

Contents

**Contributions in: PBL, Self-Regulated Learning, Engineering Design,
Leadership, Women in Engineering, Artificial Intelligence, Mastery Learning,
Building Information Modelling, STEM, Self Efficacy, Peer Learning,
Engineering Competitions, Assessment, Teacher Autonomy, Spreadsheets,
Professional Identity, COVID-19, First Year Engineering, Mental Health,
Graduate Students, Empathy, Rural and Indigenous Students, Online Learning**

Editorial 1307
Ahmad Ibrahim

**The Relationship Between Self-Regulated Learning Behavior and Attitudes in Project-Based Learning Classes:
A Case Study** 1308–1317
Yu-Sheng Lin and Yu-Hsuan Lin

This study aims to explore the relationship between students' learning behavior, perceptions of project-based learning (PjBL), and learning outcomes in the context of engineering education. The study presents a case study of PjBL implementation at a private university in Taiwan, offering valuable insights from the instructor's perspective. A survey was conducted with 209 students in PjBL classes and 50 students in non-PjBL classes, focusing on six key learning indicators: learning attitude, participation attitude, academic integration, academic conscientiousness, application attitude, and satisfaction. The findings reveal that students' self-regulated learning attitude has a significant impact on their satisfaction and application attitude, mediated by their participation attitude, academic integration, and academic conscientiousness. The study provides empirical evidence supporting the effectiveness of PjBL in enhancing self-regulated learning, student engagement, and satisfaction levels. Moreover, it suggests that fostering a self-regulated learning attitude can motivate students to actively participate in the learning process, enhance their academic integration skills, and ultimately influence their satisfaction and application attitudes. This study underscores the potential of PjBL in improving students' employability and equipping them with the necessary skills to tackle challenges in the engineering profession. The insights gained from this research can inform educational practices and curriculum design to promote effective project-based learning experiences in engineering education.

Keywords: project-based learning; self-regulated learning behavior; mechanical engineering education; course implementations; Taiwan

**Design of Arduino Uno Electronic Module for Digital Measurement of Rotational Speed in Agricultural Machinery
Actuator Systems** 1318–1329
Naji Mordi Naji Al-Dosary, Abdulrahman Ibrahim A. Alzughaihi and Ahmed Mahmoud Zeyada

Many agricultural machines and equipment and their components depend on rotatory power. Measuring the rotational speed and properly controlling the rotating parts are necessary for enhanced machine operation. A module that is capable of accurately measuring the number and rate of revolutions of rotating parts of machines is an important instrument. This paper describes the design, assembly, and deployment of an Arduino digital speed meter. It is an excellent mechatronics instructional project for undergraduate students, and its application as an efficient and cost-effective method to measure rotational speed on agriculture machinery which provides the engineering student with experience in all stages of system development. This meter is a system-on-electronic-module (SOEM), and due to its simplicity and low development cost, it is an economical and easily deployed computerized unit. The basic circuit of the Arduino digital speed meter consists of an Arduino Uno board, an optical infrared accelerometer (IR) sensor based on the return of projected infrared light from the rotating part of the machine, and a digital display to show the speed of the rotating part in revolutions per minute (rpm). An experiment utilizing these components to evaluate the rotational speed of the PTO shaft provided highly accurate measurement results comparable to the accuracy of a commercial digital tachometer. The average differential between the project developed module and a commercially available tachometer was only 4.47%. Considering the cost differential these results are very commendable. This innovative module is a cost-effective solution for hands-on instruction in mechanism design and development; it is a practical application for rapid on-site evaluation systems, while offering a simple economical method to measure agricultural power output.

Keywords: Arduino Uno; IR sensor; LCD digital display; relative error; revolution per minute; Tachometer

The Glue in Leadership: Investigating how Women Leaders in Engineering Education Value People and Connections 1330–1342
Sophia Vicente, Cheryl Beauchamp, Janice L. Hall, Holly M. Matusovich, Stephanie G. Adams and Cheryl Carrico

The experiences and strategies of women faculty serving in leadership roles is understudied in the field of engineering education. This study begins to document how women leaders in engineering education engage in leadership using the Kern Entrepreneurial Engineering Network's (KEEN) Entrepreneurial Mindset (EM) as a lens. We conducted a thematic analysis of a series of artifacts associated with a workshop that aimed to generate conversation on leadership among a group of 14 women holding a variety of leadership positions in engineering education exploring how women leaders discussed their leadership roles. We also conducted in-depth interviews with 10 of the participants. We found that the women leaders in our study emphasized the importance of people in regard to connections. Within connections people were information sources to obtain insight and were considered when managing and assessing risks. The findings expand upon the current conception of connections as described in the EM framework. As we increase our knowledge of women's experiences and strategies in leadership in engineering education, it will improve our ability to recommend methods for establishing, growing, and using connections within the field.

