

Choice in Blended Learning: Effects on Student Motivation and Mathematics Achievement

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Abstract: Over the past decade, there has been an urgent calling for the improvement of teaching and learning of mathematics. At that same time, research has provided promising findings in the value of self-regulation and choice on learning for student achievement. With the ever-increasing availability of resources for educators to support student learning, this study explores student motivation, learning strategies and learning associated with student choice in a blended learning environment. A quantitative quasi-experimental designed study revealed no significant difference in student motivation, learning strategies, or mastery of geometry content between groups of students.

INTRODUCTION

The effective learning of mathematics is crucial for students to acquire valuable life skills. Critical assessments point to the lack of student success in acquiring such skills, thus providing evidence of a need for improved mathematics education. Results of the 2019 National Assessment of Education Progress (NAEP) posted that only 34% of eighth grade students tested scored at or above proficiency (National Center for Education Statistics, 2019). In a study focused on the success and failure of community college students working towards associate's degrees, mathematics was identified as "a major stumbling block and gatekeeper area" (Hudesman et al., 2013, p. 2). As further support in the value of mathematics education, research conducted by Evans, Kochalka, Ngoon, Wu, Qin, Battista, and Menon (2015) revealed a relation between specific areas of brain structure and the numerical competency of children and adolescents. The researchers extend the study's significance in pointing out mathematical literacy as a key component in the foundation of "future academic and professional success in an increasingly technological society." (2015, p.11743)

Educators have the challenge and duty to meet every child's learning needs. In order to best meet those needs, teachers must serve as designers of the learning experiences rather than simply the main conduit of information. Effective lesson design not only helps in supporting student learning of mathematics, but it aligns with Iwuanyanwu's (2021) challenge that mathematics

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education must support the “avoidance of leading the learner to frustration, aversion, and ... hatred not only of mathematics as a subject but also ... of the teacher who handles mathematics” (Iwuanyanwu, 2021). Blended learning can equip educators with the most effective mix of tools to meet those needs as it can provide a variety of elements in a given learning experience. Reporting on a study of the effect blended learning had with secondary level science education, Longo (2016, p.35) pointed out that “by providing various approaches to learning, students are not confined to one ... style”, which is “particularly true when teachers allow for choice” (p. 35). Blended learning promises to be an approach that provides students with the opportunity of choice in their classroom learning experience, rather than being restricted to following a fixed path designed by an educator. Following fixed learning paths is an element of what Glasser (1998, p.540) would consider as obedient schooling as opposed to a more effective “useful education” aligned with the principles of Choice Theory. For this study, blended learning is defined as a purposeful mix of learning modalities, including but not limited to online tools, flipped model of lesson design, cooperative learning groups, and direct instruction.

LITERATURE REVIEW

A void exists in the literature regarding the effects of blended learning designs and strategies on student learning in secondary mathematics. While there are studies that provide support in the use of blended learning and choice as effective practices for students learning, not one is associated directly with blended learning and choice in secondary mathematics education. A study was conducted of college science courses in which students learned within a blended environment of videotaped lectures and in-class workshop time. Despite no significant difference found in summative assessment scores, students in the blended learning classes demonstrated higher levels of engagement compared to students in a more traditional learning environment (Baum, 2013). Staying with the theme of increased student engagement, in a study of secondary mathematics students, specifically two high school classes and one seventh-grade class, the blended learning experience followed a rigid flipped model that afforded students no choice of learning modality. Specifically, each student was assigned videotaped lectures to be viewed prior to class so that in-class time would be focused on students working and the teacher providing support and assistance as needed through monitoring (Hodgson et al., 2017). Overall, the research revealed a possible link between the flipped-model blend and student engagement. However, some of the results supported no difference between flipped and traditional classrooms, leading to a need for further study. Absent from this study was any type of student choice in the specific blend in the design of the learning experience.

