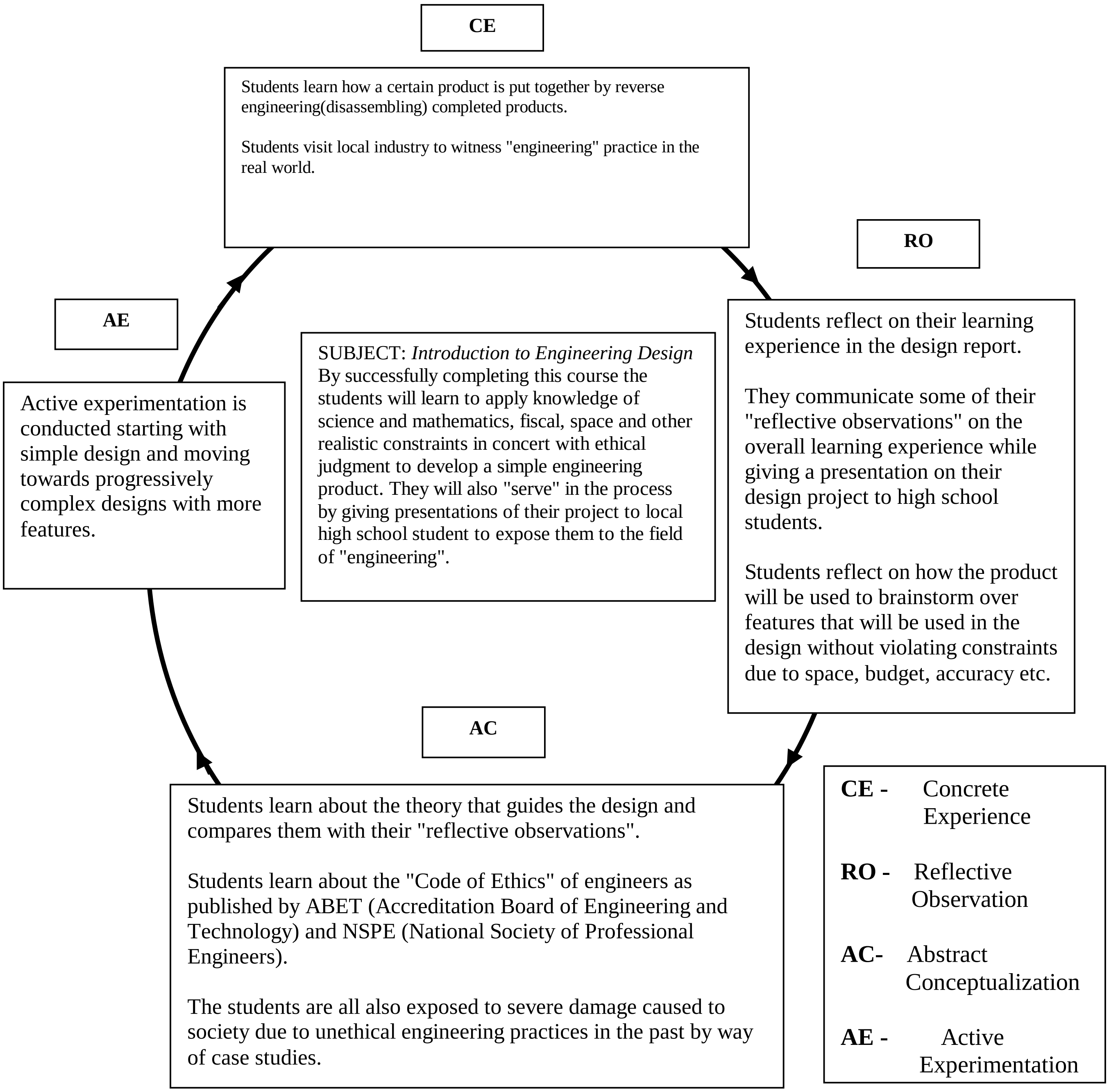


FIGURE 1 : Kolb’s Experiential Learning Cycle adopted in Introduction to Engineering Design