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Contents

Contributions in: Identity Formation, Emotions, Self-Efficacy, Communications Skills, Co-Op Programs, Social Media, Ethics, Active Learning, PBL, Flipped Classroom, Evaluation, Service Learning, Engineering Design, Ideation, Gamification, Self-Regulation, Team Building, Technical Drawing, Production Engineering, Electronics Engineering, Software Engineering, Biomedical Engineering

Ahmad Ibrahim	1725	Editorial
Nadia Kellam, Karen Gerow, Gregory Wilson, Joachim Walther and Joshua Cruz	1726–1740	Exploring Emotional Trajectories of Engineering Students: A Narrative Research Approach

As the problems that engineers are framing and solving are becoming more complex, it is becoming critical to develop a more nuanced understanding of learning that encompasses more than separate knowing and includes connected knowing. To better understand connected knowing within engineering students, we explore the role of emotion in engineering education. In particular, we attend to the primary research question, how do emotions underpin the narratives of engineering students? This narrative research project involved conducting interviews with 21 undergraduate engineering students from year one to five in their engineering program and from a diversity of engineering disciplines. Our findings suggest a trajectory of emotions including enjoyment of pre-engineering activities, nervousness about core classes, frustration and discouragement with core classes, and finally an overall satisfaction with the educational experience. Two constructed narratives are included to provide the reader with an individualized, contextual, and complex view of the lived reality of emotional trajectories. As engineering educators, the emotions of our engineering students may prove critical as we are preparing engineering graduates to make decisions and to contribute to some of the world's most pressing problems.

Keywords: narrative research; connected ways of knowing; emotions; identity formation

Ann S. Lourens and Liesl S. Pannell	1741–1753	Self-Efficacy of Engineering Students at a South African University—Findings from a Longitudinal Study
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Internationally and nationally, governments, professional body organisations and higher education institutions are launching initiatives to attract and retain women in Science, Technology, Engineering, and Maths (STEM) fields. This article reports on the fourth phase in a longitudinal study aimed at determining the levels of self-efficacy of first-year engineering students at a South African university. It further reports on the impact of co-curricular interventions, presented as a leadership development programme (LDP), that was developed to assist women engineering students (WES) belonging to the Women in Engineering Leadership Association (WELA) to improve their feelings of self-efficacy. It was proposed that these interventions could contribute to WELA members outgrowing their perceived insecurities and negative perceptions and result in well-balanced, self-assured and effective WES, and, in turn, women engineer employees. Participation in and completion of the LDP could thereby improve the retention of women in the field of engineering. To measure the self-efficacy of engineering students, the Self-Efficacy Instrument for Engineering Students (SEIES) was developed. The instrument measured students' perceived motivation and confidence relative to nine identified subscales. The findings of the study indicated no significant differences in the self-efficacy of male engineering students (MES), WES and WELA members, even though the results indicated that WELA members scored slightly higher on most of the subscales measured. Based on this study, it became evident that specifically-designed developmental programmes such as WELA could have a positive influence on the self-efficacy of WES. It is envisaged that this particular research study could lead to further research in the field of WES, with the aim of developing, supporting and retaining women in engineering fields.

Keywords: women engineering; self-efficacy; measurement; retention

Justin L. Hess, Anthony Chase, Grant A. Fore and Brandon Sorge	1754–1767	Quantifying Interpersonal Tendencies of Engineering and Science Students: A Validation Study
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Engineering and science programs seek to foster a wide range of skills among students, including a myriad of professional skills. This study describes the design of two survey constructs that align with many important professional skills, Interpersonal Self-Efficacy and Emotion Regulation. We validate these constructs alongside two prominently used empathy constructs: Perspective-Taking and Empathic Concern. By validating these constructs, this study provides educators with an easily implementable and trustworthy means of ascertaining changes in student growth resulting from their own curricular interventions. As a first step in this study, the constructs' componential structures were defined. Second, confirmatory factor analysis was employed to identify the fit of the factor structures. Third, Pearson bivariate correlations were examined to ascertain relationships between constructs. The results indicate that, with modification, each construct was structurally valid. While Interpersonal Self-Efficacy and Emotion Regulation showed moderate relationships with Perspective-Taking and Empathic Concern, Interpersonal Self-Efficacy exhibited the strongest overall correlations. Constructs componential structures are used to help explain findings and to provide concrete insights into the nuances between phenomena. These findings can facilitate future explorations on engineering and science students' professional formation.