There have been promising reports in the literature focused on student learning in college level courses as well. A study on the effects of blended learning and the flipped model used in the design of lessons in numerical methods courses at three engineering programs yielded noteworthy results. Specifically with respect to the identification of an enhanced understanding and a motivation for learning among students interviewed in focus groups (Clark et al., 2018,

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p.12). In analyzing interventions geared towards student success in mathematics, researchers pointed out that “the majority of ...interventions have emphasized content competency to the exclusion of ... self-regulatory strategies” (Hudesman et al., 2013, p.3). This identifies not only a need for self-regulatory strategies such as choice in learning interventions, but further research in its effectiveness as well. Findings from another study on college level students point to the conclusion that self-regulatory strategies purposely woven into various interventions contributed to successful learning of the objectives in a chemistry course (Zhao et al., 2014). The authors encourage a model of embedding self-regulatory strategies, with choice being among them, that are incorporated into the learning design for any content. Research of self-regulating strategies across many disciplines at the high school level, including reading, writing, science and mathematics, point out some positive effects in the overlap of aspects of metacognition and self-regulation, but concludes that more studies are warranted for content-specific research (Greene et al., 2015). Similar conclusions were found in a study of secondary physics students who demonstrated a positive efficacy and stronger confidence in solving mathematics problems if they followed metacognitive strategies throughout their learning and problem solving process (Di Camillo et al., 2020).

There is promising research regarding blended learning as an effective design for a wide range of learners. Research also supports the value of choice in the learning experiences of students and its relationship to motivation. When each of the middle school students was granted more autonomy through the offering of choice in unstructured physical education, a maximization of student motivation to engage in physical activities on a long-term basis was revealed (Kinder et al., 2020). Similarly, secondary chemistry students afforded the freedom to develop their own learning plans as well as choose their strategies to perform had increased levels of motivation and enthusiasm (Vogelzang et al., 2019). However, there is a significant lack of literature when it comes to student choice in the blended learning design. A similar need for research is in the area of secondary mathematics. This study provides a necessary step to fill that void in a way that would inform educators associated with such a critical area of learning.

The purpose of this study was to analyze the data associated with secondary mathematics students’ ability to make effective choices when given agency in a blended learning environment. In doing so, this research addresses the following questions:

1. What differences exist in attitudes about learning mathematics between students who have choice in blended learning paths compared to those without choice, as measured by a motivation and learning strategies questionnaire?
2. What differences in achievement in learning mathematics exist between students who have choice in learning paths compared to those without choice, as measured by a post-treatment assessment?

METHOD

Blended learning offers a wide range of tools and strategies to educators as they design effective learning experiences for students. Teachers have numerous choices to make in creating lessons to support the success of as many students as possible. One strategy educators can employ in this process is to put the choice of the modality of learning experience into the hands of the students themselves. Providing students with choice in their learning modality supports student agency, which “provide rich learning spaces for students and teachers” (Vaughn, 2020). Glasser’s choice theory (1998), a foundational piece to this study, provides learners with the opportunity to select from a menu of learning modalities. This research supports the notion that “with more choices and much less schooling, [students] may do very well” (Glasser, 1998, p.475). Bray & McClaskey (2013) support the assertion that student choice and voice are key elements to successful personalized learning models. By measuring the effect of the combination of blended learning tools and student choice in learning modality has on learning, educators gain valuable information to capitalize on the opportunity of providing students with the wide variety of learning modalities present among the online and more traditional tools.

Research Design

A quantitative, quasi-experimental design model, with two groups selected through convenient sampling, was used to address the research questions. Through a random selection process, one class was selected as a treatment group, while two other classes collectively served as the control group. A post-experiment questionnaire was provided to all assenting students, along with a common mathematics content assessment. Quantitative analyses were conducted on the results of the questionnaire and the assessment in alignment with each research question.