Keywords: engineering leadership; women in engineering; leadership development; engineering education

Integration of Artificial Intelligence and Machine Learning Content in Technology and Science Curriculum 1343–1357
Shao-Hsun Chang, Kai-Chao Yao, Cheng-Yang Chung, Sheng-Chieh Nien, Yao-Ting Chen, Wei-Sho Ho, Teng-Chiao Lin, Fu-Chi Shih and Tung-Chin Chung

Artificial Intelligence (AI) and Machine Learning (ML) are required subjects of Information Technology Literacy in a new curriculum required by the Ministry of Education in Taiwan requires. A few people have discussed the integration of teaching methods and curriculum design, the difficulties of teaching practice, and the assessment of the approach. This study aims to

explore. The impact of the integration on students' leaning satisfaction, problem-solving ability, and interest in taking further AI courses. Participating students were divided into an experimental group with 101 students and a control group with 99 students. MANCOVA statistics were used to analysis the data collected related to academic achievement. The results showed that the scores of students in all aspects examined with the curriculum integration of AI, Machine Learning, and Big Data were significantly higher than those of the control group.

Keywords: Artificial Intelligence (AI); Teaching Effectiveness; Curriculum Integration; Technological Literacy; Machine Learning (ML); Big Data

A Systematic Literature Review for Mastery Learning in Undergraduate Engineering Courses

1358–1385

Carlos L. Pérez and Dina Verdín

Implementing mastery learning in an undergraduate engineering course can be cumbersome, requiring instructors to restructure their evaluation and grading practices significantly. There is a lack of coherent evidence on the effects of mastery learning on undergraduate engineering students and a lack of understanding of instructors' perspectives on mastery learning. Therefore, the four objectives of this study were (1) to provide educators and researchers with an overview of how mastery learning has been applied in undergraduate engineering courses, (2) to understand the effect mastery learning has had on students' learning, (3) to understand students' experiences, and (4) document reflective feedback reported by instructors who implemented mastery learning. We employed a systematic literature review methodology to address these objectives. We surveyed eight databases for published articles. Our systematic literature review focused on studies that applied mastery learning in undergraduate engineering courses in the United States; 23 articles were reviewed and synthesized. Mastery learning was implemented through many approaches, but all implementations followed the core features of specifying learning objectives, using designated evaluation metrics to measure mastery, and providing multiple retake opportunities. The most common implementations were in Statics, Dynamics, and Thermodynamics courses. Students' final exam grades were not representative of the effectiveness of mastery learning. Yet, there was evidence that mastery learning positively affected student learning when cumulative course grades or homework grades were considered. Students' evaluation of their mastery learning experience was mixed. Five studies reported that many students learned better through mastery learning. A robust evaluation of students' experience in a mastery learning course could be ascertained better through standard survey questionnaires. After analyzing the instructor's reflective feedback, we identified 16 benefits and four limitations. We conclude the systematic review by providing recommendations for instructors considering implementing mastery learning in their undergraduate engineering courses.

Keywords: mastery learning; mastery grading; alternative educational approach; systematic literature review; engineering education

Closed-Loop Management System for Design of a Building Information Modeling Curriculum to Meet Industry Requirements

1386–1399

Xuefeng Zhao, Wangbing Li, Qiwen Luo, Jiaqi Liu, Zhe Sun, Jun Sun, Heling Zhu, Chun Huang, Mengxuan Li and Weiyu Ji

Building Information Modeling (BIM) has been one of the most significant and widely adopted advanced technologies in the architecture, engineering, and construction (AEC) industry in recent years. Unfortunately, the current BIM curriculum in colleges does not adequately prepare students for real-world AEC industry practices. Besides, numerous concerns regarding the competency requirements of the AEC industry for BIM practitioners and the targeted design of teaching content of BIM curricula, etc. remain unanswered. To enhance the preparation of BIM students for real-world AEC work, this study collected 280 questionnaires from 27 administrative regions in China and conducted data analysis to assess the disparity between the competency requirements in the AEC industry and the existing BIM curriculum in colleges. Additionally, this study presents innovative theories, namely directed closed-loop and undirected closed-loop theories, derived from the closed-loop management system. These theories are effectively integrated into college BIM education as project closed-loop and content closed-loop theories. It validates the effectiveness of the curriculum design through BIM students' academic performance. Results demonstrate that the closed-loop management design of the BIM curriculum can better match the AEC industry's competency requirements and that BIM students will better adapt to real-world AEC work.

