Work in Progress: Impact on Students Dropout rates of Introducing a First-Year Hands-on Civil Engineering Course

ALEJANDRA ESTEFANIA CERVANTES

Dr. Miguel Andres Andres Guerra, Universidad San Francisco de Quito USFQ

MiguelAndrés is an Assistant Professor in the Polytechnic College of Science and Engineering at Universidad San Francisco de Quito USFQ. He holds a BS in Civil Engineering from USFQ, an M.Sc. in Construction Engineering and Project Management from Iowa State University as a Fulbright Scholar, a Ph.D. in Civil Engineering from Virginia Tech, and two Graduate Certificates from Virginia Tech in Engineering Education and Future Professoriate. MiguelAndrés's research includes sustainable infrastructure design and planning, smart and resilient cities, and the development of engineers who not only have strong technical and practical knowledge but the social awareness and agency to address global humanitarian, environmental, and social justice challenges. For him, social justice is a concept that should always be involved in discussions on infrastructure. Related to STEM education, Miguel Andrés is in developing and applying contemporary pedagogies for STEM courses, teaching empathy studies in engineering as a tool for innovation, and assessing engineering students' agency to address climate change. Currently, MiguelAndrés is validating his framework of a Blended & Flexible Learning approach that focusses on STEM courses and its practical adaptation to overcome barriers brought up by the COVID-19 pandemic.

Work in Progress: Exploring Impact on Students Dropout rates of Introducing a First-Year Hands-on Civil Engineering Course

Estefanía Cervantes[1], Miguel Andrés Guerra[2*]

[1] Instructor, Universidad San Francisco de Quito USFQ, Colegio de Ciencias e Ingenierías, Departamento de Ingeniería Civil, Casilla Postal 17-1200-841, Quito 170901, Ecuador.

[2] Assistant Professor, Universidad San Francisco de Quito USFQ, Colegio de Ciencias e Ingenierías, Departamento de Ingeniería Civil, Casilla Postal 17-1200-841, Quito 170901, Ecuador.

* Correspondence: Miguel Andrés Guerra, MAGuerra@usfq.edu.ec.

Abstract

This Work in Progress paper will describe the second phase of an intervention that seeks to reduce dropout rates in Civil Engineering students at a private university in Ecuador. Engineering dropout is a complex construct because it involves many dimensions, some of which come from societal status quo. There is significant research on understanding the barriers, both personal and institutional, that cause student desertion throughout the major. One of these barriers is the lack of understanding of the areas of knowledge of the different engineering majors. This paper highlights a pedagogical application of an introductory course for first-year students and the contrast of the dropout numbers. The study showcases the design of the courses, student learning outcomes, and the perceptions of students about what each specific major entitles. Specifically, the study analyzed 81 first-year civil engineering students distributed among five sections of the Introduction to Civil Engineering course, two years ago. The authors reflect on the design of the intervention and explore the avenues academia could take to form new pedagogical approaches to reduce student dropout in civil engineering schools. Implications for research and practice are provided.

Introduction

In recent years, there has been a growing interest worldwide in the high rates of university dropout and the determination of its main causes and solutions [1]. Dropout affects significantly both personally and socially. Deficient education for dropouts can be reflected in a significant decline in their future economic and social well-being [2]. Furthermore, a shortage of skilled workers can undermine a country's productivity [2]. Currently, universities have high dropout rates that are evidenced in the data officially presented by official institutions. According to the United Nations Organization, dropout exceeds 40% in Latin American countries such as Colombia and Ecuador, and even 50% and 54% in Costa Rica and Brazil respectively [3]. These rates worsen significantly when emphasis is placed only on STEM careers where there is around 70% of dropouts in Latin American countries [4], [5].

