TETe

online technology and engineering classroom trends

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We as Technology and Engineering educators need to know what tools are available for online instruction and how developing online classroom environments should be used to meet our students' learning needs.

Introduction

The plight of Covid-19 has impacted our society like a tidal wave with recurring ripples being felt everywhere from the economy to education. To minimize the community spread of the virus, many K-12 schools transitioned to fully online learning or a hybrid model of online and face-to-face instruction. Based on data from the U.S. Census Bureau's Household Pulse Survey in late October 2020, households reported over 34 million (of their) school-age children were receiving online learning resources in a distance learning environment (U.S. Census Bureau, 2020). This created a chaotic state for classroom instruction and caused many educational systems to look for ways to drastically change how they have taught their students. This was especially the dilemma for Technology and Engineering educators. As defined by the International Technology Engineering Educators Association (ITEEA), Technology and Engineering Education "is problem-based learning utilizing science, technology, engineering, and mathematics (STEM) principles" (ITEEA, n.d., para. 2). Taking this definition of hands-on, minds-on authentic learning and applying it to online learning was not an easy task.

To provide the best online learning experience for students in Technology and Engineering K-12 classrooms, the authors sought

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to examine best practices and what research suggests to create these new learning spaces. However, the existing literature lacks insight into how to create these project-based learning spaces from the context of Technology and Engineering Education and even fewer from the perspective of K-12 Technology and Engineering educators. As Darling-Hammond concludes, "changes in course taking, curriculum content, testing, or textbooks make little difference if teachers do not know how to use these tools well and how to diagnose their students' learning needs" (Darling-Hammond, 2000, p. 33). We as Technology and Engineering educators need to know what tools are available for online instruction and how developing online classroom environments should be used to meet our students' learning needs. This study attempts to shed light on the trends of K-12 Technology and Engineering educators' online classroom spaces and the perceptions of their ability to effectively create learning spaces that foster engagement, collaboration, and motivation that were used during the recent pandemic.

Background on Student Motivation, Engagement, and Collaboration in Virtual Settings

Online learning environments have the ability to allow students to take a more active role in their learning. They also have the power to disengage students and create a gap in their desire to connect with their classmates and teachers as well as lose important understanding of content. The central role of student motivation, engagement, and collaboration impacts the success of the virtual learning environment and thus is imperative to understanding what current research indicates.

Motivation

Motivation is a human behavior that has been studied for decades in the context of education. One well established framework, self-determination theory (SDT) (Deci & Ryan, 1985), sets human psychological motivation on a fluid state from being amotivated, extrinsically motivated, or intrinsically motivated as visually shown (see Figure 1) in the work of Moore, Vega, Wiens, & Caporale (2020). SDT supports from the education perspective many other sub frameworks that look to determine how to best meet students' intrinsic and extrinsic motivations for learning, specifically for this review of cognitive evaluation theory (CET) (Ryan & Deci, 2000). This focuses on the intrinsic motivation of the learner and is based on the satisfaction of the learners behaving for their own sake. Technology and engineering content, especially delivered in face-to-face settings would fall into more intrinsic motivation for students as they are able to work on a project that has personal meaning or value to them. CET emphasizes three needs for students to feel competent (understand clearly what and why they are learning), have autonomy in the delivery of that content (have choices in projects, assessments, pace), and relatedness (feel accepted, respected, and cared for) (Ryan & Deci, 2000).

Literature focusing on student motivation, specifically in online technology and engineering education courses, could not be found. However, a study by Brooker et al. (2018), compares the motivation, participation, and performance of 1586 adult students varying in age and demographics in two massive online open courses (MOOCs) that had different content but similar instructional course design. The study found that most of the students who participated in the professional course were extrinsically motivated because of the need to receive professional development for their current careers. An interesting find was, "Students who identified early on that they wanted to achieve a distinction continued toward that goal throughout the MOOC regardless of their motivation to enroll, and regardless of their participation patterns in the MOOC" (Brooker et al., 2018, p. 83). This implies that the participants of the study were motivated to take the course and wanted to gain self-satisfaction but remained more motivated throughout and it is important to understand students' perspectives for taking courses to build their motivation. For the adult student or higher ed community this study supports online course content and instructional design, but what about K-12 online settings where students don't always choose the online course they are taking?

