Technological and Engineering Literacy Classes from different perspectives: A pilot study

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Abstract

This paper is a report of the early results for a study of perspectives, views and understanding of the meaning, aims and objectives of technological and engineering literacy. The data is collected from faculty and students of engineering and industrial design. The authors have been delivering technological and engineering literacy classes for more than a decade to non-engineering students in our university, thus necessitating the need to study the perceptions of two stakeholders in this experiment: The college of engineering that delivers the classes, and the department of industrial design that included the classes in their program.

The paper reports and discusses the results of initial studies for better understandings of perspectives, and expectations of engineering and industrial design students, and faculty regarding technological and engineering literacy classes and ideas. The pilot results from freshman engineering students, second year industrial design students, and faculty of engineering and industrial design are presented.

The paper introduces the purpose of the study, the questions that were asked, some interview results with selected members of engineering and design students and faculty. In addition the paper presents the trends and significances of results and how they can relate to the effectiveness of the notions of technological and engineering literacy in the education communities that these ideas meant to affect.

Introduction and Motivation: Reflections on local and national level challenges

The growth in technological literacy efforts that were initiated with two major publications *Technically Speaking* and *Tech Tally* [1,2] have brought about many interesting programs and developments in technological literacy. Schools nationally and internationally have developed classes and programs in the area of technological literacy, engineering literacy, as well as various classes that help enthusiasts to learn more about engineering and technology. The author and many of our colleagues were among the early advocators and developers of Technological Literacy programs that were offered by engineering colleges to non-engineering students, which included critical thinking and decision making as a part of Technological Literacy [3-24]. The overall objectives were to develop a national level awareness and educational effort for technological/engineering literacy. As the idea is becoming more popular we see few variations and new turns to synergistically advancing technological literacy as well as helping STEM and STEM education activities.

This study was initiated to help understand our efforts in technological literacy classes at our institutions, and in accordance to the national level research and developments. We decided to follow the definitions and descriptions that are defined in Technically Speaking. A valid and enriching approach in teaching technological literacy classes is to read the first few chapters,

discuss the ideas, and reflect on the issues that are introduced in the Tech Talley and Technically speaking [1,2]. Students in non-engineering programs find the definitions, discussion, and approach of the book very refreshing and use it through their classes and work in the undergraduate program. It is very encouraging to see more programs and more classes offered on campuses and even at the highs school level addressing technological and engineering literacy and related?

There are more than a few perspectives

The overwhelming majority of the educators teaching technological and engineering literacy classes (in the university and college levels) are faculty of engineering, industrial technology, science, or related fields. In the author's particular institutions faculty of engineering and students from Industrial Design and Engineering are involved with the technological literacy developments and classes. Our experience, after more than a decade of these efforts, shows that there are multiple perspectives and understanding regarding technological and engineering literacy and the role of the classes in these areas. Consequently, we have initiated this pilot study to have a better understanding of four groups. The groups are students and faculty in engineering and industrial design. A survey was created to identify the perspectives, ideas, and the definitions of engineering and technological literacy as well as the purpose, and the content of the classes in these areas. There have been challenges to get responses from engineering and industrial design faculty and engineering students.

The department of Industrial Design (in the College of Design) is the only department that has included technological literacy as their core curriculum. The two technological literacy classes ("From thoughts to things" and "How things work") have been selected as the core requirements for industrial design program. Students take these classes in their sophomore 2nd year. In Fall they take "From Thoughts to Things" that introduces students to engineering, technology and the processes involved in the design and exploration of engineering and development of technology. The students are introduced to *Tech Tally*, and the three dimensions of technological literacy according to *Tech Tally* in the early weeks followed by discussions and reflections on the meaning, needs, and ideation of technological literacy and why we need them for industrial design. The second class "How Things Work?" that follows in the spring and introduces basics for examining gadgets, and engineering and design artifacts that are seen in everyday life. The approach for both classes is to use systems level thinking to examine, understand, and reflect on engineering, and technological aspects of engineering and engineering artifacts. The students in "From Thoughts to things" are one of the groups that have taken the questionnaire.

The freshman-engineering students in Electrical Engineering were part of this study. Their class is an inquiry based class, with heavy focus on inquiry cycles of learning and critical thinking. The class is focusing "how you learn". The class examines the basic concepts and approaches of engineering and electrical engineering. The students of this class also read the first chapters of Tech Talley but majority of them do not like it and generally do not see the relevance of the subject to the engineering studies. They eventually accept it as a way to focus on critical thinking and decision making in technological scope. In this study we had 120 students in the Freshman Engineering class and 60 students in the technological literacy class. The data

provided is selected to show the major points and trends that are observed in the answers. We are in the process of a more detail analysis of the data. But for this paper we are focusing the major trends that shows the various perspectives that exists in the answers.