A small percentage of dropouts are due to inadequate academic performance but most of them are voluntary [6]. For this reason, in this paper, dropout is defined as a voluntary and permanent abandonment of academic studies before graduating [7]. From the institutional point of view, there are some crucial moments during a student's career where the interaction between the student and the institution has a more significant impact on dropout [6]. The first happens during

the application process, when the student contacts the institution and generates the first impressions about it [6]. These impressions, generally about academic life, can be wrong or unrealistic and can generate early disappointments that can lead to dropout. The second crucial moment is the transition between high school and college, immediately following the entrance to the institution. It is important to mention that the first semester, especially the first six weeks, can be the most challenging [6].

As mentioned before, first-year interventions are essential to decrease dropout rates [8]. Some interventions as mentorship programs, early orientation and counseling sessions, creation of faculty stewardship for new students, among others, can have an instantaneous and enduring impact in preventing student dropout [6]. On the other hand, students search intensively for the right institution and demand satisfaction from it, when this occurs commitment is generated and consequently dropout is avoided [9]. Current research shows that student satisfaction has a positive impact on student motivation, dropout decrease, funding, and recruitment efforts [10]. Therefore, institutions can also avoid dropout by recognizing and satisfying students' needs and expectations [9]. As a result, this study focuses on the second phase of a first-year workshop course intervention which aims to reduce dropout rates at the undergraduate program of Civil Engineering at a private university in Ecuador, Universidad San Francisco de Quito USFQ. We investigated the impact the course had on first- and second-year students who took the workshop course. The first phase, presented in a previous [11], showed the course design through a Charrette construction design method to develop a multiple stakeholders-focused course. During the next months we will analyze the overall dropout numbers since the workshop course was implemented and the 10 previous years, including the feedback of last-year students who participated in the workshop their first semester.

Background/Framework

For several years, there has been a lot of research focused on how to increase and maintain the number of graduates from higher education studies in Science, Technology, Engineering and Mathematics (STEM). One of the main reasons for this is because graduates of this field help a country to stay competitive, improve the global economy through greater innovation and technology, create jobs and improve [10], [12], [13]. Nevertheless, according to the American Society for Engineering Education, approximately 40 to 50 percent of students who enroll in STEM-related majors drop out before graduation [13]–[15].

Nowadays, there are many studies that have looked at student dropout rates and the reasons behind them. These studies have led many researchers to evaluate and analyze the enrollment and retention rates of STEM majors at higher education institutions and propose several actions to increase the production of STEM professionals [16]. It is important to mention that students are particularly vulnerable in the first two years of their academic programs when more than 60% of the dropouts occur [16].

Dropping out is failing to complete a specific course of action or achieve a targeted objective for which he or she originally enrolled at a particular institution of higher education [6]. There has been extensive research to determine the factors that can cause or influence this phenomenon and they can be categorized into student, institutional and other factors [15]. From the student point of view, according to the American Society for Engineering Education, the main reasons why

students drop out are deficient advising and teaching; complicated engineering curriculum and a lack of "belonging" within engineering [14], [16]–[20]. On the other hand, from the institution point of view, the main reasons why students drop out are ineffective career counseling; unsuccessful transition from high school to college due to ineffective integration between admission, counseling, advising, and student services; lack of interaction between students and faculty members both within and outside the classroom and insufficient extracurricular activities[6]. Finally, other factors that can influence students' dropout may include socio-economic status, gender, ethnicity, etc [6], [11], [15], [21], [22] Finally, a better understanding of the causes of this phenomenon will make it possible to improve interventions to reduce dropout.

Recent research shows that the low interest in STEM majors is principally due to the elevated failure rate in the first years of engineering programs [19], [23], [24]. This high failure rate in the early courses means that students are not achieving their academic goals, leading to a loss of student engagement [19]. Consequently, students tend to drop out of their originally chosen major. Therefore, to reduce early dropout, motivation [25], student achievement [26], and academic performance [27], which are directly related to student engagement, should be promoted [19].