Setting and Participants

This study took place at a large suburban high school in northeastern United States. Participants were tenth-grade geometry students enrolled in the same course. To reduce variability, a convenience sample of three classes of geometry was selected, with the students placed in the classes through partially random assignment as part of the school’s scheduling program algorithm. The classes were similar in profiles in that they had the same teacher, they had comparable class sizes, 22, 22, and 23 respectively, with students from similar mathematics backgrounds, and were physically in the same classroom with identical resources. Through a random number generator, one class was selected to be the treatment group, while the other two served collectively as the control group.

Instruments

All students and parents in the three classes were provided with appropriate assent and consent forms, respectively. All assenting students were issued an adapted version of the Motivated Strategies for Learning Questionnaire (MSLQ) (see Appendix A for the adapted versions) that relates to the purpose of this study (Pintrich et al., 1991). The MSLQ consists of Likert scale

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items with a range of indicators from 1 for “not at all true of me” through 7 for “very true of me.” Two specific sections of the MSLQ aligned to the research question were used in this study. The two sub-sections were on Motivation and Learning Strategies. A check for data integrity was supported through Cronbach’s alpha values ranging from .52 to .93, providing acceptable measures of reliability of the tool. Appendix B provides the specific MSLQ subsections that were used along with corresponding data. Additionally, students were administered a common departmental assessment to measure students’ learning of the content focused on during the timeframe of the study. This summative assessment was designed by certified mathematics teachers in this school to measure the level of understanding of content associated with right triangles identified by the Common Core State Standards for Mathematics (2010). Specifically, the standard of G-SRT: Similarity, Right Triangles, and Trigonometry was assessed by the tool.

Procedure

Assent was requested of all students in the three identified class sections for the study (see Appendices B and C for sample forms), along with consent from their parents or guardians. Anonymity was secured through the use of Google Forms to collect the questionnaire responses without collecting student identifiable email addresses. Over the course of the school year, students in all of the geometry classes at this school gained experience with blended learning modalities through a number of units of study developed as part of routine practice by the teacher. The lessons, specifically the learning tools, modality, and sequence of experiences, were designed by the classroom teacher. Each consisted of online, interactive programs for instruction, review, and/or assessment, along with in-person experiences through methods such as cooperative group learning, individual focused sessions, teacher-led mini-lectures (approximately 20 minutes in length) and modeling sessions. In previous lessons leading up to the study, students experienced each of the methods of learning that were ultimately among the choices for the experimental group or assigned as part of the control group.

To begin the unit of focus for the study, namely on the content standard of Similarity, Right Triangles, and Trigonometry, the students in the treatment group were provided the opportunity to choose their own learning path from a menu of offerings developed by the teacher. The menu consisted of the following choices: student works individually with personal control of resources that include online tutorials, interactive applets, paper-based instruction and practice with feedback from peers or teacher; student works in a small group with similar control of the afforded resources; or student works in small group that is led by the classroom teacher as far as which resources are used and when. In order to facilitate the students’ selections, the classroom teacher arranged the classroom based on the menu choices. At the conclusion of the four days, all participating students completed the questionnaire via Google Forms and the post-assessment of their mastery of the content through the departmental paper-based assessment. The post-assessment, designed by a professional learning community of Geometry teachers at the school, was administered to all students in the class, with results for the study participants extracted for analysis.

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Meanwhile, the students in the control group experienced learning of the same concepts in the focus unit in a similar manner in which they had all school year leading up to this study, which was teacher-designed with a variety of teacher-led lecture, workshop, online self-directed, flipped, and cooperative group modalities. The learning paths for the control group were designed and maintained throughout the study by the teacher, without any student choice. At the conclusion of the first four days of the focal unit of this study, all participating students in the control group completed the questionnaire via Google Forms and were assessed of their mastery of the content through the departmental paper-based assessment in the same manner as the treatment group.