The questions and the intention of the survey

Exhibit 1 shows the questions and Exhibit 2 shows the title of the questionnaire. The questions were chosen based on studies and discussions by officers and some of the active members of Technological and Engineering Literacy and Philosophy of Engineering (TELPhE) Division of ASEE . TELPhE had a series of papers, sessions, and publications to define and clarify our position on that are Technological and Engineering literacy[3-20].

Q1: What is Technological Literacy?
Q2: What should Technological Literacy classes cover?
Q3: What is Engineering Literacy?
Q4; What should Engineering Literacy classes cover?
Q5: Do you think there is a difference between Technological Literacy and Engineering? Please explain.

Exhibit 1: The questions for this study

Views on Technological and Engineering Literacy: Sharing what we think.
Thank you for your participation, and for helping our research. Please note:

1. *Please share your thoughts and ideas.*
2. *There are no right or wrong answers. PLEASE DO NOT DO GOOGLE SEARCHES, we are after what you think. Guessing is fine, if you do not exactly know the answer share with us, what you think.*
3. *We are trying to understand what are the perceptions and understandings/thoughts regarding the following.*

We truly appreciate for your thoughts, and your kind participation

Exhibit 2: The title and explanations of the questionnaire

Results and Discussions

In general students tried to provide as detailed reflections as they thought is needed. The students in the freshman engineering class, took about twenty minutes to respond to the questions and were given option to keep the questionnaire longer, however, they were all done within the twenty minutes. Students in the technologically literacy class finished their work in fifteen minutes. This group who had the most readings and discussions about technological literacy were clearly identifying main points of *Tech Tally* in particular their understanding three dimensions for the literacy as well as emphasis of critical thinking and the importance of critical thinking and decision making in all design, and technological and engineering literacy cases.

Q1. What is Tech lit?

a. *Being able to use many different forms of technology in practical way*
b. *Know about basics and ideas of technology and artifact to apply to life experience*
c. *How to use technology to solve problems*
d. *Understand technology and the ideas that come with it*

Q2. What should we teach in Tech literacy?

a. *Teach to teach yourself to use technology*
b. *Modern innovation, how they work*
c. *Use of computers, presentations, techno presentations, solving tech problems*
d. *Similar classes to engineering students to really know what need to know*

Q3. What is Engineering literacy?

a. *Understand what goes into field of Engineering*
b. *Understanding math and science*
c. *Use of engineering ideas solving problems*
d. *Understand ideas, math, physics, and all the good things*

Q4. What to teach in engineering literacy?

a. *Understand many engineering fields*
b. *Mathematics and scientific principles*
c. *Math and physics and hands on in lab*
d. *What is engineering and why!*

Q5. Difference between the two

a. *Not everyone needs engineering lit and most need tech literacy*
b. *Some overlap but Engineering needs to be more in-depth*
c. *Not much difference almost the same*
d. *Similar, overlaps in new technology and differ with how much math*

Exhibit 3. A summary of the major ideas in the freshman engineering class

Exhibit 4 shows the highlights of the concepts of the tech literacy class for industrial designers. This groups is showing a good awareness of many important issues regarding these questions.

Q1. What is Tech lit?

a. *The process of understanding what creates a successful connection between technology and the user at the systems level*
b. *Being proficient to use technology in your life*
c. *Ability to comprehend, understand, and adapt to technology and its changes*
d. *Ability to problem solving, problem identification, and dealing with problems regarding technology*
e. *Teaching how to relate, understand and use technology and the dimensions of them*

Q2. What should we teach in Tech literacy?

a. *Process ideation and constructs to help understand and use modern technology*
b. *Covers what is useful to people in their lives material manufacturing how to make websites*
c. *Understanding of what is tech knowledge, what is being able to do and making meaningful decisions in everyday life when dealing with technology*
d. *Basic computer knowledge: interface navigation, and various useful everyday technology*
e. *Should include process of narrowing problems in smaller pieces and capability to seek technological understanding and solutions*
f. *Basics, ideas, and how things are put together*

Q3. What is engineering literacy?