In the same way, Science, Technology, Engineering, and Mathematics (STEM) major dropouts are most common in the first or second year of college [17]. Additionally, studies report that students' experiences in their first-year science courses have the greatest influence on their decision to change majors [17], [28]. In a study on retention in engineering majors, researchers found that unexceptional instruction in undergraduate engineering courses led students to believe that their engineering courses would be unexceptional too and, consequently they drop out of the major [17], [29]. For this reason, implementation of intervention programs can have a relevant impact on early dropouts, especially during the first year [30]. Furthermore, studies suggest that retention rates can be increased by implementing engaging and interactive teaching methods [17], [31]–[38].

On the other hand, researchers have emphasized on the significance of students' feelings of belongingness. This feeling dramatically improves students' engagement and motivation [19], [23], [39], [40], which is particularly important in STEM majors [23]. A high level of engagement and motivation is improbable to happen in traditional lecture classes [25], because this potentially produces a barrier between teachers and students [18]. Hence, to decrease the dropout rate, it is essential to review the syllabus of the introductory courses and the teaching methodologies used in them. In addition, it is important to illustrate practical and real applications of their future careers [23], [24].

The main objective of this WIP is to assess the intention of students to continue their studies in civil engineering after assisting a first-year intervention at Universidad San Francisco de Quito USFQ, where civil engineering professors designed a course catered to expose first year students to a taste of the upcoming years [11]. The purpose of this course was to teach students what civil engineering is all about, basic concepts that may be useful in later semesters, and notions of what they will experience throughout their career. Therefore, it is expected that after receiving this course, the students' commitment, satisfaction and intention will influence their decision to stay in the civil engineering career [11], [41]. Moreover, through the implementation of

methodologies based on teamwork and class projects the course intends to promote a space for dialogue between students and civil engineering professors.

Methodology

This study is based on the hands-on course for first year student in civil engineering at the Universidad San Francisco de Quito USFQ in Quito, Ecuador. The course was design based on the guidelines stated by the National Charrette Institute for charrette design [11] and considering common factors influencing student dropout along their academic life. The four factors addressed are: intention, commitment, integration, and student satisfaction [11].

The course was designed to expose students to all possible tracks within the field through two-week modules that combined lectures with various types of learning activities. Activities included hands-on projects, experiential learning, industry connection, participation in mentoring programs, and standard tests, with each type of activity weighing around 20±5% per module. The course was taught by high-level professors, including USFQ alumni, to ensure student satisfaction and their integration into academic life. Hands-on projects, experiential learning, and on-site visits aimed to increase engagement and intent to study civil engineering, while mentoring programs connected first-year students with advanced students and professionals who could provide insights about career paths. These types of interventions also functioned as a filter to identify students who were not interested in civil engineering, but early exposure to the field could potentially change their career paths and prevent dropout in later semesters. For more information on the content and methodology of the course, please refer to the document cited below [11].

The first part of this study, which is reported in this article, uses a qualitative approach [42], [43] using a structured survey as the instrument for data collection. Data was collected during the Fall 2022 semester with students from the civil engineering first-year hands-on course with a total sample size of n=81 students. For this study, the researchers conducted a survey after students finished their first-year hands-on course (n=81 students). The survey contained both closed- and open-ended questions. The survey aimed for students to self-report their engagement and motivation about continuing with their major.

For *data analysis*, surveys were administered using Google Forms and cleaned up in Excel software. Responses were coded to show how the first-year hands-on course influences students' decision to continue their major studies and how it increases their commitment and motivation. The students' responses were coded for content analysis, using a priori and emergent codes, following the guidelines of Saldana [44] and Yin [43]. The codes were grouped by general themes. The sets of questions were divided into three phases. The first set of questions were open questions that inquired about what civil engineering is and the identification of the purpose of various areas of civil engineering knowledge. The second set of questions concerned their future after graduation by asking if they knew what activities they would do once they graduated and how often they think they will make it. Finally, the third block of questions inquired about the influence of the course on their decision to continue or drop out the degree.