Keywords: confirmatory factor analysis; correlation analysis; emotion regulation; interpersonal self-efficacy; empathy; biomedical engineering; earth science

Rodrigo Fernando Herrera, Juan Carlos Vielma and Felipe Muñoz La Rivera 1768–1775 Impact of Microteaching on Engineering Students' Communication Skills

In current educational processes, it is common to find that students make use of oral presentations with the purpose of exposing a specific topic within the contents of a subject. These types of presentations are also intended for students to learn or improve oral presentation techniques, which generally enrich their communication skills. However, these activities are usually carried out without prior preparation or without well-defined terms of reference, obtaining different results, even within homogeneous groups of students. The objective of the paper is focused on determining the effect of microteaching on engineering students' oral presentation techniques and improve communications skills. To measure its impact, three courses of different levels of the civil engineering career were selected (152 students), separating in each of them two groups of students. Each group of students has been asked to prepare different oral presentations. The first group of students prepared the presentation in a traditional way, while, the second group of students prepared the presentation as if it were a microteaching session. The oral presentations of the groups were evaluated, finding that the microteaching has a favorable impact on the improvement of the communications skills of the students.

Keywords: microteaching; performance of students; oral presentations; engineering students; engineering education

Fabrice Mantelet, Frederic Segonds and Camille Jean 1776–1784 Additive Creativity: An Innovative Way to Enhance Manufacturing Engineering Education

The present paper considers two pedagogical approaches that are mixing creativity tools and Additive Manufacturing (AM) knowledge and evaluates them through the originality and feasibility of the ideas generated as well as the satisfaction of the students. This experimentation was conducted in an engineering school with two groups of postgraduate students during a one-day Project-Based Learning module (PBL). This study points out that closely mixing creativity tools and AM knowledge all along the module gives better results in term of originality, feasibility, and student satisfaction than a more traditional approach disconnecting them. We believe this work can improve existing teaching activities enabling students to gain hands-on experience with additive creativity to better face tomorrow's challenges.

Keywords: additive manufacturing; creativity; innovation; additive creativity

Jacqueline C. McNeil and Alex D. Beebe 1785–1797 Students' Ease, Time, and Coping with Transitions from Co-op to the University

Cooperative educational programs are becoming increasingly popular at engineering schools. Many research studies have reported numerous benefits of students that go on co-op assignments. This research used Wendlandt and Rochlen's framework, combining Stage Theory and transitional theories for students' transition back to the institution after co-op assignments. Students' were surveyed and interviewed after summer, fall, and spring co-op experiences. The study's results are based off 353 responses from surveys. This research shows students' ease of transition, time of transition, and coping mechanisms for transitioning back to the institution after going on co-op assignments. It was found that 33% of students reported they had difficulty transitioning to the institution after co-op assignments. Students' engineering major was significant with ease and time of transition. Sex was significant for ease of transition. Students' engineering program and sex were predictive factors for students' ease of transition. Many students' coping skills were not adequate to deal with the transition back to the institution.

Keywords: co-op programs; transitions; engineering

Edward Berger and Edward Pan 1798–1811 Relationship of Blog and Video Usage Patterns to Academic Performance in Undergraduate Mechanics

This article describes a study about blogging and video technology usage and academic performance in a sophomore mechanics class with enrollment of 120 students. Two conceptual frameworks from learning science inform the discussion of student usage of social technologies and their impact on academic performance. This study employs data collected from 83 consented students on three surveys, technology usage data, and gradebook data to triangulate how students use the technologies, and what academic outcomes they achieve. Students are divided into four student cohorts, broken down by final course grade, and the results explore attitudes, usage, and technology adoption for each cohort. Open response data help describe the complex ecosystem driving student choices about technology usage as well as their academic outcomes. Although generally viewed as helpful, the video resources have a differential impact on student performance across grade bands. Students who earn good grades have better command of their resources (both the technology content, and their peers), using them both efficiently and effectively. Poor students struggle to use their resources effectively and are less active collaborators—either in person or online.

Keywords: social media; worked-example effect; illusion of explanatory depth

Cigdem Turhan and Ibrahim Akman 1812–1821 Integration of Social Media into Engineering Education: A Comparative Study on Perceptions of Faculty and Students

For a number of years, the effects of incorporating social media into education systems has invoked the interest of researchers, academicians and students. Yet, the enthusiasm of students in utilizing social media for learning is met with reluctance on the faculty's part in abandoning the traditional ways of teaching. This study compares the students' and faculty's acceptance of the utilization of social media in engineering education from different perspectives. A survey approach has been used for this purpose and 57 faculty and 85 students from the engineering faculties participated in the study. The research model used was tested using the least square regression technique. The results show existence of significant diversity between the faculty and students in the factors affecting the ethical usage. Concerning the general usage, this diversity exists in only the awareness. These results are expected to provide insight into the issues that act as barriers towards a more open, collaborative and learner-centered higher education platform.