a. *How and why systems work together to create and output*
b. *Functional understanding to the detail of how and why*
c. *Being able to critically and methodically think and deconstruct problems.*
d. *We hope they tech literacy and more, but the engineering literacy has to have more mathematical tools, and science based creativity*
e. *How engineering is done? How to relate to engineering? (not easy, I have tried)*
f. *How to understand and deal with engineering problems and solutions?*
g. *How to work in design teams that are engineering dominate and be able to deal with them*

Q4. What to teach in engineering literacy?

a. *Should break down systems to create functions*
b. *Teach importance of different elements that create functions from systems level view*
c. *Took kits and ways to methodically take apart and analyze systems to solve problems*
d. *Math, science, and relevant vocabulary*
e. *How to go from vague ideas to actual problems in technical fields*
f. *How do engineers think?*
g. *Why do engineers think, solve problems, and act they way they do?*
h. *Design perspectives from engineering and Design*

Q5. Difference between the two

a. *They both deal with systems, from different perspectives*
b. *Biggest different should be the correlation of the user and applications*
c. *Tech literacy scopes a grander number of people and engineering literacy less since*
d. *Engineering literacy is more abstract and deal with more realistic ideas that are doable*
e. *Tech lit is more ideas, ideations, and constructs to help see what is possible*
f. *Engineering literacy focuses on problem solving ways, tech literacy is more problem break down, understanding and critical use of facts ideas without getting too much into technical detail*
g. *The difference is in dealing with technology and engineering process and how to use and relate the dimensions of knowing, capability, competency, and decision making*
h. *Ethics should be discussed in both with great examples since people are involved*

Exhibit 4. A summary of the major ideas in the technological literacy class

The above exhibit provide a list of mostly identified characteristics and highlights of how different people in different fields think and deal with the concepts of engineering and technological literacy. However, we are will be collecting more data.

Exhibit 5 shows faculty's perspectives. It is hard to summarize the wide variety of the answers (even with the limited number of responses that we have had so far). In some of the cases we did one-on-one interviews to clarify their perspectives.

Q1: What is Tech lit?

a. *Teaching engineering to non-engineers.*
b. *Knowledge and understanding of technology and its use in every day life*
c. *Mostly how to think about technology, critical analysis and thinking, and being able to understand different human aspects of technology*
d. *Teaching engineering to non-engineers*

Q2: What should we teach in Tech literacy?

a. *Theoretical overview of engineering principles and methods, with technical examples*
b. *Practice, think, learn, and do breaking down technology into functional and understandable pieces*
c. *Tools, and practice of being able to think in systems, and understand basics from applications*
d. *Not sure, has to do with how to deal, understand, use, and learn about technology and their connections*
e. *Theoretical overview of engineering principles and methods, with technical examples*

Q3: What is engineering literacy?

a. *How engineers works, makes, and deals with managing and creative technology*
b. *How to work with engineering with basics and the needed basic communication and vocabulary*
c. *How engineering design is, and how engineers deal with artifact*
d. *How do engineers approach design and how to understand them in a collaborative as well as social environments*
e. *Same as Technological Literacy*

Q4: What to teach in engineering literacy?

a. *The basic that engineers value? What they are and why are they important for the engineering designer*
b. *The Process of systematic analysis of products with engineering angle and perspective*
c. *Who and why engineers are trained and how non engineers should relate to them*
d. *Same as Technological Literacy*

Q5: Difference between the two

a. *The ideas of knowledge, practical aspects, and problem solving have a lot overlap with different focus and perspective from the outsiders*
b. *One reviews and deals with how to understand the process and role of technology, the other is how those who create and design technological things think and do*
c. *No there is not difference*

Exhibit 5. A summary of the responses by the six faculty of Industrial design

Engineering Faulty mostly did engage deeply in answering the questions. In some cases we did interviews and during those discussions there were more questions than answers by the Engineering faculty.

Q1: What is Tech lit?

a. *Teaching people to understand fundamental technology concepts*
b. *The ability to utilize technology to achieve common societal tasks. For example, checking email, using Excel for family budgeting, making use of home automation tools, tools for setting up an on-line business through Amazon, how to use the Apple App store*
c. *I am not sure how one would define "technological literacy"*

Q2: What should we teach in Tech literacy?

a. *That is hard, technology is a very broad field. I think basic concepts in all aspects of technology. Computer systems, mechanical systems, etc*
b. *such a class should discuss commonly used technologies in society and provide students with hands on experience with these technologies.*
c. *Unknown*

Q3: What is engineering literacy?