Complementing the work of Deci & Ryan (2000), a study conducted by Hsu, Wang, & Levesque-Bristol (2019) looked at the SDT framework in online learning settings and its implications for student motivation. The researchers surveyed 330 undergraduate students in seven different online courses. The Likert scale survey instrument gathered students' perceptions of autonomy of the learning climate if basic psychological needs were met in autonomy, competence, and relatedness to the content, their motivation to participate in the course, and the learning outcomes of knowledge transfer. Their results showed patterns in students' higher perceptions of learning gains and self-determined motivation as well as course grade with learning climates (Hsu

Figure 1.
Three Phases of Motivation According to SDT

Amotivation	Extrinsic Motivation	Intrinsic Motivation
Possessing no motivation to engage; possessing feelings of incompetence or a lack of understanding of the value of an activity	Being motivated by an external force such as grades or instructor praise	Being motivated by an internal force such as personal satisfaction or joy

(Deci & Ryan, 2000 as cited in Moore et al., 2020, p. 2)

et al., 2019, p. 2168). The findings clearly show that motivation for learning and higher learning outcomes are met when the three basic needs proposed in SDT (autonomy, competence, and relatedness) are used in the design and structure of a course.

Technology and engineering students often find intrinsic motivation because of the nature of project-based learning and the ownership that comes from working through a problem toward a solution, but when that type of hands-on motivation is removed in an online setting what happens to the overall motivation of the student? Motivation with other key contributors builds a solid foundation for successful learning. It is necessary to recognize and embrace these important key factors when teaching or learning. Strategies need to be developed over time to improve instruction at all levels. Motivation is a key element in student learning.

Engagement

Engagement plays a key role in student learning. In Technology and Engineering content engagement can be seen while students are designing and building a project to satisfy the challenge. It is thinking and displaying the act of gaining knowledge. Student engagement must be achieved in both face-to-face and in online learning. Mandernach (2009) shows that when students are learning in an online environment, it may be even more important for engagement to be considered due to the isolation of students in their learning environment. She also recommends that to enhance students' engagement the teacher should:

1. Integrate active learning environments with authentic learning tasks;
2. Foster a personal connection with students; and
3. Facilitate the process of learning in an online environment.

(Mandernach, 2009, p. 1)

Studies centering on online-specific student engagement for Technology and Engineering education were not found. However, Axelson & Flick (2011) found that "student engagement" has come to refer to how involved or interested students appear to be in their learning and how connected they are to their classes, their institutions, and each other. Students who develop connections to the course or instructor are said to be engaged. This can only happen when the students are exposed to rich learning opportunities (Axelson, 2011). Instruction quality is found to be important in the engagement of all students and organized instruction is a key component.

Many studies contend that learning starts with engagement. According to Shulman (2005, 38), "learning begins with student engagement." This, in turn, leads to knowledge and understanding. Once the knowledge is understood then it can be performed. Engagement for learning is a fundamental purpose of education (Shulman, 2005). Students need to be engaged in the learning process. As seen in engineering and technology classrooms, a student's depth of knowledge is demonstrated in hands-on minds-on projects.

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Students who are engaged choose challenging tasks, display initiative in learning, show effort and concentration, and demonstrate positive behavior during learning (Groccia, 2018. These characteristics of engagement are typically found in face-to-face engineering and technology learning experiences. Creating an engaged online learning experience for students is imperative. Students need to feel connected and inspired to gain knowledge. The learner cognitively processes throughout the experience and compares past experiences (Groccia, 2018). The learner connects these experiences and develops engagement at various levels. When students achieve a higher level of thinking they will continue to develop new skills.

In 2011, Young and Bruce found that student engagement was defined as the interest and motivation students have in their own learning of course content. Students need to find the subject or topic relevant. When students are actively involved in lessons, their sense of engagement increases (Young, 2011). Providing engaging online experiences for engineering and technology may have

some challenges. Through understanding the needs of students, instructors will need to overcome online teaching challenges.