Keywords: social media; engineering education; learning; ethics

Yasser E. Ibrahim 1822–1828 Integrated Evaluation of Teaching Effectiveness: A Case Study

Student evaluation of teaching is considered one of the main elements in assessing the quality and effectiveness of teaching of a faculty member. In most cases, the student evaluation is conducted at the end of the semester to assess all aspects of the course in terms of performance of the instructor and adequacy of the teaching resources. However, student evaluation of a course at the end of the semester may not necessarily reflect the actual performance of the instructor, as it may be affected by other factors such as the grading style of the instructor and the grade expected by the student upon completing the course. In this regard, there is a need to better assess the teaching effectiveness, especially in cases where student evaluation is used as the primary criterion for assessing the faculty member. In this research, an approach was adopted to assess the teaching effectiveness whereby the student evaluation at the end of the course is complimented by another one mid-way as well as classroom observation conducted by the department chair. This approach was tested on thirteen undergraduate courses in the Engineering Management program for different program years. A total number of 346 students participated in the evaluation of teaching effectiveness. The results obtained from the three evaluations mentioned above were compared and the grades of the students in these courses were considered to investigate their effect on the students' evaluations. The integrated evaluation that combines and averages the three evaluations minimizes the misleading effect of traditional SET, normally conducted at the end of the course, which is sometimes affected by the grades expected by students. The whole process gives a clear picture and appears promising as a comprehensive assessment tool of teaching effectiveness.

Keywords: teaching effectiveness; class observation; students evaluation; assessment

Academic success of engineering students in sophomore and junior years have been tied to their successful navigation of the first-year program that typically includes fundamental courses in engineering, programming, and mathematics. While mathematics is a core of engineering, it is often cited as a reason for poor performance in sophomore courses. Addressing this challenge, this paper reports a first-year course to bridge the student knowledge gap between engineering, programming, and mathematics, and demonstrates improved student learning. This new course was designed and taught for two years to 233 students. Student performance in the proposed course and follow-up sophomore circuit analysis course is tracked and analyzed. The effectiveness of the proposed course is validated through an increase in student performance and their perceptions of their learning experience across several academic years. Results showed that students have a better understanding of engineering and programming concepts as evidenced by their performance in the proposed first-year course, and in the follow-up sophomore circuit analysis course. In comparison with control and experimental groups, the number of students who are at risk of failure in Circuit Analysis course has decreased from 32% to 25%. Additionally, the number of students that have the potential to succeed but needs motivation has increased from 17.6% to 27%.

Keywords: active learning; first-year; problem-based-learning; programming efficacy; student perception

Problem based learning is a student-centered pedagogy that often develops some of the skills required of engineering graduates, and an inquiry based laboratory might be an appropriate platform for its implementation. The study described in this paper focused on an inquiry based electronics laboratory offered to junior electrical engineering students at a leading college in Israel. It is the first course where students are exposed to problem based learning and experience how engineers work. In light of the course's unique characteristics, the study examined whether a change in the students' academic motivation has occurred as a result of the course. Fourteen electrical engineering students participated in the study which utilized quantitative and qualitative tools. The study found a decrease (small effect) in the students' relative autonomy index, which had been caused mainly by a decrease in their intrinsic motivation and an increase in their external regulation. This change could be explained by the findings, according to which, the students' need for competence was not met during the course. Possible causes for this lack of fulfillment are the difficulties experienced by most students to adjust to independent learning and to cope with the complexity of the problems studied on the course. Such difficulties are known in the literature as associated with problem based learning, and the paper offers various ways to overcome them.

Keywords: problem based learning; inquiry based laboratory; motivation; electronics laboratory courses

An open issue in Project and Problem Based Learning (PjBL and PBL) research is how the project topic or the “problem” can be selected or constructed systematically. This issue has been investigated in the field of didactics of mathematics and one of the proposed teaching formats is “study and research paths” (SRPs) based on the principles of the Anthropological Theory of the Didactic (ATD). We hypothesize that the methodology for problem design and analysis associated to SRPs can enrich the application of Project and Problem Based Learning in engineering education. We conducted a case study on the design and experimentation of an SRP, implemented in a course of General Linear Elasticity of a degree program in Mechanical Engineering. The results show the potential of the SRP and its associated devices such as the Question-Answer maps to support the a priori design of a proposed project topic or problem. Q-A maps show to be useful both for teachers and students to describe and manage the knowledge involved. The SRP is compatible with the principles of PBL and enriches it with tools to explicitly deal with the design and preliminary analysis of project topics, as well as with the analysis of observed project work.

