Global Journal of human-social science: G
Linguistics & Education
Volume 23 Issue 8 Version 1.0 Year 2023
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-460X & Print ISSN: 0975-587X

Student Engagement and Motivation in Post-Pandemic Higher Education Mathematics: A Concept Paper

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Abstract- During the past three years, mathematics educators have had to adjust to the online education system and develop new approaches, strategies, and practices to keep students engaged and motivated. Student engagement and motivation have been established in existing research as vital aspects of education. To promote engagement and motivation during the pandemic, mathematics educators have focused on positive working relationships with students, highlighting values such as care and empathy. Mathematics educators have also adopted various technological tools to enhance student engagement and motivation. As institutions have begun to reintroduce face-to-face classes in the post-pandemic era, there is a need to re-examine these approaches, and how they may be sustained or improved. A significant gap that has remained unexplored in the literature is how mathematics educators maintain or enhance student engagement and motivation upon transitioning to face-to-face or hybrid classes in the post- pandemic era.

Keywords: mathematics education, student engagement, student motivation, engagement theory, post-pandemic.

GJHSS-G Classification: LCC: LB1025-1050.75

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I. Introduction

Over three years have passed since the onset of the Coronavirus 2019 (COVID 19) pandemic. The sudden onset of the pandemic has caused educational institutions around the world to shut down, with many transferring their classes from face-to-face settings to the onlinemode of delivery in an instant. The United Nations Educational, Scientific and Cultural Organization (UNESCO) reported that educational institutions in 185 nations had declared closure since April of 2020, thereby hindering the education of up to 1,542,412,000 students, which comprised 89.4% of overall enrolled learners around the world (Marinoni et al., 2020).

During these three years, mathematics educators across all levels have had to rapidly adjust to the mandated online education system.

Although online education has existed for years before the COVID 19 pandemic, it was only offered as an alternative mode in most institutions, with face-to-face classes being the mainstream mode of learning. The sudden shift to online education during the COVID 19 pandemic came without the chance for prior planning and without detailed guidelines or standards. As such, instructors and educational leaders had to develop their own online teachingstyles, select from a variety of online learning platforms, and establish their online learning environment, all within a short span of time (Albano et al., 2021). The emergency transition was then accompanied by several learning costs for students, such as poorer attention, reduction in study efforts, and unnatural social situations within the digital environment that served as obstacles to student learning (Gjerde et al., 2021). These early days of the pandemic were undoubtedly a difficult period for students and educators alike.

The transition to the online setting was purported to be relatively manageable for mathematics, as it is an abstract subject matter that does not necessitate a physical environment, laboratory, or equipment (Brunetto et al., 2022). However, a key issue faced by educators across all subjects and all levels, especially during the early days of the pandemic, was the reduction of student engagement and motivation within the online setting (Albano et al., 2021; Brunetto et al., 2022; Koh & Daniel, 2022). Online education presented substantial challenges regarding student engagement and motivation compared to the conventional face-to-face classroom because students were separated from their instructors by the computer screen.

Student engagement, defined as the student's level of involvement and interaction withthe lessons, has been purported to enhance student's active learning, which is essential in mathematics (Koh & Daniel, 2022). Active learning involves more practical and hands-on exercises that allow students to explore and make meaning out of the lessons. Student motivation, defined as the student's drive or desire to learn, has also been cited as a vital element for improving mathematics learning and performance (Nofriyandi & Andrian, 2022). In this concept paper, I discuss current knowledge regarding higher education students' motivation and engagement in mathematics, and highlight the research gap regarding how to maintain or enhance student engagement and motivation within the post-pandemic era. Recommendations for practice, policy, and theory based on the knowledge and information provided are also presented in this paper.