As seen in many studies and works, engagement is important for a student's learning. Engagement is needed for both the instructor and the student and is seen as a vital part of education. Our educational environment requires many resources and conditions to exist. Valuable experiences and activities allow students to grow. Through engagement, students and professionals can learn from one another. Engagement creates lifelong learning for all.

Collaboration

As the literature indicates, students who are intrinsically or extrinsically motivated by course content are more likely to engage. (Ryan & Deci, 2000; Mandernach, 2009). Extrinsic motivators come naturally in the school system in the way of grades and honors, but the goal of most educators is the true and deep intrinsic motivation for their students to want to learn for their own sake. In many face-to-face Technology and Engineering classrooms, students are motivated by and engaged in project-based learning (PBL) and the natural collaboration that is embedded in many design challenges. In virtual or hybrid technology and engineering classrooms this project-based collaboration is still present but not without challenges.

Collaboration can be defined as "to work jointly with others or together especially in an intellectual endeavor" (Merriam-Webster, n.d.). The benefits of collaboration and collaborative learning environments in education have been extensively documented (Laal & Ghodsi, 2012; Gokhale, 1995; Hargis, 2005; Marra, Steege, Tsai, & Tang, 2016). Collaborative examples in academic classrooms, both in person and virtual may take on the form of group problem solving, pair-sharing, discussion reflections, debates, and team-based tasks (Cornell University Center for Teaching Innovation, n.d.). These collaborative examples match much of what Technology and Engineering educators develop for their classroom learning experiences and the research backs the importance for students to have these experiences.

The work of Laal & Ghodsi (2012) summarizes from the empirical research, "[collaborative learning environments] compared with competitive and individualistic efforts, has numerous benefits and typically results in higher achievement and greater productivity, more caring, supportive, and committed relationships; and greater psychological health, social competence, and self-esteem" (p. 489). The study by Gokhale (1995) examined the effectiveness of individual versus collaborative learning in a Technology and Engineering classroom. The study evaluated 48 basic electronics students in two undergraduate courses through the use of test analysis and questionnaires. The results found that students who participate more in collaborative learning perform better on the critical-thinking aspects of tests. Gokhale (1995) also offers recommendations for Technology and Engineering educators based on the findings:

> "For collaborative learning to be effective, the instructor must view teaching as a process of developing and enhancing students' ability to learn. The instructor's role is not to transmit information, but to serve as a facilitator for learning. This involves creating and managing meaningful learning experiences and stimulating students' thinking through real world problems." (Gokhale, 1995, p. 30)

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Hargis (2005) supports this recommendation and adds that meaningful virtual communities where students feel they belong see useful benefits and can contribute as a group have the power to intrinsically motivate students. He argues however, that just providing "websites as resources" isn't enough. "A virtual community needs to include other parameters, ones that the students cannot locate or achieve on their own…project-based learning can fortify a well-built [virtual] community" (Hargis, 2005, p. 160). Structuring our online collaborative experiences in a way that requires students to naturally need one another to solve design challenges and work for the greater good together may be the key to finding the online intrinsic motivation we are searching for. Collaboration is important in fostering relationships among students and promotes a positive learning environment. Collaboration encourages students to work toward a common goal together.

This practice leads towards enhanced problem-solving skills. Collaboration is a key component of learning.

Purpose

There are various key factors that contribute to a student's learning. Motivation, engagement, and collaboration are the foundation for student learning and development and are achievable goals for educators to attain. Questions were developed around these essential factors and technology. Survey questions were sent to current Technology and Engineering teachers. These findings will help teachers derive the best instructional strategies and technologies for students during online instruction.

During face-to-face instruction, students in Technology and Engineering courses are minds-on, hands-on with authentic project-based learning. However, in the current state of education with many schools delivering content in a hybrid or completely online setting, many T&E courses are being delivered in a completely different presentation style. The purpose of this study is to gather data on the current trends in T&E online courses and gauge the current perceptions of engineering educators in their classrooms' engagement, motivation, and collaborative online setting.