Keywords: project based learning; course design; study and research path; general linear elasticity

As demand for engineers grows, emphasis is increasingly placed on introductory engineering courses to engage, educate, and retain students. Team-Based Learning (TBL) is a pedagogy that shifts instruction from a lecture-based paradigm to a structured learning sequence that includes individual preparation outside of class followed by active, in-class problem-solving exercises completed by student teams. As part of the individual preparation, students may watch recorded videos of lectures, often at an accelerated speed. While the acceleration of videos has the potential to increase students' learning efficiency, the impact on comprehension is unclear. Two studies were conducted to understand students' viewing habits of video lectures, and to determine whether video acceleration and training can increase students' learning efficiency without significant loss in comprehension. A preliminary study surveyed university students from an introductory engineering course on Decision Support Systems and Computer Programming about their lecture video viewing habits, and found that a sizable subset of students watch videos at an accelerated rate. The main study placed students in one of three groups that practiced watching videos at 1X ($n = 16$), 2X ($n = 16$), and 3X speed ($n = 15$), and then tested comprehension at 3X. Results from the preliminary survey revealed that approximately 30% of the students watched the preparatory videos at accelerated speeds in their introductory engineering course. Results from the main study showed that participants were able to accelerate videos up to 2X and with practice, able to maintain the same comprehension levels as participants watching at normal (1X) speed, whose comprehension levels decreased over time. However, 3X acceleration lowered comprehension, regardless of practice at higher speeds.

Keywords: team-based learning; video acceleration; flipped classroom; active learning

The flipped classroom has been introduced to promote collaborative learning and higher-order learning objectives. In contrast to the traditional classroom, the flipped classroom has students watch prerecorded lecture videos before coming to class and then “class becomes the place to work through problems, advance concepts, and engage in collaborative learning”. In this paper, the active flipped learning was applied in engineering mechanics class to combine flipped classroom with active learning in order to establish an active flipped learning (AFL) model, aiming to promote active learning. Eighty sophomores engineering students, most of whom are African-American students, participated the active flipped learning. To compare the effect of AFL, the traditional teaching was applied in the first half semester and pre- and post-tests were used to evaluate their learning performance. After the mid-term exams, five flipped models were applied to five topics. All of the students attended these flipped models. Pre- and post-tests were conducted for the AFL. The survey results were analyzed to compare students' learning self-efficacy and satisfaction between the traditional and the active flipped classroom. Compared to the traditional classroom, students' learning motivation is obviously enhanced in the AFL classroom, with students' interest, curiosity and learning initiatives in curriculum promoted, intrinsic goal orientation further strengthened, in which students tend to have less extrinsic goal orientation and lower test anxiety than the students in the traditional classroom, but with improved control beliefs and self-efficacy for learning. In the traditional classroom, students use more rehearsal and elaboration strategies, while in the flipped classroom, students use more organization strategies and prefer to use critical thinking strategies to raise relative questions about teaching content and video materials. Students in the AFL model use more strategies of resource management, such as time and study environment, effort regulation,

peer learning, and help seeking than in the traditional model. In comparison of different student groups, the AFL model effectively improves students' motivation in both long and short learning time groups, but the effects are not obvious on the low GPA students. From the perspective of gender, the AFL model helps to increase the male students' learning motivation, while female students use more learning strategies in task value, control belief and self efficacy in traditional model. Therefore, the instructors should pay more attention in improving the learning motivation and effectiveness of low GPA group and female students in the flipped classroom. In summary, the AFL model, by taking advantage of advanced technology, is a convenient and professional avenue for engineering students to strengthen their academic confidence and self-efficacy in Engineering Mechanics by actively participating in learning and fostering their deep understanding of engineering statics and dynamics.