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II. Student Engagement and Motivation

In their Engagement theory, Kearsley and Shneiderman (1998) proposed that student learning is enhanced with meaningful engagement through interactions and worthwhile activities. Based on this theory, instructors can keep students engaged through strategies that involve collaboration, active learning, and projects that can make authentic contributions (Kearsley & Shneiderman, 1998). Various theories for learning motivation exist, such as the self- determination theory, which posits that humans are motivated by intrinsic and extrinsic factors (Gopalan et al., 2017). As such, students may be intrinsically motivated by their own desire to learn or extrinsically motivated by rewards such as obtaining good grades or recognition from educators and peers (Gopalan et al., 2017). Student engagement and student motivation have both been cited as significant factors for improving student success, retention, and program completion (Ní Shé et al., 2023; Nofriyandi & Andrian, 2022). Furthermore, since the emergence of new educational theories and technological advancements, the educational paradigm has leaned more towards student-centric ideals and practices over instructor centered ones, which calls for increased levels of student autonomy and engagement.

As social beings, humans learn best from each other through communication and cooperation (Engel et al., 2023). Students often relied on interactions with their peers and educators for support and motivation. Although all types of interactions were perceived to be meaningful for online learning, students' interactions with their peers appeared to be the strongest factor (Bolliger & Martin, 2020). The value of student-student interactions may be rooted in the sense of community, which is a valuable psychological aspect of online learning (Bolliger & Martin, 2020). However, with the pandemic and subsequent educational shutdown, students were forced to work in isolation away from their peers and educators, making it difficult to collaborate and maintain healthy social connections. A survey of 711 higher education staff and students from 41 different countries showed that loneliness and isolation were the most significant challenges they experienced during the COVID 19 shutdown (Leal Filho et al., 2021). Students especially missed having face-to-face interactions with their peers and educators (Leal Filho et al., 2021; Turan et al., 2022). As a university student in Turkey stated, "[online education] doesn't offer the interaction that face-to-face education does" (Turan et al., 2022, p.11). This lack of interaction may demotivate students from attending online classes or participating in online activities.

Educators deemed the atmosphere and circumstances of online education to be ineffective, leading to a more superficial form of student engagement wherein educators could not always feel the students' presence in classes (Brunetto et al., 2022; Sum & Oancea, 2022). For instance, university mathematics professors from different countries expressed feelings of estrangement during the start of the pandemic as they lectured for two hours without receiving any feedback from students, which was frustrating for them because they were used to the participative styles of teaching that are often used in complex abstract subjects such as mathematics (Brunetto et al., 2022). In previous face-to-face classes, mathematics educators were able to form groups of students to solve a mathematical problem, ask questions when necessary, and discuss the solutions as a class. However, these practices were made difficult in the online setting where student engagement was significantly reduced (Brunetto et al., 2022). Higher education students in a study involving 23 institutions across the United States have indeed reported significantly less participation in online classes than in their previous face-to- face classes (Wester et al., 2021). Educators are thus challenged to implement strategies that enable active interaction and engagement, such as group discussions (Engel et al., 2023). Unlike in the physical classroom, educators and students are separated from each other in the online classroom, thereby limiting opportunities for such strategies (Ahmad et al., 2022).

Mathematics educators, like their counterparts in other subjects, had felt the magnitude ofdistance not just from their students but also from their practice of teaching as they were unable to apply some of their established teaching strategies online (Albano et al., 2021). Students struggled to understand complex mathematical concepts in their online classes without the in- person guidance of their instructors, which led to disengagement and demotivation. Students were also undergoing major adjustments in various aspects of their lives, which may have left them with little energy and motivation for school. Furthermore, the emergency transition to online education has highlighted the social inequity in students, with many less privileged students having issues with lack of digital tools or skills for online education. Some educators expressed their worries that students who had trouble accessing or utilizing online education would be left behind and that this would lead to more pronounced inequity once everyone returns to face-to-face classes (Albano et al., 2021). Educators have thus had to discover or develop new approaches, strategies, or practices to improve student engagement and motivation, and to reach all students during the COVID 19 pandemic (Ahmad et al., 2022; Brunetto et al., 2022; Doño & Mangila, 2022; Hunter et al., 2022; Koh & Daniel, 2022).