To guide this focus, the researchers focused on the following question:

What are the current trends in technology and engineering teachers' perceptions toward the use of engaging, motivating, and collaborative online learning in technology and engineering courses?

Methodology

The researchers used a mixed-methods approach to gather information from educators in the T&E Education field. A survey was generated to determine themes from Likert-type and open-ended questions based on the sample population's self-perceptions of T&E online classroom development, perceptions of their students' behaviors, and comfort level in online environments. The survey instrument included measurements on a Likert scale and the data analysis included descriptive statistics. The analysis also looked at the variance between the scores within the sample to determine if a correlation exists between variables. In addition, the survey instrument was designed to collect responses in a spreadsheet for coding to determine common themes from the responses. Using mixed methods, the data was analyzed using a coding system based on the Grounded Theory Approach (Strauss & Crobin, 1994) and statistical tests. Four different coders independently analyzed the qualitative data and worked together to compare the initial analysis data and refine an open coding system into general themes, often known as axial coding. Next, independent analysis occurred using the refined coding system. Once coders completed the second independent analysis, they organized and integrated trending themes through selective coding to explain the common occurrences in participant responses. The goal of the statistical analysis and grounded theory comparative analysis was to identify trends with the data to generate a comprehensive picture of best practices in technology and engineering online learning.

The study was conducted through ITEEA and made available only to current members and yielded 48 anonymous survey responses. While some demographic data was gathered including years of online teaching experience, the socioeconomic status of the student population was not included in the demographic data. This can create some bias as resources available for online teaching cannot be accounted for in the analysis of the data. The instrument questions were developed by the research team to gather information on current classrooms and identify themes and trends using qualitative coding methods. The questions in the instrument make the basic assumption that the classroom environment has drastically changed due to required hybrid and/or online learning. The questions could be leading if hybrid and/or online learning had little impact on the classroom environment at the time of the study.

Participants Demographics

Requests for participants within the ITEEA membership and other state Technology and Engineering education affiliated organizations were sent via ITEEA emails and website postings. After soliciting the potential participant pools, 46 T&E educators agreed to participate and their data was collected. The type of association with education that respondents identified included: 21 (45.7%) high school teacher; 11 (23.9%) middle school teacher; six (13.0%) post-secondary; three (6.5%) administrator; two (4.3%) elementary; one (2.2%) middle & high school; one (2.2%) researcher; and one (2.2%) program consultant. The gender the respondents identified was split 29 (63%) male and 17 (37%) female. Of the 46 respondents, 29 (63%) were 45 years and older while 17 (37%) of the respondents reported being between 18 and 44 years old. The years of teaching experience reported by the respondents included 27 (61.4%) with 11+ years' experience; 10 (22.7%) 2-5 years' experience; five (11.4%) 6-10 years' experience; and two (4.5%) 0-1 year experience. Respondents also self reported that their online teaching experience included the majority (52.2%, 24/46) who only had 0-1 years' experience teaching online. Online teaching experience for 2-5 years was reported by 14 (30.4%) of the respondents and 11+ years of online teaching experience was reported by six (13%) of the respondents. The smallest portion of teachers responded that they had 6-10 years of online teaching experience—two (4.3%). Finally, respondents also identified their experience learning online included: 19 (40.4%) 2-5 years online learning experience; 18 (39.1%) 0-1 years online learning experience; five (10.9%) with 6-10 years online learning experience; and four (8.7%) with 11 or more years online learning experience.

Findings

Motivation

The educator survey responses showed that most of their online students were motivated during online learning with 21.3% (10/46) being motivated often, (44.7%, 21/46) motivated, and (27.7%, 13/46) sometimes motivated. When the educators were asked how they would rate their instructional practices in terms of their ability to motivate students during online learning, their response was positive with only (4.3%, 2/46) saying they

