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Impact of Growth, Purpose, and Sense of Belonging (GPS) Mindset Intervention on Student Retention Rates in Asynchronous Mathematics Courses

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Abstract

This paper will study the effects of incorporating a Growth, Purpose, and Sense of Belonging (GPS) mindset intervention on student retention rates within asynchronous mathematics courses. Specifically, the research hypothesis suggests that integrating the GPS mindset intervention into these courses will yield a statistically significant improvement in student retention rates. To evaluate the impact, data were collected from Calculus III, Differential Equations, and Linear Algebra courses across multiple semesters—Fall 2018, Spring 2019, Fall 2022, and Spring 2023. Comparative analysis was performed to explore the effectiveness of the intervention. Preliminary findings from the study indicate that GPS mindset intervention plays a pivotal role in elevating student retention rates in asynchronous mathematics courses. These results contribute to the ongoing discourse on academic retention strategies and underscore the potential benefits of mindset interventions in educational settings.

Key Words: GPS mindset, growth mindset, purpose, sense of belonging, student retention

Resumen

Este estudio tiene como objetivo estudiar los efectos de incorporar una intervención de mentalidad de Crecimiento, Propósito y Sentido de Pertenencia (GPS) en las tasas de retención de estudiantes dentro de cursos de matemáticas asincrónicas. Específicamente, la hipótesis de la investigación sugiere que la integración de la intervención de mentalidad GPS en estos cursos producirá una mejora estadísticamente significativa en las tasas de retención de estudiantes. Se recopilaron datos de los cursos de Cálculo III, Ecuaciones Diferenciales y Álgebra Lineal a lo largo de varios semestres: otoño de 2018, primavera de 2019, otoño de 2022 y primavera de 2023 para evaluar el impacto. Se realizó un análisis comparativo para explorar la efectividad de la intervención. Los hallazgos preliminares del estudio indican que la intervención de estudiantes en cursos de matemáticas asincrónicos. Estos resultados contribuyen al discurso actual sobre las estrategias de retención académica y subrayan los beneficios potenciales de las intervenciones de mentalidad en entornos educativos.

Palabras clave: mentalidad GPS, mentalidad de crecimiento, propósito, sentido de pertenencia, retención de estudiantes

Introduction

Education is pivotal in shaping individuals' lives and preparing them for success in their chosen fields. Within mathematics education, exploring effective teaching strategies has been ongoing research to enhance student learning outcomes and retention rates. Asynchronous online learning has gained significant attention, especially after the COVID-19 pandemic, where remote instruction has become the new norm. In this context, it becomes crucial to investigate innovative approaches that can foster student engagement and retention.

The Growth Purpose Sense of Belonging (GPS) mindset has emerged as a promising educational intervention. While the GPS mindset has been widely explored in various educational contexts, its specific application and impact in asynchronous mathematics teaching in urban community colleges remains underexplored.

This paper aims to bridge this gap in the literature by examining the effect of implementing a GPS mindset intervention in asynchronous mathematics courses in an urban community college setting.

Carol Dweck's seminal work on the growth mindset (Dweck, 2006) emphasizes the role of students' beliefs about their abilities in shaping their academic achievement. Additionally, studies by Blackwell, Trzesniewski, and Dweck (2007) and Paunesku et al. (2015) demonstrate the positive impact of growth mindset interventions on student motivation, engagement, and academic performance.

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Furthermore, research by Hulleman and Harackiewicz (2009) and Oyserman (2007) underscores the importance of purpose and relevance in learning, suggesting that connecting academic content to real-life applications can enhance student interest and persistence. Moreover, studies on the sense of belonging, such as those by Good et al. (2003) and Walton and Cohen (2011), highlight the role of inclusive environments and supportive relationships in promoting student engagement and achievement.

Hypothesis

This study examined the use of GPS mindset intervention in asynchronous mathematics courses and its potential impact on student retention rates. Prior research has shown the positive effects that incorporating the GPS mindset in the classroom can have on student achievement and engagement. However, a larger body of research is needed to examine the impact of GPS mindset interventions, specifically in asynchronous mathematics courses. This study was undertaken to begin that research and discussion.

The hypothesis for this study was as follows: Implementing a GPS mindset intervention in asynchronous mathematics courses will significantly increase student retention rates. The study sought to test this hypothesis by comparing retention rates in asynchronous mathematics courses before and after implementing the GPS mindset intervention.

Literature Review

The literature on the GPS mindset in education is vast, covering many scholarly articles. This section will summarize key studies directly relevant to this paper.