Notably, some mathematics educators have indeed managed to establish strategies and practices that elicited better student engagement within the online setting during the pandemic (Brunetto et al., 2022;

Hunter et al., 2022; Koh & Daniel, 2022; Suripah & Susanti, 2022). Careand empathy were particularly vital aspects of mathematics education during this difficult time (Koh & Daniel, 2022). Mathematics educators provided much support to students through various methods, such as flexibility in requirements, online office hours, and prompt feedback (Barrot & Acomular, 2022; Doño & Mangila, 2022; Koh & Daniel, 2022). In fact, one study showed that interactions between educators and their students increased during the pandemic, supposedly because educators allowed more flexible online office hours and students did not have to physically travel to educators' offices (Wester et al., 2021). Prompt feedback and positive reinforcement were also highly valued during the pandemic, as students gained motivation from the appreciation shown by their educators (Doño & Mangila, 2022). These methods allowed educators to ensure that students kept in pace and were comfortable with the classes (Barrot & Acomular, 2022; Koh & Daniel, 2022; Wester et al., 2021). Especially during difficult periods of transition, such supports can make students feel that their instructors sincerely care about their learning and may thus be more engaged in their learning.

Educators also added personal touches to lessons, such as the injection of humor or the use of friendly and conversational tones to relay their care and empathy towards their students (Barnett & Cho, 2023; Barrot & Acomular, 2022; Koh & Daniel, 2022; McWatt, 2021; Menezes & Costa, 2020). As mathematics is often portrayed as a difficult and serious subject, mathematics educators believed that injecting humor is important to make the subject more appealing, improve teacher-student relationships, stimulate mathematical thinking and communication, and foster an overall positive learning environment (Menezes & Costa, 2020). The use of memes and emojis was particularly popular among educators in the online setting as it helped in making students feel more comfortable (Barrot & Acomular, 2022; Sum & Oancea, 2022). Educators also emphasized the value of sending light-hearted and encouraging messages with their students to establish the human connection and make up for the physical distance in online education (Barrot & Acomular, 2022; McWatt, 2021). Some students have expressed their appreciation towards educators who used up a small portion at the begin of each class to get to know their students and establish a personal bond with them (Barnett & Cho, 2023). With the burden of the pandemic beginning to ease in several areas, it is imperative that educators maintain the care, empathy, humor, and support given to their students as another potentially difficult period of transition and adjustment from fully online to face-to-face or hybrid classes isunderway.

III. Use of Technology in Mathematics Education

Mathematics is a subject that requires both creativity and critical thinking skills (Suripah & Susanti, 2022). Students must not only rely on rote memorization of mathematical laws and formulas but also think critically and creatively on how to apply them to solutions for mathematical problems. For this reason, teaching and learning mathematics can be difficult and tedious for many. The use of digital technologies in teaching mathematics, particularly those that offer interactive features, is one way to help students not only grasp the complex abstract concepts of mathematics but also activate their creativity and critical thinking (Ní Shé et al., 2023; Suripah & Susanti, 2022). In this way, students may be more motivated and engaged with the lessons.

Educators who have adjusted well to the online setting have begun to appreciate the advantages of technological advancements. For instance, the use of websites with multimedia features was found to improve student motivation to learn mathematics (Suripah & Susanti, 2022). Multimedia websites offered not only interactive features for better student motivation and engagement but also simplicity and easier accessibility compared to complex learning platforms (Suripah & Susanti, 2022). Some educators also noted that the online classroom allowed for a more balanced dynamic, wherein students who previously did not participate in discussions within the physical classroom felt more at ease and shared their ideas more in the online classroom (Hunter et al., 2022). This comfort brought by online education wherein student status had a much lesser effect on how students behaved brought about each student's individuality. Although Wester et al. (2021) have reported reduced overall student participation in online learning, it is possible that some students may find this setting more comfortable (Hunter et al., 2022). Moving forward, having the option of online education alongside face-to- face classes may be beneficial as an alternative for such students.