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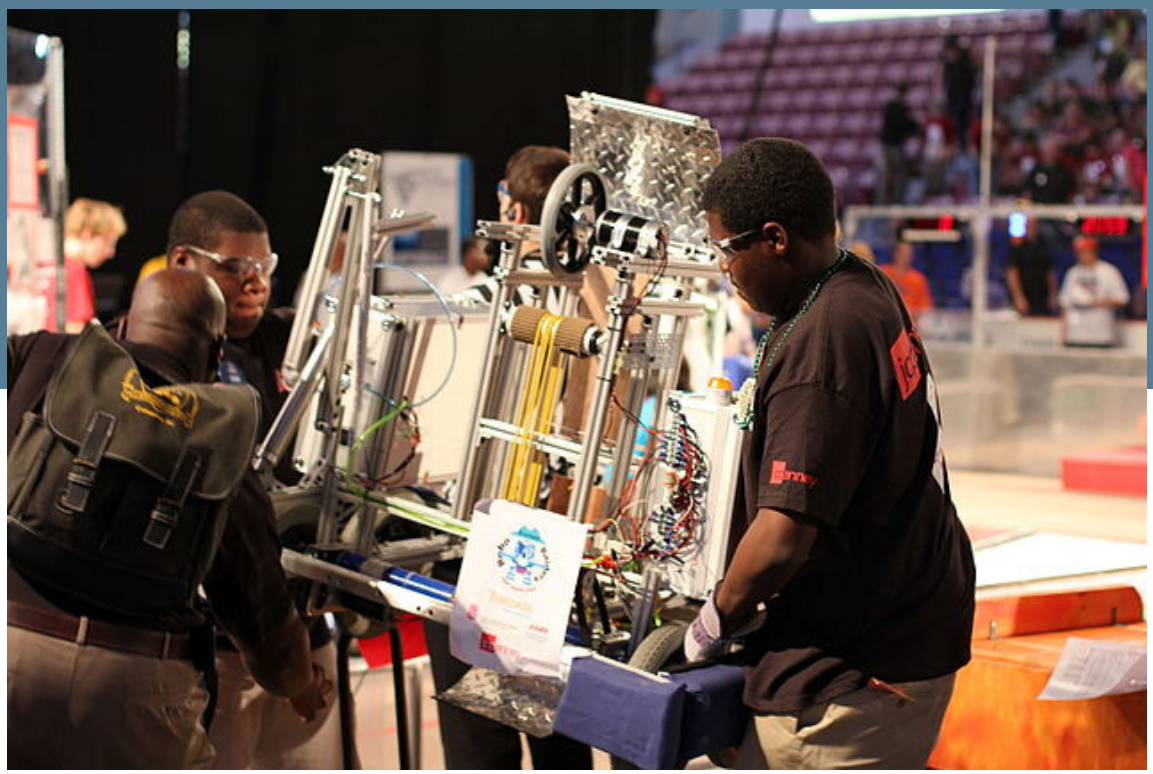


struggled to motivate their students. The educators surveyed found numerous ways to motivate their students, many using multiple means. Developing meaningful and respectful relationships with students was the method that most (87.5%, 42/46) respondents stated using. Another method (70.8.%, 34/46) was establishing high expectations and clear goals. Rounding out the top three methods of motivation was promoting a growth mindset rather than a fixed mindset (54.2%, 26/46). According to the coding of the responses, teachers are able to motivate their students during online instruction. Strategies that are working for the online educators include, but are not limited to, the following; developing meaningful and respectful relationships with students, establishing expectations and clear goals, and promoting a growth mindset rather than a fixed mindset.

Engagement

Survey responses suggest that the best way to promote engagement in online learning was by using a Learning Management System (LMS) and live chat combination (43% 16/47) The second most popular form of communication to promote engagement was using an LMS alone (23.4% 11/47). Instructors found that using an LMS, live chat, and a discussion trifecta was used 17% of the time (8/47). A five-point Likert Scaled question asked instructors how well students use online tool(s) to engage in lessons: 1 (*students do not use online tools to engage in lessons*) to 5 (*students use online tools daily to engage in lessons*). 40.4% (19/47) responded that students use online tools daily to engage in lessons and 25.5% (12/47) found that students use online tools to engage sometimes. 21.3% (10/47) responded that students use tools daily to engage in lessons. There are many obstacles for educators in online learning. It is important to encourage learner interactions. An open-ended question asked respondents what they find challenging in the design and implementation of online tools for student engagement. According to the coding of the responses, instructors are challenged with the following: developing and continuing student interaction, students using online tools, students having access to the internet, and the instructor having adequate time to create and implement meaningful learning for their students.