Keywords: BIM education; college education; engineering education; closed-loop management

Evaluation of Various Aspects of the 11th Grade Engineering Curriculum: A Mixed-Methods Study

1400–1416

Yousef F. Alfarraj and Adel R. Althubiani

This study explored a twofold evaluation of the engineering curriculum from the perspectives of teachers, supervisors, and field experts. It evaluated the extent to which certain curriculum elements were achieved in the curriculum and the level of perceived self-efficacy of the curriculum's teachers and supervisors. The study adopted a mixed-methods approach utilizing a sequential explanatory design. This design involved two semi-structured questionnaires that were applied to 112 teachers and supervisors (62 males and 50 females) while a semi-structured interview was applied to 12 teachers and supervisors as well as to seven engineering experts, both academic, i.e., university professors, and professional. The results revealed that the curriculum elements and the perceived self-efficacy were achieved on a "medium" level with (66.8%) and (67.2%), respectively. It was also revealed that there were no statistically-significant differences attributed to the gender variable. Furthermore, the study identified the advantages and disadvantages of implementing the 11th grade engineering curriculum of the Pathways System. Some of the main advantages were familiarizing students with the concept of engineering and its fields as well as introducing basic computer software. The disadvantages, however, were outlined as the lack of specialized teachers; the weak sequencing between the course and its prerequisite (physics); the inconsistency between the course description and its content; and the insufficiency of the practical part of the course and the necessary equipment for students to engage in engineering practices. As a result, the curriculum was found to be lacking in preparing students for the job market or the next educational stages including the preparatory year of university.

Keywords: engineering and computer science pathway; engineering curriculum; STEM; curriculum elements; self-efficacy

Impact of Peer Learning on the Academic Performance of Civil Engineering Undergraduates: A Case Study from China

1417–1433

Bin Sha, Xiaoyu Guo, Qinfang Zhong and Houren Xiong

Structural mechanics is a demanding but very important professional basic course for civil engineering undergraduates. In this study, peer learning was applied to a structural mechanics course through specific methods such as sequential teaming method, randomly selected collective scores method, bonus points, and penalty points. A quasi-experimental study compared the treatment group and the control group using a mixed qualitative and quantitative research method consisting of interviews and questionnaires. The results showed that compared to the control group, peer learning improved the final exam score by 8.2 points and reduced the failure rate by 15.2%. However, the treatment group did not have a higher evaluation of classroom and learning gains than the control group. Peer learning can also play a role in character education, as it improves students' problem-solving skills, communication skills, teamwork skills, time management skills, and teacher-interaction skills. Social avoidance and personal preferences severely restrict more active participation in peer learning, and targeted improvement measures will be implemented in the future.

Keywords: qualitative and quantitative research; cooperative learning; character education; academic performance; psychometric measurement

Lin Yuan and Qing Lei

Engineering competitions have emerged as challenging and motivating forms of practical educational activities worldwide. However, differences exist in the perception, development and operation of engineering competitions across different cultural contexts. Guided by Activity Theory, this study constructed a basic activity model for engineering competitions, focusing on two dimensions: resource flow and rule constraints. A comparative case study was conducted to examine engineering competitions in China and the United States from a horizontal perspective, considering the two dimensions. The findings reveal shared similarities in the emphasis on engineering design competitions and consistent evaluation factors for similar types of competitions. As for the differences, engineering competitions in China are predominantly driven by national policies, with a primary focus on the electronic information field. Participants and communities prioritize competition results, which has led to a well-established institutionalized resource flow system, high participation rates, and extensive involvement in universities. However, excessive motivation can sometimes lead to utilitarian problems. Conversely, engineering competitions in the United States are primarily driven by engineering professional societies and encompass a broader range of fields. Participants and communities prioritize competition processes, but the attitudes towards engineering competitions vary among universities and competitions. The non-institutionalized resource input may result in unequal access to competition opportunities, especially for financially disadvantaged students. In conclusion, recommendations for optimizing engineering competitions as a tool for enhancing the engineering students' abilities and professional development were given.