Technologies specifically designed for mathematics education, such as GeoGebra, Desmos, and Mathematica were also listed as potential tools for improving student engagement (Albano et al., 2021; Ní Shé et al., 2023; Suripah & Susanti, 2022). GeoGebra provides various resources for mathematics across all levels, with features such as spreadsheets, interactive geometry, and computer algebra systems, among others (Pope, 2023). Similarly, Desmos offers digital classroom activities for all levels, as well as various tools including a graphing calculator, scientific calculator, and geometry tools, among others. Notably, these two applications are free to download, which also makes them a valuable tool for reducing the inequity in online education (Pope, 2023). As a testament to the

usefulness of such technologies, an Italian mathematics educator shared how they utilized the Mathematica software to clearly write out mathematical procedures without using a graphic tablet (Albano et al., 2021). Such tools have been found to be beneficial for their pragmatic efficiencies in expediting computations and their epistemic value in strengthening students' mathematical understanding (Ní Shé et al., 2023). As more and more technologies for mathematics education continue to be developed, educators have more options to be creative with their lessons and explore various technological features whether online or in the physical classroom.

With the plethora of tools and software used in online education, students may be vulnerable to e-learning fatigue or the extent to which students become overloaded from being continuously immersed in technology (Reed, 2022). During the pandemic, students were unable to leave their homes, explore campus environments, or participate in outdoor activities. Instead, they spent most of their time in front of computer screens or tablets, which could then lead to e- learning fatigue. Based on a survey of 50 students from Historically Black Colleges/Universities (HBCU), students experienced various levels of e-learning fatigue during the COVID-19 pandemic, which then led to moderate to extreme stress and anxiety (Reed, 2022). In particular, the use of multiple learning platforms at the same time was purported to lead to digital fatigue in students (Sarangal & Nargotra, 2022). Students may have felt confused and overwhelmed with the constant switching between different online learning platforms, leading to their digital or e- learning fatigue. As useful as these digital tools can be, it is important for educators to find the right balance and consistency to avoid students' feelings of saturation or being overloaded with technology use.

The chat function of online media was further noted as a useful tool for online mathematics education as it allowed educators to not only provide support for their students in a comfortable manner, but also to obtain their feedback regarding the lessons (Barrot & Acomular,2022; Brunetto et al., 2022). The use of social media for online education was cited as a more student-centric way to reach students during the COVID 19 pandemic shutdown (Barrot & Acomular, 2022; Sum & Oancea, 2022). Student engagement was purported to be better in social media platforms compared to other learning systems as students regularly checked their notifications in social media outside of educational purposes (Barrot & Acomular, 2022; Sum & Oancea, 2022). Educators used social media to "go where students are, and not wait for students to come to where they are" (Sum & Oancea, 2022, p. 17). Some social media platforms even offered free data availability for better access to chat functions, which educators found to be useful especially for students with limited resources or poor internet connectivity (Barrot & Acomular, 2022). Other tools that higher education teachers used for improving student engagement in the online setting included online polling and breakout room discussions (Koh & Daniel, 2022). With these strategies and practices, mathematics educators appeared to have found comfort in the online setting for mathematics education. The next question thus arises from the current evidence: How do mathematics educators maintain or enhance student engagement and motivation with or without the help of digital technology upon transitioning to face-to-face or hybrid classes in the post-pandemic era?

IV. Current Research Gap

The post-COVID 19 era is a whole new period that includes a reintroduction of the pre- COVID 19 practices and the lessons learned from the COVID 19 educational shutdown. It is an era brimming with possibilities of new strategies, practices, and educational paradigms that educators may utilize to enhance higher education (Hunter et al., 2022). As institutions have begun to reintroduce face-to-face classes or shift to hybrid classes, there is a need to re-examine the approaches, strategies, and practices that have best served mathematics educators during the pandemic, and how they may be sustained or improved (Albano et al., 2021; Brunetto et al., 2022; Hunter et al., 2022).