a. *Teaching people to understand engineering concepts*
b. *Engineering Literacy is the ability to use knowledge/facts/techniques associated with an Engineering discipline to solve problems that have given constraints/specifications*
c. *I would guess that engineering literacy is ability to communicate and reflect related to engineering work (e.g., problem solving, designing, etc.)*

Q4: What to teach in engineering literacy?

a. *Key points of various engineering fields*
b. *Writing report, completing self reflections, completing regular journal entries of one's thoughts to help understand how a "solution" came about*
c. *Such a class should cover how to break problems down into smaller pieces and cover various techniques that can be applied systematically to solve these smaller problems, and how the smaller problems' solutions can then be integrated to solve the bigger initial problem*

Q5: Difference between the two

a. *No, in the broadest term they are the same*
b. *Cannot comment, as I cannot define technological literacy.*
c. *Yes. Technological Literacy would be people making use of tools that have been designed for the general public to intuitively use for completing common everyday tasks. While Engineering Literacy is more about using fundamental techniques and knowledge to conduct problem solving for problems with well defined constraints. One can be Engineering Literate without being Technological Literate and vis-verse. Though I would think it is more often the case that newly graduated Engineers will be Technologically literate, while a vast majority of Technological Literate people in society are not Engineering Literate*

Exhibit 6. A summary of the responses of faculty of Engineering

In discussions and interview engineering faculty, wanted to emphasis the difference between technology and the know-how of how to create technology. They emphasized the true engineering will need a deep science and math basis. They mentioned the importance of engineering responsibility. The classes should make sure students understand the responsibility of engineers. Engineers cannot make mistakes and training helps them to create, maintain, and propose new technology and engineering product. They also mentioned that in technological literacy we should teach how things work and why. They emphasized that the literacy classes no matter how they are done, will not be sufficient to be able to act and get a job as an engineer. They wanted to make sure that there should be a clear line for the students that literacy is not capability, is it the know how.

The following are highlights of 4 retired and established faculty in engineering who were kind to share their thoughts. They have extensive experience trying to understand engineering and technology, and also trying to train students. Some of the faculty mentioned that in 70's they created seminars and activities to reach out the non-engineering students.

Q1: What is Tech lit?

a. *A technologically literate person is able to read articles in magazines such as Scientific American, Discovery, and Science News and understand perhaps 20% to 50% of it*
b. *Should be able to intelligently discuss technological information with other people with similar backgrounds*
c. *I suppose they could make decisions about technical things that do not require a college degree in the particular subject*
d. *Could understand and help others understand Technical articles and news items*
e. *S/he can understand the basic operation of an automobile, a cell phone, a microwave oven, a radio, and TV set. This person can make intelligent decisions about purchasing such equipment. This person could even write articles for popular literature*

Q2: What should we teach in Tech literacy?

a. *Help student know and practice thinking and analysis all that contains in technological literacy*
b. *The role of critical thinking in using and advancing technology*
c. *The relationship between technology and life, and technology and engineering*
d. *Help students know why engineering are different, and how to work with them*

Q3: What is engineering literacy?

a. *Very close to tech literacy but with depth*
b. *Should be able to apply college level material in technology in their personal discipline*
c. *Know how engineering is done, taught, and how engineers work*
d. *Help students know why engineering are different, and how to work with them*

Q4: What to teach in engineering literacy?

a. *More thinking and analysis process of engineering*
b. *Being able to intellectually discuss concepts and even do back of the envelope calculation with basic confidence*
c. *Help student how to learn on their own if they have to expand their knowledge of technology and engineering*

Q5: Difference between the two

a. *There is overlap, but only in the subjects covered*
b. *They should have similar thinking about analysis and concepts are for both subjects*
c. *The engineering subjects are more in depth and more mathematical. They should be clearly indicated*
d. *Perhaps technological literacy would have to deal with people and ethical issue more and less technical issues*
e. *They both need to be able to understand, explain, and discuss about engineering and technology. But with slightly different perspective*

Exhibit 7. A summary of the points made by select group of established and retired faculty of engineering

A brief discussion and summary of the findings

Based on the answers to questionnaire and discussions with faculty, graduate, and undergraduate students one can find few general trends that are clearly appearing in the answers.

First, almost all of the participants did value technological literacy. They also understood the importance for a national awareness of technological literacy. This is an important issue. Similar discussions in 2006 when the first new classes were created on many campuses did show this important awareness. In 2006 and 2007 while many industrial partners agreed about the importance of technological classes, a number of engineering faculty did not appreciate nor supported such classes and thought the students could use the classes to compete in the job market with our engineering students.