Keywords: active flipped learning; engineering mechanics; the flipped classroom; the traditional classroom

Aline Cazarini Felício and **Jorge Muniz Jr** 1888–1896 Evaluation Model of Student Competencies for Discussion Forums: An Application in a Post-Graduate Course in Production Engineering

This study aims to propose a competency assessment model for students in online discussion forums, using the Rubrics scoring tool and the Bloom's Taxonomy to define evaluation feedback. First, the competencies to be evaluated in on-line discussion forums for theoretical courses in engineering courses were identified, then, the curricular guidelines of the engineering courses and the competencies identified in the literature by the research authors were considered. A questionnaire was developed with experts to evaluate the proposed model, comparing it with other models of skills assessment already used by them. The proposed model was evaluated by the specialists, with the average scale of more than 4 points for all items. All items were better evaluated when compared to models commonly used by the experts. The overall general index of instrument validity is 90%. It used as a pre-test of the model in two classes of a discipline of a postgraduate course in production engineering of a university of the interior of the state of São Paulo. Three lecturers evaluated the forums of the referred classes according to the proposed model to verify the reliability of the same. The reliability of each item of the proposed model was greater than 82%. The research contributes to the engineering education literature as it provides a new way of assessing competencies in discussion forums.

Keywords: competency evaluation; rubrics; Bloom's taxonomy; discussion forums

Sung-Hee Jin 1897–1909 Collaborative Instructional Models for Teaching Community Service to Engineering Students

This study aims to develop instructional models for service learning in engineering education and verify their effectiveness using a formative research methodology. Two types of instructional models were developed through literature review: (1) engineering design-based service learning and (2) instructional design-based service learning. This study examined the effects and improvements of instructional models for service learning by applying the models to the service-learning courses. Twenty-six students participated in fall 2015 and 64 in fall 2016. The following variables were measured to determine effectiveness: study time and study efforts for service learning, learning outcomes, learning satisfaction, student empathy, engineering design skills, satisfaction with community service activities, and volunteer motivation. Student reflection journals were analyzed to identify the strengths, weaknesses, and improvements of instructional models. The results of this study show that these instructional models help students guide service-learning activities and achieve their learning goals. Specific guidelines have been suggested for designing service-learning activities, taking into account the improvements that students have recommended.

Keywords: service learning; engineering design; community engagement; service activity; community service

Greg J. Strimel, Eunhye Kim, Scott R. Bartholomew and **Diana V. Cantu** 1910–1929 Examining Engineering Design Cognition with Respect to Student Experience and Performance

This study investigated the design cognition and performance results of secondary and post-secondary engineering students while engaged in an engineering design task. Relationships between prototype performance and design cognition were highlighted to investigate potential links between cognitive processes and success on engineering design problems. Concurrent think-aloud protocols were collected from eight secondary and 12 post-secondary engineering students working individually to design, make, and evaluate a solution prototype to an engineering design task. The collected protocols were segmented and coded using a pre-established coding scheme. The results were then analyzed to compare the two participant groups and determine the relationships between students' design cognition, engineering experience level, and design performance. Significant differences between participants with secondary engineering experiences and those without were found in regards to the amount of time various cognitive processes were employed to complete a design task. For the given design scenario, students with secondary engineering experiences achieved significantly higher rubric scores than those without. Improved design performance was also found to be significantly correlated with more time employing the mental processes of *analyzing*, *communicating*, *designing*, *interpreting data*, *predicting*, and *questioning/hypothesizing*. Important links between educational experiences in engineering design, prior to college, and student success on engineering design problems may indicate necessary shifts in student preparation.

Keywords: engineering; design; cognition; performance

Radul Milutinović, Biljana Stošić, Mladen Čudanov and **Velimir Štavljanin** 1930–1938 A Conceptual Framework of Game-Based Ideation

The ideation process has a great impact on the success of innovation projects, given that innovation is development and implementation of new ideas. Ideation is often identified as a key component of the "fuzzy front end", and recognized as one of the highest leverage points for a firm. Today's democratizing innovation has led to a situation that the best ideas for new products and services no longer originate only from companies' staff. Instead, they come from almost anywhere and anyone. By opening up the ideation phase in the digital era, companies actually open their doors to external experts and solution-providers, searching for new partners and new technologies to incorporate into their existing products and services. Having this in mind, the goal of this study is to propose an integrated approach to collaboration in the phase of ideation, which would be in line with the concept of open innovation and supported by an appropriate business model. Accordingly, this paper enables understanding of how game-based ideation fits into innovation models; how games are incorporated into ideation processes; how games affect creativity and the nurture of ideas; how to develop a sustainable business model for this concept; and how to implement it in a real-life business environment.