Data Analysis

At the conclusion of the first four days of the unit, when the treatments were applied, both the experimental and the control groups were administered the appropriate portions of the MSLQ. Results were analyzed for significant differences in student perceptions pertaining to each subsection of the questionnaire, namely motivation and learning strategies. Two separate two-tailed *t*-tests were conducted to check for significant differences among groups. The first *t*-test compared the difference in levels of motivation and satisfaction of learning styles from students who had a choice in their learning paths against those who did not. The second *t*-test compared the difference in content and skill assessment results between the students who had choice in their learning paths and those who did not. All data were screened for missing values, revealing that there were two students in the control group who responded to the questionnaire, but did not take the content assessment during the time of the study.

RESULTS

Research Question 1: What differences exist in learning mathematics between students who have choice in blended learning paths compared to those without choice, as measured by a motivation and learning strategies questionnaire?

Analysis was conducted on the data to address each of the research questions via a two-tailed *t*-test for difference in means between the students who had choice in their learning paths and the students who did not. The mean score for each student was determined by taking the mean value of the 19 questionnaire prompts that measured motivation. The scores from the questionnaire associated with students' motivation in learning are as follows: The students in the treatment group, who had a choice of learning paths ($n = 7$, $M = 4.94$, $SD = 0.84$), were comparable to students in control group who had no choice in their learning path ($n = 21$, $M = 5.03$, $SD = 0.75$).

When the focus in the questionnaire was on learning strategies, the scores with the treatment students who had choice were as follows ($n = 7$, $M = 4.26$, $SD = 1.06$). The scores for the students in the control group are ($n = 21$, $M = 3.98$, $SD = 1.00$). The mean score for each student was determined by taking the mean value of the 17 questionnaire prompts that focused on

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students' learning strategies. Table 1 provides a concise listing of the results.

	Treatment				Control			
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>SE</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>SE</i>
Motivation	7	4.94	0.84	0.32	21	5.03	0.75	0.16
Learning Strategies	7	4.26	1.06	0.40	21	3.98	1.00	0.22

Table 1: Descriptive Statistics of Questionnaire

Trends in the data revealed that students who had a choice in their learning path scored lower on the motivation section of the survey ($M = 4.94$, $SE = 0.32$) than the students who were directed to follow the path designed by the teacher ($M = 5.03$, $SE = 0.16$). The difference, -0.09 , BCa 95% CI $[-0.889, 0.714]$, was not significant $t(26) = -0.25$, $p = .810$; additionally, it represented a small-sized effect, $d = 0.12$. Conversely, students who had choice in their learning path scored higher on the learning strategies portion of the survey ($M = 4.26$, $SE = 0.40$) than the students who followed the teacher-designed experience ($M = 3.98$, $SE = 0.22$). The difference, 0.28 , BCa 95% CI $[-0.737, 1.303]$, was not significant $t(26) = 0.62$, $p = .550$; however, it represented a larger effect than in motivation, $d = 0.28$.

Research Question 2: What differences in achievement in learning mathematics exist between students who have choice in learning paths compared to those without choice, as measured by a post-treatment assessment?

Results of the mathematics assessment are as follows: Students with choice in their learning path ($n = 7$, $M = 40.50$, $SD = 6.10$); Students in the control group who did not have choice as part of their learning experience ($n = 19$, $M = 41.16$, $SD = 7.29$).

	Treatment				Control			
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>SE</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>SE</i>
Content Assessment	7	40.50	6.10	2.31	19	41.00	6.69	1.67

Table 2: Descriptive Statistics of Content Assessment

Students who had choice in the design of their learning paths scored lower on the mathematics assessment ($M = 40.50$, $SE = 2.31$) than the students who were directed to follow the path designed by the teacher ($M = 41.16$, $SE = 1.67$). The difference, -0.66 , BCa 95% CI $[-6.824, 5.508]$, was not significant $t(24) = -0.23$, $p = .820$; additionally, it represented a small-sized effect, $d = 0.09$.