The second important observation is the fact that there still seems to be some disagreements about definition, and need of Technological literacy. In addition, the contrast with engineering literacy is also of interest. It seems that after over 12 years of work by ASEE's Technological Literacy division and various publications and papers trying to establish awareness about technological literacy and engineering literacy we still have a long way to go.

The third important point is the fact that most faculty and almost all students of Industrial Design did show a more in-depth understanding of what is the goal of technological literacy. This can be seen in their answers. Overall most of them included in more details providing more in-depth answers about critical thinking, and the dimensions of technological literacy. They also show interest by providing more the details and explanations of their answers. In particular the faculty valued the critical thinking and decision-making capabilities that technological literacy classes provide for the Industrial Design students. The students do show more detailed understanding when compared to engineering students. This is not surprising since they are taking classes in

the area. However, many still refer to their technological literacy classes as their engineering requirements.

Conclusion and final remarks

The main objective of this paper is to report attitudes and ideas that students and faculty in our institution have regarding Technological and Engineering literacy. Our institution has been creating classes, and working with colleges of engineering, design, and other interested colleges to promote Technological literacy across the campus. In addition, our team has been active at the national and international level promoting ideas and classes in Technological Literacy and recently also Engineering literacy.

It is important for all the all of us and all the programs that are vested in the effort to have a common agreement and ideas of what these classes are together. Perhaps we need to identify major definitions and expectations of Technological literacy. Perhaps there are more than a few versions of technological literacy. Should they be the same for University and High school? ASEE's TELPhE Division, as the leaders of these efforts have adapted the definitions set by Tech Talley. Perhaps we need to think about expanding the definition and providing other variety and options.

This is a work in progress and we have found that while there are some good signs of students who are trained in technological literacy have a reasonable ideas and approach, there is a lot more to do.

A call for action for creating Synergy and coherence

We know that nations with better understanding of technological and engineering literacy are going to be the leading forces of today and tomorrow[2]. In order to have national impact (which is going to impact local efforts, since local interested at reflecting national values and excitements) we need to reach out beyond the publications at ASEE conferences, workshops and similar great venues. There is a need for different avenues and venues for our thoughts and efforts. We should continue and expand our efforts and keep growing our engagements with ASEE and other wonderfully effective venues. However, we need to carry our message to reach higher, wider constituents, and better levels at the national and international engagements. We need to reach various audiences. We need to look into wider and broader reaching publications and platforms and create new ones. Consequently, there seems to be a need for our colleagues and interested associates to reach out to local and national news papers, this also includes international platforms such as ASEE PRISM, IEEE Spectrum, Physics today, American

Physics Teachers, Popular Science, Scientific America, nature, and many other deep reaching publications and venues to expand out reach and enrich our message.

To help all who wish to be involved, we should provide a repository of informative and widely available material for all interested patrons. We should think about becoming national speakers and promoters. While acting locally and promoting great thoughts and ideas, we need to connect to national and international possibilities. Finally we need to keep assessing and evaluating our outcomes, interview our constituents, and keep moving our goals and objective to have better, more profound, and more connected message of Technological and Engineering Literacy.