As for the course characteristics, all the first semester students in civil engineering must take a first-year hands-on workshop course at Universidad San Francisco de Quito USFQ. The main

objective of this course was to teach students what civil engineering is all about and what they will experience throughout their career. Therefore, it is expected that after receiving this course, the students' commitment and intention will influence their decision to stay in the civil engineering career. Moreover, through the implementation of methodologies based on teamwork and class projects the course intends to promote a space for dialogue between students and civil engineering professors. Finally, the methodology of the course concentrates on achieving students' satisfaction.

On the other hand, the course content includes basic concepts of most of the knowledge areas of civil engineering such as: construction materials, structures and seismic analysis, environment and water resources, Geotech and soils mechanics, highways and transportation, construction engineering and sustainability. Furthermore, the learning activities of the course included lab practices, experiential learning, role-model activities, among others.

Results

This study is a work in progress, as a result, the results obtained in this section are qualitative results obtained through surveys carried out with students once the first-year course has finished. In the following studies, quantitative results dropout rates will be obtained. The students who took the course mainly reported that it was useful for them to learn more about civil engineering and that they are motivated to continue and finish their undergraduate studies. The following table summarizes the results:

Table 1. Results obtained from the study

After taking the first-year course students…:	Student responses ideas and statements
Perceived the engineering curriculum can be accessible to understand and fun to learn	- Decreased perception of the difficulty of the engineering curriculum - Confidence about the topics learned during the course
Identified the various areas of knowledge and practice of civil engineering as a major	- Better understanding of what civil engineering is - Identification of the purpose of some of the knowledge areas of civil engineering
Significantly increased their feelings of belonging	- Feelings of belonging

Considered the coursed **prepared them for what to expect in their future semesters**	- Usefulness of the course for their next semesters
Perceived an increase in their commitment and motivation to continue their studies	- Commitment to continue with their studies - Motivation about their next semesters and professional life

First, student self-reported answers stated that after completing the first-year course they consider that the **engineering curriculum can be accessible to understand and fun to learn**. For example, one student stated, "My knowledge has expanded a lot, I learned in a simple way from the technical names on construction to the participants involved in the development of construction projects." Furthermore, students feel confident in what they have learned during the course: "I know a lot about construction materials", "I think that one of the most important characteristics after finishing the course is the fact of knowing how to differentiate the materials", "It seems funny to me to think that the roads seek to connect a point A with a point B, but for that you have to analyze elevations, natural faults, surveying, etc."

Second, student self-reported answers mentioned that the first-year course helped them to have a **better understanding of the major and to identify the different knowledge areas of civil engineering**. One student reported, "I liked the course because it gave me a general idea of everything that can be done in civil engineering." Other students said, "The course allows students to "fall in love" with the degree and really make them realize whether it is what they want to pursue. In addition to teaching all the fields that can be studied and therefore, in the future, specializing" and "My teacher explained to me the different areas that exist in civil engineering in which I could work."

Third, student self-reported answers suggested that after completing the first-year course their **feelings of belonging had increased**. One student reported, "The course helped me to have a base of what I am going to do in the future, and it was a great help to meet more friends of my career." Other student said, "The teacher made everything very dynamic and made me feel part of my career." Other student mentioned, "The course influences a lot because it has been something that I liked and I would like to continue being part of this career."

Fourth, student self-reported answers mentioned that the first-year course was very useful because **it prepared them for what to expect in their future semesters**. For example, one student stated, "A large part of engineering is the design of structural plans, in these you can see all the characteristics that the construction will have and how it will be carried out on the site, for this you need to use different software that allow you to carry out the design of a project. The handling of AutoCAD, a 2D and 3D modeling software, is important throughout the degree and is considered a main tool for civil engineering." Other students said, "From my perspective, the first-year course is important because it gives us a general notion of what my major will be during the 4 years that I am going to study it, and it gives us the basic notions for more technical

subjects of the major that I am going to take in the future" and "The software learned in class seems to me an excellent application and very useful for civil engineering".