Keywords: engineering competition; Activity Theory; engineering education; comparative case study

A Systematic Review of PBL Literature: In Search of Implementation Guidelines for Engineering Situated Problem Design, Facilitation, and Assessment

1450–1463

Andrew Olewnik, Amanda Horn, Laine Schrewe and Scott Ferguson

Problem-based learning (PBL) is recognized as a pedagogical approach that is well-suited to preparing engineering students for the realities of the profession, but there are persistent implementation challenges that serve as barriers to broad adoption. This systematic literature review focuses on three facets of PBL – design, facilitation, and assessment – in search of operational guidelines for engineering faculty considering a transition to PBL. Findings led to two broad conclusions. First, there is a need for research on methods to support engineering faculty in problem design. Second, while current research provides thorough support for PBL facilitation and suggestions for assessment, there is a need for additional research to evaluate the efficacy of the various models of facilitation and assessment suggested by the literature.

Keywords: assessment; facilitation; problem-based learning; problem design

Relation between Teacher Autonomy Support, Student Self-Efficacy, and Behavioral Engagement: A Moderated Mediation Model in Project-Based Team Learning

1464–1477

Shaoyan Wu, Bixuan Zhang and Tingting Cao

Team learning is a widely used teaching approach within the realm of engineering pedagogy. However, there hasn't been much discussion of the teacher's function as a designer of the learning environment, particularly in terms of promoting student engagement in team-based learning. To fill this gap, this study creates a self-determination theory-based model of how teaching strategies and task types affect students' behavior engagement in team learning conditions. An empirical study of 255 questionnaires from Chinese students majoring in Engineering Management and Engineering Cost was conducted. The findings showed a beneficial association between teacher autonomy support and student behavioral engagement, with self-efficacy serving as a partial mediating factor. Additionally, the study demonstrated that exploratory learning significantly moderated the link among teacher autonomy support and student self-efficacy. This investigation broadens the study context to team-based learning, combining teachers and students to build an effective bridge between teaching and learning. Furthermore, the study underscores the significance of matching teaching styles with task characteristics in project-based team learning, providing valuable insights for addressing undesirable behaviors like free-riding.

Keywords: teacher autonomy support; self-efficacy; behavioral engagement; exploratory learning; self-determination theory

Investigating Factors Influencing Spreadsheets Competency of Undergraduates: Domain-Based vs Tool-Centered Learning Approach

1478–1488

Lena Djordjević Milutinović, Lazar Raković, Radul Milutinović and Marton Sakal

Spreadsheets have become an indispensable part of the business world, and it is crucial that they are integrated into the corresponding study programs' curricula. However, despite their widespread use in organizations and higher education courses, there are still some challenges associated with their utilization. The risk of using spreadsheets can be singled out as very significant, and it is directly conditioned by the quality of the spreadsheet model. Although these are well-known issues, their interconnection with learning-approach has not been sufficiently explored. This paper presents the research on the interdependence of the risk of use and the quality of the spreadsheet model on the one hand, and the learning approach (tool-centered vs domain-based), on the other hand. The participants in the study were from two universities, fourth-year students of Business Informatics and Operations Management students. Both groups of students have taken courses that involve working with spreadsheets. The spreadsheet course for Business Informatics students was based on a tool-centered learning approach, while Operations Management students undertake more domain-based learning approach. Furthermore, Business Informatics students took the spreadsheet course after several programming and database courses, and therefore had a solid IT background. Operation management students took multiple courses related to problem-solving, engineering, and quantitative methods. The total number of participants was 60. Contrary to the assumption that students with greater IT background would create higher-quality spreadsheets, the results indicate no significant difference in quality between students with and without an IT background. Additionally, domain-based learning did not result in better-quality spreadsheet models. The study also explored students' attitudes toward spreadsheet risks. Students who were more familiar with spreadsheet risks, best practices and model development frameworks, created higher-quality spreadsheets with fewer errors. Consequently, incorporating lessons related to spreadsheet risks and best practices in spreadsheet courses can positively impact the quality of students' spreadsheet models. Finally, the study highlights the need for end-users and organizations to be aware of the risks that spreadsheet applications can pose in business decision-making. This paper should point out the importance of necessary improvements in curriculum of spreadsheet courses since it is evident that the mistakes have been made in training spreadsheet end-user developer for more than 30 years.