Collaboration

Of the four questions pertaining to collaboration in online Technology and Engineering courses, three were asked on a five-point Likert scale ranging from 1 (*not comfortable, no collaboration*) to 5 (*extremely comfortable, deep collaboration*). When asked how they would rate their activities as providing meaningful collaboration, the majority responded that they used instructional strategies that allow for deep connections to peers, the content, and the teacher (71%, 33/46). The majority of respondents also replied that most of their students collaborate in online class when given the chance or at a basic level (70%, 32/46). When asked how comfortable they felt designing and implementing meaningful collaborative activities for online students, only a small portion of the respondents felt comfortable or extremely comfortable (37%, 17/46). The final qualitative question asked respondents what was challenging or not working well in designing and implementing

online collaborative activities. The major challenges teachers were facing to create collaborative spaces included; lack of teacher training, comfort of students to collaborate, building relationships with teachers/peers online, and subject matter not allowing for collaborative opportunities.

Discussion

The following discussion aims to provide context regarding the suggested findings of this research study toward the implementation of these trends in T&E Education classrooms. The results indicate that motivation, engagement, and collaboration alone are not the only trending issues or challenges that Technology and Engineering teachers face when working in virtual learning settings. Based on the respondents' answers to the major challenges they are facing, five core issues were pulled from the data including: access, motivation, engagement, collaboration, and teacher training and support.

Access

Access was a common educator response that the authors initially hadn't considered as impacting educators to the extent that was reported. Access involves students' availability to join class online, remain during the allotted time frame, and complete assigned activities without interruption. Multiple educators identified inconsistent and slow internet connections in addition to hardware malfunctions as major obstacles during online instruction. In a systematic literature review of hybrid-learning environments, researchers identified the importance of setting up and testing technology in advance for effective online-learning environments (Raes et al., 2020). Equipment tests allow program implementers to identify and service faulty hardware but does not address slow or inconsistent internet connections. An online environment requires students to persist in remaining engaged as the teacher is not physically present to regulate the environment (Raes et al., 2020). One participant noted the "students' ability to get online and accountability to do and finish work" as a challenge to engage students. A slow or inconsistent internet connection can deter students who are already struggling to engage in the online environment.

Motivation

Motivation does not always come intrinsically. Often, students need external motivation and rely on outside forces such as teachers. Learning online can provide obstacles to students and many times teachers are the first point of contact to step in. Being able to implement motivational strategies into instruction has an impact on students' willingness and desire to be engaged and collaborate with their peers in the online environment. Educators have numerous strategies that work both in the classroom and online including, but not limited to, developing meaningful and respectful relationships with students, establishing high expectations and clear goals, and promoting a growth mindset rather than a fixed mindset. The use of these strategies and others are likely to help move students to be intrinsically motivated, engaged in class activities and assignments, and be willing to collaborate with their peers. Most study participants reported implementing different combinations of these strategies within their classrooms, which was successful in the participants' classrooms as most reported that "my practices motivate my students" or "my practices highly motivate my students." Murphy and Rodríguez-Manzanares (2009) found that "teachers may need to develop approaches to and awareness of both intrinsic and extrinsic ways of motivating students in these contexts. The study participants use a combination of intrinsic motivation, i.e., promoting a growth mindset rather than a fixed mindset, and extrinsic motivation factors such as developing meaningful and respectful relationships with students to inspire students.