Finally, student self-reported answers stated that the first-year course **increased their commitment to continue with their studies**. For example, one student said, "I have a clearer idea of what my career as a professional is going to be. I feel very convinced that I want to do this for the rest of my life." Other students said, "I liked the course and I will do my best to continue my studies because it is something I like." Furthermore, students feel motivated to continue their studies and about their future professional life: "The course had a positive influence, since learning more about the materials and elements involved in a construction, this motivated me to want to continue studying this career, which despite being complicated, has its positive side." Other students mentioned, "In first semesters the subjects are really boring and having a course like this motivates me to discover everything that the major can offer" and "We have an idea of what we are going to do for the rest of our lives and, at least for me, I loved it."

Discussion

According to the American Society for Engineering Education, the main reasons why students drop out are deficient advising and teaching; complicated engineering curriculum and a lack of "belonging" within engineering [14], [16]–[18], [23]. Introducing a first-year hands-on civil engineering course aims to reduce dropout rates at the undergraduate program. Many students stated that the course helped them easily understand basic engineering concepts. Additionally, students described the course as dynamic, interactive and interesting, compared to their other courses. This is particularly important because retention rates can be increased by implementing engaging and interactive teaching methods [17], [31]. Furthermore, students reported that they feel more committed and motivated to continue their undergraduate studies.

After the students finished the first-year hands-on course, they were able to successfully understand basic engineering concepts and recognize the different knowledge areas of civil engineering. Due to the methodology of the course, it was possible to transform a content usually taught in a complicated way to a didactic and easy to understand one. Since the course was not a traditional lecture class, this allowed to produce a high level of engagement and motivation [25], which are extremely important to reduce early dropout [25], [26].

On the same way, after the students finished the first-year hands-on course, their feelings of belonging increased considerably. Students mentioned that the course allowed them to meet other students of their career due to the implementation of methodologies based on teamwork and class projects. Furthermore, these methodologies also promote a space for dialogue between students and civil engineering professors, which improves students' satisfaction [11]. It is important to mention that implementing engaging and interactive teaching also increase students' retention rates [17], [31].

Finally, the first-year hands-on course was also designed to teach students what civil engineering is all about and what they will experience throughout their career. This led the students to consider that the course was very useful for their future academic performance. For instance, one of the students said that the course gave them a better understanding of technical subjects and an idea of what civil engineering will be like throughout their career. Consequently, students felt

motivated to continue studying civil engineering. Also, students mentioned that the course motivated them to discover everything that the major can offer and, therefore, students also presented an increase in their commitment to continue their studies which are extremely important to reduce early dropout [25], [26].

Conclusions and Future Work

For several years, there has been an increase in students' dropout rates, particularly in STEM. There has been extensive research to determine the factors that can cause or influence this phenomenon and they can be categorized into student, institutional and other factors [13]. This study focused on how to reduce dropout considering students' factors which are deficient advising and teaching; complicated engineering curriculum and a lack of "belonging" within engineering. This study assessed students' engagement, commitment, and motivation after a first-year intervention at Universidad San Francisco de Quito USFQ, where civil engineering professors designed a course catered to expose first year students to a taste of the upcoming years. The objective was that the course will influence their decision to stay in the civil engineering career. After receiving the course, students self-reported that they perceive engineering curriculum can be easy to learn and understand. Also, students were able to have a better understanding of various areas of knowledge and what to expect for future semesters. Students also showed an increase in student feelings of belonging, commitment, and motivation to continue their studies. Future study includes evaluation of academic dropout rates occurred in a 4-year period since the course began and a comparison with the previous decade dropout rate.

References

[1]   C. Marquez-Vera, C. R. Morales, y S. V. Soto, «Predicting School Failure and Dropout by Using Data Mining Techniques», *IEEE Rev. Iberoam. Tecnol. Aprendiz.*, vol. 8, n.º 1, pp. 7-14, feb. 2013, doi: 10.1109/RITA.2013.2244695.