DISCUSSION AND CONCLUSION

There is insufficient evidence of a significant difference in the students' attitudes towards learning mathematics given a choice in their learning modalities based on the results of the

questionnaire. However, close analysis of the data provided valuable information. For example, the data showed that the students in the experimental group, which received both metacognitive experiences as well as the ability to choose their learning paths in a new unit, had the highest mean score in the learning strategies questionnaire. Findings contribute to the research that a blended learning model has a positive effect on students' motivation for learning (Yagci, 2016) and with a meta-analysis that revealed a positive correlation between students' metacognitive processes and their performance on academic tasks (Dent & Koenka, 2015). The lack of any significant difference between the groups may be attributed to the amount of choice afforded the students, supporting research that too many choices may contribute to added stress to the students in the learning process (Aiken et al., 2017). A more "collaborative" approach, as described in their research, offers choice in the design of the learning paths without overwhelming the learners in the process. The findings of this study and previous research strengthen the call to provide students with a quality education that includes choice as opposed to "coerced schooling" (Glasser, 1998).

For the second research question, the data demonstrated a lack of significant effect on the students' learning of mathematical content. This aligns with Cabi's (2018) research on students who used a specific blended learning version, namely the flipped classroom model, as compared to students who learned more directly from the classroom teacher. Conversely, Alsancak Sirakaya and Ozdemir (2018) revealed that students in a flipped-model learning environment achieved significantly greater than students in a more traditional blended learning environment. In this study, blended learning is defined as a purposeful mix of learning modalities. Perhaps the right mix is critical as seen when students, who learned the mathematics because they were required to prepare to teach it to others, demonstrated higher achievement in problem solving in mathematics than students who learned solely for themselves (Muis et al., 2015).

The research questions associated with this study focused on student motivation and learning strategies, as well as learning of content. Although neither question yielded a substantial effect, the study may have value in line with literature associated with student choice and its positive effect on adolescents' perceptions of autonomy (Williams et al., 2016).

The data indicated no significant differences between groups in measuring levels of motivation, learning strategies, and content knowledge. However, results are promising in that students who had a choice in their modality of learning did not suffer any setbacks with respect to their scores on summative assessments. Although this research strived to analyze the effect student choice in blended learning design has on student learning of mathematics, it does still recognize the value an effective mathematics teacher has on designing learning experiences for students. In this case, students who did not have a choice in their learning paths were not merely assigned a set of lessons in a random fashion. Instead, they experienced learning modules as designed by a certificated, experienced mathematics teacher who carefully matched the best methods they thought would help these specific students with the district curriculum. In either case, it would be wise to be prudent in the overall number of modalities within each choice offered so as to not overwhelm the learner. As indicated in research on the effects of the amount of modalities and

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online tools infused in lesson designs, Wang (2021) found that students with a lesser number of learning technologies performed better on assessments than those with too many tools (Wang, 2021).

Limitations of the study included the small number of students involved in the study, which may be a reason for the large margin of error in the statistical analyses. While this researcher was fortunate to find one teacher who had three classes of the same course, only a fraction of each of the classes assented to participate in the study. Students who did not provide appropriate assent were still included in the learning and assessment design, but did not complete the questionnaire. Furthermore, the duration of the study may have been too brief for any significant learning to take hold. Lastly, another limitation of the study is that it is only quantitative in structure for both research questions, therefore leaving a void in any informative anecdotal data and themes that may typically come from qualitative interview techniques.

Future Considerations

The limitations identified provide insights for considerations in any future research. Previous research, along with findings from this study, provide direction for future analysis regarding the value of student choice of blended learning design as a powerful, effective combination in the learning of mathematics. Expanding the duration of treatments designed to build students' self-regulatory development, along with the time for students to absorb and thoroughly learn the concepts, arise as key elements for future research designs.

Additionally, the inclusion of qualitative methods such as interviews of students will widen the breadth of information available to educators working to meet the needs of learners. The questionnaire used in this study did not gain access into the reasoning students had for their choices made in the learning paths, specifically what motivations they had for their selections. Similarly, students in the groups who had no choice were not asked about how they felt about being directed to follow a strict path designed by their teacher. Such insight from the learners would provide valuable depth to the current research available as well as constructive feedback for the educators involved in this study.

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