Engagement

Maintaining the same level of engagement in an online learning environment versus a face-to-face classroom has its challenges. Making students feel connected is valuable when creating a welcoming online learning experience. Young (2011) found that engagement was largely dependent on the instructor's personal connection with students; students need to feel that they matter whether online or in a classroom. Making connections with students allows students to find similarities or comparisons with the instructor. The student then becomes connected to the online class and to the instructor. Engagement occurs when a learner interacts with their education. When asking an open-ended question about the level of engagement in teaching an online course, the responses overwhelmingly mentioned experiencing problems. A participant found that, "it's easy for them (students) to hide in an online environment and do nothing." Another respondent found something similar about student engagement problems, "Some students will not, which leaves others to pick up the slack even more than normal." The authors saw these responses and other coding pointing to the problem of student engagement in an online learning environment.

Collaboration

Educators reported that, when trying to develop a collaborative experience, they faced challenges in online learning when there was a lower level of comfort, less online community building, and the course, resources, or activities did not lend themselves to collaboration. Respondent comments show that the ability to create a level of comfort is difficult within the online setting due to some home situations, activities or content that do not lend themselves to collaboration, and the commitment to collaborate. A study by Marra et al. (2016) investigated the student learning outcomes of undergraduate engineering students in an online collaborative group engineering design project. The findings support the need for the instructor to prepare students and model expectations for collaboration in an "ongoing" manner throughout the course, not just in the beginning, and that the students in the engineering course reflected that they felt their collaboration skills improved when using Google Drive as a collaborative tool within the design challenge (Marra et al, 2016, p. 13). For example, one participant reported "students [were] uncomfortable collaborating that way" as a challenge in the online environment. Modeling different methods of online collaboration provides students with an example of how to interact positively as well as the teacher expectations for collaboration.

Teacher Training and Support

Teacher training and support emerged as a core concept when it was noted that participants began to mention challenges in the design or implementation of online tools for student engagement or challenges in designing and implementing collaborative activities. These responses showed, with additional training and support, many of the challenges being faced would be drastically minimized. For example, a response to the open-ended questions about challenges to implementing and designing for engagement or collaboration included "I feel like I need more help with all of this, but I don't even know who to ask, and I feel like I'm too busy messing with modifying curriculum to have time to deal with it all. I am already working 10-12 hours every day on my teaching duties. When I really think about all of this stuff, I feel like a failure, so I try not to focus on it and hope my students will turn out ok in spite of all this." This response and others suggested that, of the respondents' challenges, most are a result of not having support or "knowing" how to overcome issues in the design and implementation of engagement or collaborative activities. Belastock (2020) corroborates this finding, "Teachers have the most significant impact on student learning, but without ongoing support and training, individual educators cannot take full ownership of technology-enhanced education."

Recommendations for Practitioners

The following recommendations aim to help classroom teachers navigate the complexities of teaching virtual technology and engineering courses.

School systems and administrators could provide ample and continuous training on how to teach in an online environment. If resources are available from the school district, a resource list and training opportunities could be shared to allow teachers and students to receive maximum benefit. Providing training will allow teachers to spend less time learning how to use available technologies and be better prepared to implement the resources in class with their students.

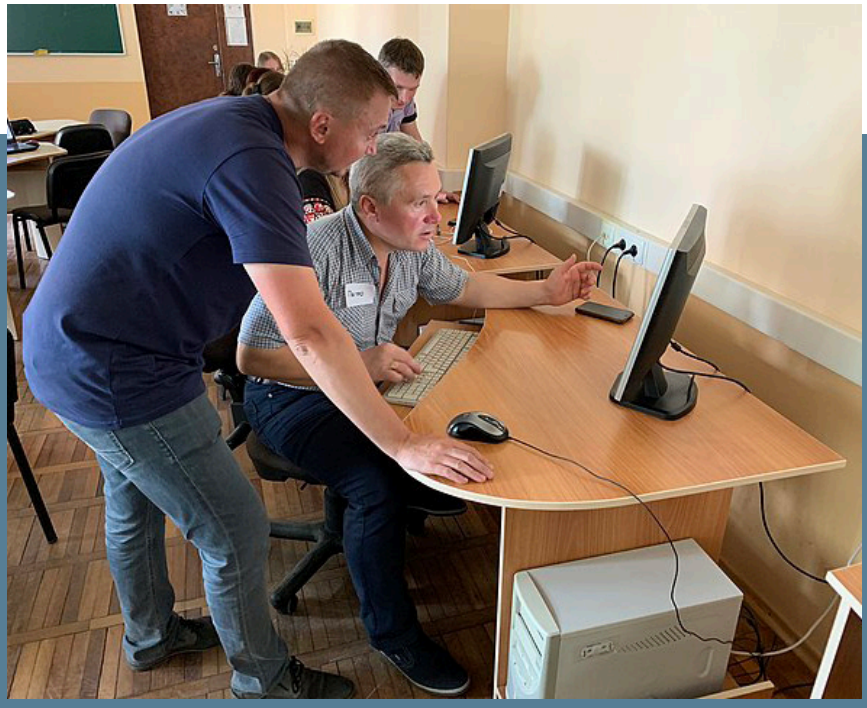
School systems and administrators could also provide an online-unified learning management system (LMS) for teachers to utilize with their students. An LMS has the capability to support students to be engaged in their learning. A district-unified system ensures that all teachers and students are using one system instead of students being required to learn to work in numerous systems. LMSs provide numerous ways for teachers to create engaging and collaborative lessons and activities for the students and teachers.