[2]   S. Lee y J. Y. Chung, «The Machine Learning-Based Dropout Early Warning System for Improving the Performance of Dropout Prediction», *Appl. Sci.*, vol. 9, n.º 15, p. 3093, jul. 2019, doi: 10.3390/app9153093.

[3]   A. Mayra y D. Mauricio, «Factors to predict dropout at the universities: A case of study in Ecuador», en *2018 IEEE Global Engineering Education Conference (EDUCON)*, Tenerife: IEEE, abr. 2018, pp. 1238-1242. doi: 10.1109/EDUCON.2018.8363371.

[4]   A. Del Savio, K. Galantini, y A. Pachas, «Exploring the relationship between mental health-related problems and undergraduate student dropout: A case study within a civil engineering program», *Heliyon*, vol. 8, p. e09504, may 2022, doi: 10.1016/j.heliyon.2022.e09504.

[5]   H. Murzi *et al.*, «Cultural dimensions in academic disciplines, a comparison between Ecuador and the United States of America», en *2021 ASEE Virtual Annual Conference Content Access*, 2021.

[6]   V. Tinto, «Defining dropout: A matter of perspective», *New Dir. Institutional Res.*, vol. 1982, n.º 36, pp. 3-15, dic. 1982, doi: 10.1002/ir.37019823603.

[7] H. Coates y L. Ransom, «Dropout DNA, and the genetics of effective support».

[8] M. Mariño, C. Ubidia, M. Guerra, y F. Jativa, «WIP: Designing a First-Year Hands-on Civil Engineering Course to Reduce Students Dropout and Improve the Overall College Experience», en *2022 ASEE Annual Conference & Exposition*, 2022.

[9] C. B. Schertzer y S. M. B. Schertzer, «Student Satisfaction and Retention: A Conceptual Model», *J. Mark. High. Educ.*, vol. 14, n.º 1, pp. 79-91, nov. 2004, doi: 10.1300/J050v14n01_05.

[10] K. M. Elliott y D. Shin, «Student Satisfaction: An alternative approach to assessing this important concept», *J. High. Educ. Policy Manag.*, vol. 24, n.º 2, pp. 197-209, nov. 2002, doi: 10.1080/1360080022000013518.

[11] M. Mariño, C. Ubidia, M. Guerra, y F. J. Valverde, «Work in Progress: Designing a First-Year Hands-on Civil Engineering Course to Reduce Students Dropout and Improve the Overall College Experience», presentado en 2022 ASEE Annual Conference & Exposition, ago. 2022. Accedido: 10 de enero de 2023. [En línea]. Disponible en: https://strategy.asee.org/work-in-progress-designing-a-first-year-hands-on-civil-engineering-course-to-reduce-students-dropout-and-improve-the-overall-college-experience

[12] «Utility-value intervention with parents increases students' STEM preparation and career pursuit». https://www.pnas.org/doi/10.1073/pnas.1607386114 (accedido 10 de enero de 2023).

[13] «2116613_stem_policy_paper_web_rev.pdf». Accedido: 10 de enero de 2023. [En línea]. Disponible en: https://www.un.org/osaa/sites/www.un.org.osaa/files/docs/2116613_stem_policy_paper_web_rev.pdf

[14] L. Paura y I. Arhipova, «STUDENT DROPOUT RATE IN ENGINEERING EDUCATION STUDY PROGRAM», *Eng. RURAL Dev.*.

[15] A. Sithole, E. T. Chiyaka, P. McCarthy, D. M. Mupinga, B. K. Bucklein, y J. Kibirige, «Student Attraction, Persistence and Retention in STEM Programs: Successes and Continuing Challenges», *High. Educ. Stud.*, vol. 7, n.º 1, p. 46, ene. 2017, doi: 10.5539/hes.v7n1p46.

[16] Y. Chen, A. Johri, y H. Rangwala, «Running out of STEM: a comparative study across STEM majors of college students at-risk of dropping out early», en *Proceedings of the 8th International Conference on Learning Analytics and Knowledge*, en LAK '18. New York, NY, USA: Association for Computing Machinery, mar. 2018, pp. 270-279. doi: 10.1145/3170358.3170410.