References

1. Pearson G., and A. T. Young, *Technically Speaking: Why All Americans Need to Know More about Technology*. National Academies Press (2002).
2. Pearson G., and E. Garmire, *Tech Tally: Approaches to Assessing Technological Literacy*. National Augustine, N. (Chair), National Academies Committee on Prospering in the Global Economy of the 21st Century, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, D.C., National Academies Press (2005).
3. Bassett, Gregory, John Blake, Adam Carberry, Jerry Gravander, William Grimson, John Krupczak Jr, Mani Mina, and Donna Riley. "Philosophical Perspectives on Engineering and Technology Literacy, I." (2014).
4. Blake, J.W., Cheville, A., Disney, K.A., Frezza, S.T., Heywood, J., Hilgarth, C.O., Krupczak Jr, J., Libros, R., Mina, M. and Walk, S.R., 2016. Philosophical and Educational Perspectives on Engineering and Technological Literacy, III.
5. Korte, Russell, Mani Mina, Iraj Omidvar, Stephen T. Frezza, David A. Nordquest, and Alan Cheville. "Philosophical and Educational Perspectives on Engineering and Technological Literacy, II." (2015).
6. Krupczak, John, Mani Mina, Robert J. Gustafson, James F. Young, and Scott Vanderstoep. "Minors as a Means of Developing Technological and Engineering Literacy for Non-Engineers." In *American Society for Engineering Education*. American Society for Engineering Education, 2012.
7. Krupczak, John, John W. Blake, Kate A. Disney, Carl O. Hilgarth, Randy Libros, Mani Mina, and Steven R. Walk. "Defining engineering and technological literacy." *Philosophical and Educational Perspectives in Engineering and Technological Literacy 3* (2012): 8.
8. Krupczak, John, Mani Mina, Robert J. Gustafson, and James Young. "Development of Engineering-Related Minors for Non-Engineering Students." In *American Society for Engineering Education*. American Society for Engineering Education, 2010.
9. Krupczak, John. "Technological Literacy: Assessment and Measurement of Learning Gains." *age* 23 (2013): 1.
10. Blake, J.W.. (2010). Technological Literacy, EAC ABET and TAC ABET Accreditation Criteria. *Proceedings of the American Society for Engineering Education 2010 Annual Conference*, June 20-23, 2010, Louisville, KY.
11. Krupczak, J.J., "New Developments In Engineering For Nonengineers: Functional Analysis as a Framework for Understanding Technology," *Proceedings of the American Society for Engineering Education 2009 Annual Conference*, June 17-19, 2009, Austin, TX.
12. Krupczak, J. J., Bassett, G. "Work in progress: Abstraction as a vector: Distinguishing engineering and science," fie, pp.1-2, 2012 Frontiers in Education Conference Proceedings, 2012.

13. Mina, M. “Work in Progress – Minor in Engineering Studies: Teaching Engineering Concepts to Non-Engineering Students, *Proceedings of the 37th ASEE/IEEE Frontiers in Education Conference*, October 10 – 13, 2007, Milwaukee, WI. (2007).
14. Mina, M. “Work in Progress – Minor in Engineering Studies: The Role of Engineering Colleges in Providing Technological Literacy, *Proceedings of the 38th ASEE/IEEE Frontiers in Education Conference*, October 22 – 25, 2008, Saratoga Springs, NY. (2008).
15. Mina, M. “Minors in Engineering Studies: Teaching Technology to Non-Engineers - First Results,” *Proceedings of the American Society for Engineering Education Annual Conference*, June 22 - 25, 2008, Pittsburgh, PA. (2008).
16. Gustafson, R. J. and B. C. Trott, “Two Minors in Technological Literacy for Non-Engineers,” *Proceedings of the American Society for Engineering Education Annual Conference*, June 15-18, 2009, Austin, TX. (2009).
17. Krupczak, J.J, M. Mina, R.J. Gustafson, and J. Young, “Development of Engineering-Related Minors for Non-Engineering Students, *Proceedings of the American Society for Engineering Education Annual Conference*, June 20-23, 2010 Lexington, KY. (2010).
18. Gustafson, R. J., J.J. Krupczak, M. Mina, and J. Young, “Educational Objectives and Outcomes for Technological Literacy Programs at College Level, *Proceedings of the American Society for Engineering Education Annual Conference*, June 23-26, 2011 Vancouver, British Columbia, Canada. (2011).
19. Krupczak J.J, M. Mina, R. Gustafson, J. Young, “Minors as a Means of Developing Technological and Engineering Literacy for Non-Engineers,” *Proceedings of the American Society for Engineering Education 2012 Annual Conference*, June 10-13, 2012, Austin, TX
20. Mina, M., Ringholz, D. “Integrating design and bridging activities of the engineering and the design college: Merging language cultures, creativities, and perspectives,” *IEEE Frontiers in Education Conference 2013* , pp.1626-1628
21. Mina, M. “Liberating engineering education: Engineering education and pragmatism,” *IEEE Frontiers in Education Conference 2013*, pp. 832- 837
22. Stein, B., & Haynes, A. (2011). Engaging faculty in the assessment and improvement of students' critical thinking using the critical thinking assessment test. Change: the magazine of higher learning, 43(2), 44-49.
23. Stein, B., Haynes, A., & Redding, M. (2007). Project CAT: Assessing critical thinking skills. In Proceedings of the 2006 National STEM Assessment Conference, Deeds, D, and Callen, B.(eds) Springfiled, MO: Drury University.
24. Stein, B., Haynes, A., Redding, M., Harris, K., Tylka, M., & Lisic, E. (2010). Faculty driven assessment of critical thinking: national dissemination of the cat instrument. In Technological Developments in Networking, Education and Automation (pp. 55-58). Springer Netherlands.