Some mathematics educators in previous studies have expressed their desire to continue the strong working relationships and use of educational technologies that they have established in the online classroom during the pandemic as they transition back to the face-to-face or hybrid settings (Brunetto et al., 2022; Hunter et al., 2022; Sum & Oancea, 2022). Others have considered the pandemic as an opportunity to re-evaluate mathematics education and improve upon their practice (Albano et al., 2021). Some have actually found the situation to be liberating, as it gave them room to develop and apply new educational strategies and practices away from tradition (Albano et al., 2021). With the different insights, reflections, and plans of mathematics educators from the COVID 19 educational shutdown, the gap in the literature now lies ahead with how or if mathematics higher education will evolve come the post-pandemic era.

In a multinational survey of mathematics educators, participants highlighted the need for more research on how to teach mathematics in an engaging way (Bakker et al., 2021). More than the cognitive element of mathematics education, the educators expressed the need for educational approaches that can empower students, develop their identities, and allow them to appreciate the value of mathematics in their daily lives (Bakker et al., 2021). As we are entering

the post-pandemic era, these gaps in the literature need to be addressed to promote a smooth transition back to face-to-face or hybrid classes.

V. Recommendations

On account of the existing knowledge and research gaps regarding the role of digital technology on student engagement and motivation in higher education mathematics, I present some theoretical and practical recommendations for the post-pandemic era. The topics of student engagement, student motivation, and the use of technology in mathematics higher education are not necessarily novel. However, there remains to be a dearth in the literature regarding how these topics are interconnected (Ní Shé et al., 2023). Some underexplored factors in the field of mathematics higher education that could be addressed in future studies include assessment, program quality, learner support (Martin & Bolliger, 2022). Furthermore, in light of the current state of the world, it is imperative to examine these topics within the new lens of the post- pandemic era. Future researchers are encouraged to explore how mathematics educators restructure their lessons with the continued use of technology while maintaining the personal and human aspects of teaching as physical classes reopen (Sum & Oancea, 2022). Koh and Daniel (2022) also recommended further meta-syntheses or theoretical analyses of student engagement strategies used during the pandemic that could be relevant in the post-pandemic era.

Future researchers are encouraged to utilize qualitative approaches to elicit the experiences and perceptions of mathematics educators who have begun transitioning to face-to- face and hybrid classes in the post-pandemic era regarding student engagement and motivation. In their systematic review of learner satisfaction, which included student engagement and motivation, in higher education, Martin and Bolliger (2022) highlighted a dearth of qualitative studies. While previous researchers have identified factors for learner satisfaction, such as student engagement and course delivery, there is still a need to understand how mathematics educators utilize these factors to improve student learning.

Practical recommendations based on the existing literature include the adaptation of current best practices to face-to-face and hybrid classes. Although online office hours are no longer necessary due to the eased pandemic restrictions, mathematics educators may continue to keep open lines of communication for students who are still adjusting to the physical setting or still recovering from the effects of the pandemic (Doño & Mangila, 2022; Koh & Daniel, 2022). Mathematics can be a particularly challenging subject matter if students are unable to grasp the logic or concepts behind mathematical laws, formulas, and problems. Maintaining open communication outside of the classroom may help students feel more engaged and motivated as they can easily receive the support they need. Providing immediate feedback has also been cited as an important factor for student engagement during the pandemic (Ahmad et al., 2021; Doño &Mangila, 2022). With the return of face-to-face classes, mathematics educators can capitalize on this strategy in their physical classrooms, and allow students to process and reflect on the lessonsin real time.

The return of physical classes does not necessarily mean the end of online resources. With the advantages of technology use in education discovered during the pandemic (Brunetto etal., 2022; Hunter et al., 2022; Suripah & Susanti, 2022; Turan et al., 2022), mathematics educators may continue to utilize multimedia websites, asynchronous online resources and activities, or chat functions to keep students engaged outside of the physical classroom. When implementing synchronous classes, educators are encouraged to schedule them at the beginning of the day when students are still alert and attentive (Chen et al., 2020). Asynchronous tasks and activities may then be scheduled towards the latter part of the day. With this type of setup, students may be more engaged in each and every online activity given by the educators (Chen et al., 2020).