Keywords: spreadsheets courses; spreadsheet models; spreadsheet errors; higher education institutions

Impact of Practical Teaching for the Professional Identity Development of Engineering Students

1489–1498

Fusheng Zhu, Hongjie Zheng, Yujia Huang, Fei Tang and Ying Wang

Professional identity education is a primary goal of university courses. While existing studies on the cultivation of professional identity have focused on theoretical education and didactic teaching by case models, this study explores the influence of practical teaching on the professional identity development of engineering students using primary data from a questionnaire survey. The study randomly selected 378 freshmen majoring in electrical engineering at a Chinese university and evaluated their professional identity after participating in social practice teaching courses using existing questionnaires, of which 367 were valid. To clarify the benefits and effects of practical teaching, this study also investigates practice effectiveness and practical teaching with a self-administered questionnaire. Finally, a data model is constructed to explore the mechanism of the role of social practice teaching methods on professional identity. The results show that (1) the social practice teaching method has a significant positive enhancing effect on the professional identity of engineering students; and (2) social practice teaching effectiveness has a significant positive

mediating effect on professional identity through the mediating variables task drive, hands-on ability, and character function, while effect feedback shows a weak positive effect.

Keywords: engineering students; professional identity; social practice teaching; mediating effect

Grades and Grade Anomalies Before, During, and After Remote COVID-19 Instruction for First-year Engineering Majors: Overall Trends and Gender Inequities 1499–1512

Alysa Malespina and Chandralekha Singh

In this research we use grades and “grade anomalies” to investigate student performance before, during, and after the period of COVID-19 remote instruction in courses for first-year engineering majors. We also use these measures to investigate gender equity in these courses. We define grade anomaly as the difference between a student’s grade in a course under consideration and their grade point average (GPA) in all other classes thus far. If the grade in a class is lower than a student’s GPA, we say they have a “grade penalty”, and if it is higher we say they have a “grade bonus”. We investigated all required courses for this group of students and found that the Engineering and English Composition courses tended to have grade bonuses, while Mathematics, Physics, and Chemistry courses tended to have grade penalties. We broadly find that both grades and grade penalties showed positive trends during remote instruction and deteriorated after remote instruction. We also find that there were many more gender differences in grade anomalies than in grades. We hypothesize that women’s decisions to pursue STEM careers may be affected more by the grade penalty received in required science courses than men’s because their grade penalties are often larger during all time periods studied. Furthermore, the grade penalty measure can be easily computed by institutions concerned with equity.

Keywords: gender; equity; grades; grade penalty; grade anomaly; remote instruction; COVID-19

Overlapping Coping Mechanisms: The Hidden Landscapes of Stress Management in Engineering Doctoral Programs 1513–1530

Gabriella M. Sallai, Kanembe Shanachilubwa and Catherine G. P. Berdanier

As many as 70% of engineering graduate students in the United States consider departing their master’s and doctoral programs at any given time. This strong consideration for attrition relates to the chronic stress these students experience in graduate school and the engineering discipline’s normalization of stress in the name of academic rigor. The ongoing mental health crisis in higher education in the United States leads us to consider what stressors do engineering graduate students have to contend with and how are they coping with these stressors to improve their experiences and remain in their programs. In this work, we modify the COPE Inventory to be applicable to a graduate student context and explore these students coping mechanisms. Through semi-structured interviews with $n = 42$ engineering graduate students, content analysis, and an abductive approach, we determine the stressors including advisor relationship, research, department, questioning departure, negative mental health, and systemic stressors that our participants experience and the variety of coping mechanisms and coping styles they use to reduce these stressors. Results show that participants often combine coping mechanisms to manage their stress. The coping landscapes in this study visualize these combinations. The widespread use of multiple coping mechanisms at any given time indicates that engineering graduate students are actively trying to reduce their stress and that they must work hard doing invisible labor to persist through graduate school. Teaching students how to establish open communication with advisors and faculty and promoting support structures for students to know they are not alone in their experiences would greatly benefit engineering graduate students and improve retention and persistence in graduate programs.

Keywords: engineering graduate students; attrition; coping; mental health; stressors

Comparing Empathy Between Male and Female Undergraduate Engineering Students 1531–1541

Justin L. Hess

This multiphase quantitative study explores variation in how male and female engineering students empathize. Phases 1 and 2 compare male and female engineering student responses to two empathy constructs: perspective-taking and empathic concern. Phase 3 explores differences based on post-course survey reflections representing how male versus female first-year engineering students perceived using empathy in their curricular design projects. Students were from a biomedical engineering program in a large urban university in the USA (Phase 1) and first-year engineering students at a large rural university in the USA (Phases 2 and 3). Results show that female engineering students reported greater empathic concern than male students. First-year engineering female students also reported greater perspective-taking tendencies. First-year female engineering students reported empathizing during engineering design projects to a greater extent than male peers, including both cognitive and affective empathy types. Taken together, findings suggest there is a gendered nature of empathy in engineering, and thus it is important for engineering instructors to consider variation between male and female students’ use of empathy when seeking to foster it in their curriculum. When organizing engineering design teams, instructors may capitalize on the empathic strengths of female students to ensure effective stakeholder integration and responsiveness.