Teachers could maintain continuous communications with their students. Getting to know students, whether in person or online, is essential to building relationships. Students who feel valued are more motivated and have an enhanced desire to be engaged. Creating and maintaining a positive relationship with students allows teachers to be engaged with their students and students to be engaged in their learning.

Local governments and communities could ensure that they support and continue to grow their infrastructure to handle online technology capabilities for their citizens. This will promote technological literacy and the ability for citizens to learn and work from home. Covid-19 proved to the world that being able to access the internet is becoming a necessity and not a luxury.

Summary

The study set out to explore current trends of T&E educators' perceptions, frustrations, and successes while teaching in a virtual or hybrid setting through a mixed-methods analysis of participants' responses to a survey instrument. The quantitative analysis of the Likert-scale questions for collaboration, engagement, and motivation in online student learning used descriptive statistics to look for variance between scores within the sample and if correlations existed between variables. The qualitative analysis of data, based on the Grounded Theory Approach (Strauss & Corbin, 1994), included investigating the text-based responses of educators' perceptions toward the challenges for designing and implementing online tools for engagement and collaborative activities. The comparative analysis of the participants' open-ended text responses included three rounds of coding with open codes, axial codes, and selective coding. Five main themes emerged



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from the selective coding analysis of the data including (1) Access – such as connectivity and software availability was identified as a prevalent challenge to delivering quality online education, (2) Motivation – where students are on a range of motivation to complete, engage, and collaborate with online learning, (3) Engagement – with participants seeing students lack engagement or participation in online learning as a major challenge, (4) Collaboration – where participants faced challenges in online learning where there was a lower level of comfort, less online community building, or the content or course activities did not lend themselves to collaborative experiences, and (5) Teacher Training and Support – if the challenges mentioned by participants had the appropriate support or additional training, the challenges would be addressed and corrected.

The analysis revealed three promising trends for Technology and Engineering educators teaching online and hybrid learning including (1) most students can use a variety of learning management systems, discussion forums, or live chats to engage, (2) educators are using various experiences and combinations of instructional strategies to keep students motivated in their online classes, and (3) most teachers were able to use instructional strategies to promote collaboration between their students and with their students in online learning environments. Despite these positive trends, the analysis also revealed areas where technology and engineering educators need support to improve online experiences for their students. These include teacher training and continuous support for online learning instruction geared toward engagement, motivation, and collaboration in hands-on content, a unified online learning management system (LMS), and a web-based infrastructure to ensure secure and equitable access for all students to learn online. These findings led the authors to develop the recommendations for specific supports around these specific areas of need. It is believed that that the recommendations are larger societal issues as well, however, for the future of online T&E Education to be beneficial for our students, we must look closer at the teacher training and support systems that can be developed to help them in hands-on content areas to foster motivation, engagement, and collaboration. Future work and investigation need to be done to determine the specific types of continuous training that can be provided for T&E educators and the best practices in instructional approaches to support technology and engineering educators and their students in online learning.

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