[17] J. Watkins y E. Mazur, «Retaining Students in Science, Technology, Engineering, and Mathematics (STEM) Majors», *J. Coll. Sci. Teach.*, vol. 42, n.º 5, pp. 36-41, 2013.

[18] R. M. Marra, K. A. Rodgers, D. Shen, y B. Bogue, «Leaving Engineering: A Multi-Year Single Institution Study», *J. Eng. Educ.*, vol. 101, n.º 1, pp. 6-27, ene. 2012, doi: 10.1002/j.2168-9830.2012.tb00039.x.

[19] M. T. Lopez-Diaz y M. Pena, «Contextualization of basic sciences in technological degrees», en *2020 IEEE Frontiers in Education Conference (FIE)*, Uppsala, Sweden: IEEE, oct. 2020, pp. 1-5. doi: 10.1109/FIE44824.2020.9274070.

[20] M. A. Guerra y C. Gopaul, «IEEE region 9 initiatives: supporting engineering education during covid-19 times», *IEEE Potentials*, vol. 40, n.º 2, pp. 19-24, 2021.

[21] C. Bungău, A. P. Pop, y A. Borza, «Dropout of first year undergraduate students: A case study of engineering students», *Balk. Reg. Conf. Eng. Bus. Educ.*, vol. 2, n.º 1, pp. 349-356, dic. 2017, doi: 10.1515/cplbu-2017-0046.

[22] C. Ubidia, M. Guerra, y H. Murzi, «Understanding Student's Perceptions of Cultural Dimensions in construction majors: Deconstructing barriers between architecture and civil engineering students», en *2022 ASEE Annual Conference & Exposition*, 2022.

[23] M. López-Díaz y M. Peña, «Encouraging Students' Motivation and Involvement in STEM Degrees by the Execution of Real Applications in Mathematical Subjects: The Population Migration Problem», *Mathematics*, vol. 10, p. 1228, abr. 2022, doi: 10.3390/math10081228.

[24] M. A. Guerra, H. Murzi, J. C. Woods Jr, y A. Diaz-Strandberg, «Understanding Students' perceptions of Dimensions of Engineering Culture in Ecuador», en *2020 ASEE Virtual Annual Conference Content Access*, 2020.

[25] J. A. Gasiewski, M. K. Eagan, G. A. Garcia, S. Hurtado, y M. J. Chang, «From Gatekeeping to Engagement: A Multicontextual, Mixed Method Study of Student Academic Engagement in Introductory STEM Courses», *Res. High. Educ.*, vol. 53, n.º 2, pp. 229-261, mar. 2012, doi: 10.1007/s11162-011-9247-y.

[26] M. M. Handelsman, W. L. Briggs, N. Sullivan, y A. Towler, «A Measure of College Student Course Engagement», *J. Educ. Res.*, vol. 98, n.º 3, pp. 184-192, ene. 2005, doi: 10.3200/JOER.98.3.184-192.

[27] T. Floyd-Smith *et al.*, «A Multi Institutional Study Of Connection, Community And Engagement In Stem Education: Conceptual Model Development», presentado en 2010 Annual Conference & Exposition, jun. 2010, p. 15.59.1-15.59.9. Accedido: 11 de enero de 2023. [En línea]. Disponible en: https://strategy.asee.org/a-multi-institutional-study-of-connection-community-and-engagement-in-stem-education-conceptual-model-development

[28] A. Christopher Strenta, R. Elliott, R. Adair, M. Matier, y J. Scott, «Choosing and leaving science in highly selective institutions», *Res. High. Educ.*, vol. 35, n.º 5, pp. 513-547, sep. 1994, doi: 10.1007/BF02497086.