Keywords: ideation; gamification; online platforms for open innovation; innovation community; business model

Iris Bento Da Silva and **Oswaldo Luiz Aghostinho** 1939–1950 A Strategy for Teaching and Learning Technical Drawing

The present study describes a strategy for teaching and learning technical drawing, by enhancing students' skills in spatial perception. This strategy was proposed by means of literature review, which identified the strengths and weaknesses of technical drawing concepts up to date. This study allowed to construct a framework in which contains a general guide to address this strategy. It is a method in which students play an active role, initially manually sketching and on the drawing board before proceeding to the computer. The manual drawing was supported by origami systems, and Piaget's pedagogy to understand the space-plane relationship. From another point of view, it was used the problem-based learning on the drawing by computer to draw components that were drawn by hand. The research was conducted over two years in the course of industrial engineering. Purposive sampling was used to select 32 students participating in this research. The principal findings of this research concern the evolutionary learning of the orthogonal projections that enable students to draw objects in the plane that they first saw in the space.

Keywords: technical drawing; strategy; learning; spatial perception; framework

Self-regulated learning or self-regulation is defined broadly as the interaction between the learner, problem, and learning environment. A self-regulated learner tends to be more successful academically. Furthermore, lack of employing regulatory strategies may lead to a failed problem-solving attempt. Research suggests that self-regulation is a recursive, dynamic, complex, and contextual activity. The objective of this research was to understand the influence of contexts in students' engineering design process during a Capstone design course. We recruited two groups, 18 students in total, from the Biological Engineering Department and another two groups from the Mechanical and Aerospace Engineering Department at Utah State University, USA. All groups were working in a fully funded senior Capstone design course. We collected and analyzed various qualitative data using Dym & Little's design process and Butler & Cartier's self-regulation frameworks. The primary qualitative data, which was from the participants' design journal, were segmented and coded by four engineering designers. Our findings suggested that the participants' self-regulation during the design process was influenced mainly by the nature of the design process itself, the nature of the project in the respective discipline, and the participants' experience.

Keywords: self-regulation; design process; in-context strategies

A new criteria-driven team building software is designed specifically for Computer Science or Software Engineering students. This research intends to find whether the cohesiveness in the student capstone project teams improves when the teams are built using the proposed courseware, named *Psychographd* as compared to when teams are built through random assignment. The criteria for the software are based on the findings of the doctoral thesis of the lead author. The teams are built on the basis of the results of criteria-centric self-evaluation questionnaire built into the software, which each student will have to answer so as to be considered a candidate for a team. Two hundred students had participated in this research; out of these 200, 100 students had used *Psychographd* for forming teams and the other 100 students had formed teams through random assignments. Cohesion is measured and compared in the teams that were formed using the *Psychographd* and those that had not used *Psychographd*; for measuring the cohesiveness in teams, modified Group Environment Questionnaire is used. A sharp increase in the cohesion among the team members is reported for the teams that were formed using the *Psychographd*. Some unique features of the *Psychographd* are (a) 128 research based criteria for team formation (b) elimination of the chances of occurrence of "orphan student" problem (c) multiple team alternatives for each student.

Keywords: CATME; team-maker; team building; criteria; software engineering

Despite emphasis on sustainable development by a variety of international organizations including the accreditation organization ABET, many undergraduates conceptualize sustainability in more narrow terms than internationally accepted definitions of sustainability and sustainable practice. This study examines the breadth and depth of student perceptions of what sustainability is, their beliefs regarding sustainability, and how they can and will contribute to a more sustainable future. Differences and similarities between engineering students and those outside of engineering in business, education and environmental majors are highlighted. Responses to three short answer questions from a survey administered to 228 engineering undergraduates and 186 undergraduates in other majors are thematically coded and analyzed qualitatively. Consistent with previous studies, many engineering students (almost 50%) and a majority of students outside of engineering (over 60%) operationalize sustainability as an environmental issue, neglecting aspects of social and economic equality that are widely recognized as being essential pillars of sustainable development. As professionals in their chosen profession, students see their most likely contributions to sustainability as reducing waste through recycling and reuse, making more efficient use of resources, and using renewable energy. When asked to identify what they are least likely to contribute to in terms of sustainability over their professional lives, students again point to reducing waste and making efficient use of resources. However, many also see contributing to public advocacy and policy change as well as creating sustainable products and structures as areas where they are unlikely to contribute during their careers. These results suggest that many students may misperceive sustainability as a vague concept that does not lend itself to action or that sustainable development is only an issue of environmental protection without regard to the promotion of social and economic equality.

Keywords: engineering education; environmental impact; sustainability; sustainable development; student beliefs