Educators should also strive to maintain a sense of community with their students regardless of the educational media used (Barnett & Cho, 2023; McWatt, 2021). Higher education students highly valued interpersonal aspects of online learning, such as virtual group discussions, group assignments, and peer interactions (McWatt, 2021). Barnett and Cho (2023) also recommended that educators quickly learn and use students' names and preferred pronouns, and have more personal conversations with their students so as to foster this sense of community. It should be noted, however, that these practical recommendations were made based on findings from studies conducted during the COVID 19 pandemic. As such, these findings may have been influenced by various external factors, including the crisis of the pandemic itself and students' oreducators' reactions to it (Turan et al., 2022). As the post-pandemic era moves forward, there may be more evidence upon which to base best practice recommendations on.

Nonetheless, educators should still strive to maintain their digital competencies in thetransition back to face-to-face classes, as it has proven to be an imperative aspect of students' learning success (Albano et al., 2021; Engel et al., 2023; Turan et al., 2022). As Italian educators in Albano et al.'s (2021) study expressed, educators themselves are lifelong students with the need for continuous learning in their discipline. This includes keeping up to date with the latest digital technologies for mathematics education and the ability

to utilize such technologies to promote student collaboration and self-regulated learning (Engel et al., 2023). It is also vital thateducators are able to teach and support students in using digital technologies that are more sophisticated so as not to discourage them (Ní Shé et al., 2023). With the myriad of educational technologies available in the modern era, it is imperative that educators remain knowledgeable and confident in not only using them but also guiding their students on navigating them.

In terms of policy, it is vital for educators to undergo continuous training on digital technologies for education to maintain their digital competence. The training should not only focus on improving educators' digital skills but also their confidence in utilizing those skills as many educators tend to underestimate their skills or choose not to explore the various digital options and software features for education (Brunetto et al., 2022; Inamorato dos Santos et al., 2023). Educator training should not be limited to knowledge and practices of online education, but also be focused on their beliefs regarding technology (Brunetto et al., 2022). This is especially important for older educators who may not feel comfortable using digital technologies (Inamorato dos Santos et al., 2023). If educators do not change their negative beliefs about digital technology use in education, the knowledge they obtain may be rendered useless and the practices they learned may not be implemented (Brunetto et al., 2022). It is imperative that educators' knowledge, beliefs, and practices regarding digital technologies and online education are targeted as a whole in training. Institutional policymakers are thus encouraged to continue promoting digital transformation in higher education as a way to cultivate educators' digital competencies and confidence (Inamorato dos Santos et al., 2023).

Policymakers are also encouraged to keep the option of online classes open for students who may be more comfortable with this setting. In line with this, Turan et al. (2022) recommended providing in-service training to enhance educators' competencies in terms of online education. These approaches, strategies, and practices discovered and enhanced during thepandemic era are not simply temporary remedies for the pandemic conditions, but can be adapted as improvements for mathematics higher education in the long run.

VI. Conclusions

The transition of mathematics education from face-to-face to online to hybrid settings from pre- to post-pandemic has served as a challenge for educators in terms of keeping their students engaged and motivated to learn (Brunetto et al., 2022; Sum & Oancea, 2022). The physical distance and lack of meaningful interactions in online education led to students' feelings of isolation and demotivation (Leal Filho et al., 2021; Turan et al., 2022). Mathematics educators, who are used to participative styles of teaching due to the complex and abstract manner of their subject, found it extremely difficult to keep their students engaged during this period (Brunetto et al., 2022).

Although educators have made effective use of technological advancements to address this challenge (Albano et al., 2021; Suripah & Susanti, 2022), the gap in the literature remains regarding how to maintain or enhance student engagement and motivation upon transitioning to face-to-face or hybrid classes in the post-pandemic era. Previous authors have noted the need to re-examine mathematics higher education approaches, strategies, and practices before and during the pandemic to arrive at an effective balance for the post-pandemic era (Albano et al., 2021; Brunetto et al., 2022; Hunter et al., 2022). More research is urgently required to obtain best practices for this new transition period.

Declarations

Availability of data and materials: Not applicable.

Funding: This research received no external funding.

Acknowledgements

To my family and friends.

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