Keywords: empathy; engineering design; quantitative; gender

Designing Elementary Digital Game-based Engineering Interventions for Rural and Indigenous Students 1542–1555

Amanda Obery, Nicholas Lux and Paul Gannon

Investigating how elementary students see themselves as engineers will help researchers and educators more clearly develop effective engineering education interventions. With early interventions, students can begin the process of developing an engineering identity, and possibly diversify the field in the future. This study investigates how elementary students from rural contexts and on an Indigenous Reservation view engineering as a basis for the design of identity-congruent digital games. Data was collected through surveys and drawings and used to create a framework for early engineering education interventions using identity-congruent digital games. Results suggest a nuanced understanding of engineering identity being possibly influenced by contextual factors such as gender, rurality, and indigeneity. These findings provide insight into how educators and digital game developers might create engineering interventions based on how students in rural and Indigenous contexts view engineering.

Keywords: engineering education; digital game based learning; elementary; identity based motivation; rural; indigenous

Perceived Task Value of Engineering Undergraduates During COVID-19 Pandemic 1556–1565

Jonathan D. Anderson, Oenardi Lawanto, Brian Mark Crookston and Wade H. Goodridge

The Corona Virus-19 globally disrupted education severely in March 2020 and has continued through 2023. It has had far reaching impacts on engineering education and yet it provides an opportunity for researchers to understand this type of event’s impact so that we can be well equipped for potential future disruptive events. This paper describes a novel study that used an online learning value and self-efficacy scale survey to collect data on perceived task value and student self-efficacy during a forced transition to online learning in a western university’s sophomore level engineering mechanics course and a junior level hydraulic engineering course. This was an initial study that was investigating these constructs using the Online Learning Value and Self-Efficacy Scale. Data was additionally collected a year later with new participants in the same classes now taught in a traditional face-to-face fashion. Comparative results indicate that students who started in face-to-face classes preferred and felt they could do better in the face-to-face components more so than the online components, and that students who were earlier in their academic career were more likely to have higher ratings of self-efficacy in a forced online learning environment than students enduring the transition later in their academic career.

Keywords: task-value; online learning value; pandemic; Covid-19; OLVSES; engineering

Kristin Sandberg, Jean Mohammadi-Aragh, Jenna Johnson, Shane Brauer and Deborah Eakin

Engineering needs in the workforce continue to rise. Filling these needs requires recruiting future engineers to colleges and universities. However, this is not an easy task. One area that has been explored in the attempt to reach students for engineering is offering engineering or STEM classes to K-12 students. This research investigated engineering classes offered specifically at the high school level. These courses and factors related to them were analyzed for relationships with engineering recruitment and discipline selection. Historical data was used to study the effect of high school engineering courses on engineering recruitment. The availability of engineering courses in Mississippi high schools was analyzed with the percentage of graduates from that high school who entered the largest engineering school in the state. A nationwide sample of current undergraduate engineering students was used to study the influence of high school engineering participation on engineering discipline selection. Analysis found significant relationships between the availability of high school engineering courses and engineering school recruitment. Engineering availability correlated to a higher percentage of students entering engineering. Participation in these engineering courses was also significantly associated with choice in certain engineering disciplines.

Keywords: engineering recruitment, K-12 engineering, pre-engineering, high school engineering, engineering major

A Comparative Quantitative Study of Engagement, Learning Environment, and Educational Outcomes of High-Achieving Engineering Students*Ibukun Osunbunmi and Ning Fang*

Studies have shown that students' college experience and involvement in academic and non-academic activities are pivotal in determining what educational outcomes they attain in college. However, little is known about how high-achieving engineering students' college experience compares with the national norm. This paper investigates the extent to which the two groups differ in terms of the quality of effort expended, college environmental emphasis, and attainment of the desired educational outcomes. It is shown that high-achieving engineering students spend more time and invest more quality effort in academic tasks than the national norm. High-achieving engineering students also make more significant progress toward the desired educational outcomes than the national norm. The perception of high-achieving engineering students about their environment is not different from the national norm. This study corroborates the theory of involvement that educational achievement is directly related to engagement.

Keywords: high-achieving engineering students; progress toward the desired outcomes of college; quality of effort; college environment