[29] G. Lichtenstein, H. Loshbaugh, B. Claar, T. Bailey, y S. Sheppard, «Should I Stay Or Should I Go? Engineering Students' Persistence Is Based On Little Experience Or Data», en *2007 Annual Conference & Exposition Proceedings*, Honolulu, Hawaii: ASEE Conferences, jun. 2007, p. 12.1277.1-12.1277.22. doi: 10.18260/1-2--2177.

[30] S. Pal, «Mining Educational Data to Reduce Dropout Rates of Engineering Students», *Int. J. Inf. Eng. Electron. Bus.*, vol. 4, n.º 2, pp. 1-7, abr. 2012, doi: 10.5815/ijieeb.2012.02.01.

[31] E. Brewe, L. Kramer, y V. Sawtelle, «Investigating student communities with network analysis of interactions in a physics learning center», *Phys. Rev. Spec. Top. - Phys. Educ. Res.*, vol. 8, n.º 1, p. 010101, ene. 2012, doi: 10.1103/PhysRevSTPER.8.010101.

[32] H. Velásquez, M. Guerra, y M. Jimenez, «Exploring Interdisciplinary Contributions to More Sustainable Solutions in the Built Environment and Infrastructure Development Students», en *2022 ASEE Annual Conference & Exposition*, 2022.

[33] C. Ubidia, M. Guerra, V. Guerra, y C. Gallardo, «Work in Progress: Collaborative Environments in Architecture and Civil Engineering Education–Case Study», en *2022 ASEE Annual Conference & Exposition*, 2022.

[34] M. Guerra y Y. Abebe, «Pairwise elicitation for a decision support framework to develop a flood risk response plan», *ASCE-ASME J Risk Uncert Engrg Sys Part B Mech Engrg*, vol. 5, n.º 1, 2019.

[35] M. A. Guerra y T. Shealy, «Operationalizing Prototyping as a Design Method for More Sustainable Infrastructure Projects», en *Proceedings of the 16th Engineering Project Organization Conference (EPOC 2018)*, 2018, pp. 148-157.

[36] M. A. Guerra y S. Tripp, «Theoretically comparing design thinking to design methods for large-scale infrastructure systems», en *DS 89: Proceedings of The Fifth International Conference on Design Creativity (ICDC 2018), University of Bath, Bath, UK*, 2018, pp. 168-175.

[37] J. Acosta y M. A. Guerra, «Validating Guerra's Blended Flexible Learning framework for Engineering Courses», en *2022 ASEE Annual Conference & Exposition*, 2022.

[38] M. Guerra y T. Shealy, «Teaching user-centered design for more sustainable infrastructure through role-play and experiential learning», *J. Prof. Issues Eng. Educ. Pract.*, vol. 144, n.º 4, p. 05018016, 2018.

[39] S. Zumbrunn, C. McKim, E. Buhs, y L. R. Hawley, «Support, belonging, motivation, and engagement in the college classroom: a mixed method study», *Instr. Sci.*, vol. 42, n.º 5, pp. 661-684, sep. 2014, doi: 10.1007/s11251-014-9310-0.

[40] T. M. Freeman, L. H. Anderman, y J. M. Jensen, «Sense of Belonging in College Freshmen at the Classroom and Campus Levels», *J. Exp. Educ.*, vol. 75, n.º 3, pp. 203-220, 2007.

[41] N. Granja, V. Guerra, y M. A. Guerra, «Give me a coffee break! Pilot study on improving exam performance and reducing student stress», en *2022 ASEE Annual Conference & Exposition*, 2022.

[42] J. W. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE Publications, 2013.

[43] «(PDF) Robert K. Yin. (2014). Case Study Research Design and Methods (5th ed.). Thousand Oaks, CA: Sage. 282 pages.» https://www.researchgate.net/publication/308385754_Robert_K_Yin_2014_Case_Study_Research_Design_and_Methods_5th_ed_Thousand_Oaks_CA_Sage_282_pages (accedido 11 de febrero Robert K. Yin de 2023).

[44] J. Saldaña, *The coding manual for qualitative researchers*, 2nd ed. Los Angeles: SAGE, 2013.