General Application of GPS in Education

The GPS mindset has increased attention in education due to its potential to enhance student engagement, motivation, and learning outcomes (Canning et al., 2018; Good et al., 2012; Walton & Cohen, 2011; Blackwell et al., 2007; Hulleman et al., 2010). Growth mindset interventions, which focus on the belief that intelligence and abilities can be developed through effort and learning, have positively impacted academic achievement across various age groups and subject areas (Dweck, 2006; Yeager & Dweck, 2012). Purpose interventions, emphasizing the relevance and meaningfulness of learning tasks, also have demonstrated effectiveness in increasing students' motivation, persistence, and performance (Yeager et al., 2014; Hulleman & Harackiewicz, 2009). Moreover, fostering a sense of belonging within the learning environment has been linked to enhanced academic engagement, well-being, and achievement (Freeman et al., 2007; Strayhorn, 2012; Walton et al., 2015).

GPS in Mathematics Teaching

The application of GPS mindset interventions in mathematics education has yielded promising results in various educational contexts. Incorporating a growth mindset in mathematics teaching has been found to improve students' mathematical problem-solving abilities, motivation, and self-efficacy (Boaler, 2013; Blackwell et al., 2007; Good et al., 2003). Research also suggests that emphasizing the purpose of learning mathematics can help students appreciate its relevance to their lives, fostering greater interest and perseverance (Hulleman et al., 2010; Stipek et al., 1998).

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Creating a sense of belonging in mathematics classrooms, particularly for underrepresented or marginalized student populations, has been linked to increased participation, persistence, and success in mathematics courses (Rattan et al., 2012; Beilock et al., 2010; Wilson et al., 2015). Studies examining GPS mindset interventions in higherorder mathematics courses, in both two-year and four-year colleges, have revealed significant improvements in student retention, engagement, and achievement (Bettinger et al., 2013; Paunesku et al., 2015; Webber et al., 2013).

GPS in Asynchronous Mathematics Online Teaching

As online learning continues to expand, applying GPS mindset interventions in asynchronous mathematics courses has become an area of growing interest. Research has shown that fostering a growth mindset in online mathematics courses can improve students' self-regulation, motivation, and academic performance (Aguilar et al., 2014; Chen & Bembenutty, 2018). Purpose interventions in online learning environments have also demonstrated their effectiveness in increasing students' engagement and persistence in mathematics courses (Hulleman & Godes, 2010; Lam et al., 2014). Additionally, cultivating a sense of belonging in asynchronous mathematics courses can alleviate isolation and promote student success (Ali et al., 2014; Rovai & Wighting, 2005). Several other studies have explored the impact of GPS mindset interventions in online mathematics courses, reporting improvements in student retention rates, satisfaction, and achievement (Paunesku et al., 2014; Yeager et al., 2016; Walton et al., 2018).

My Contribution

This study on the effect of the GPS mindset in asynchronous mathematics teaching in an urban community college can significantly contribute to the growing body of literature in several ways. Few studies explicitly focus on the GPS mindset in the context of asynchronous mathematics classes, and my research aims to address this gap.

The following areas contribute to the novelty and relevance of this study:

1. Unique context: While the literature review covers research conducted in various educational settings, this study specifically focused on an urban community college. This unique context presents challenges and opportunities, such as diverse student backgrounds and varied levels of preparedness.

2. Longitudinal data: Data was gathered over multiple semesters to examine the GPS mindset's effect on asynchronous math teaching over time. Longitudinal data helps uncover trends and patterns not visible in one-time studies.

3. Post-COVID-19 era: The swift growth in asynchronous classes during and following the COVID-19 lockdown highlights the importance of my research. As schools adjust to remote and hybrid learning, studies on teaching methods like the GPS mindset are crucial for educators, administrators, and policymakers.

This study examined the impact of the GPS mindset in asynchronous math classes, a topic not widely covered in current research. Using long-term data and combining different research methods, I hope this paper will fill a gap in our understanding of the GPS mindset in online mathematics teaching in higher education.

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Methods

Participants

The study focused on students taking online math courses (Calculus III, Differential Equations, and Linear Algebra) at a college over four semesters: Fall 2018 and Spring 2019, before the introduction of the GPS mindset, and Fall 2022 and Spring 2023, after the GPS mindset was introduced. The courses were traditionally taught during Fall 2018 and Spring 2019 without any GPS mindset strategies. Then, starting in Fall 2022 and continuing into Spring 2023, the GPS mindset approach was implemented.

The purpose was to compare the outcomes of students from the two periods to assess the impact of the GPS mindset. Students from the first set of semesters (Fall 2018 and Spring 2019) acted as a control group, providing a benchmark against which to measure the effectiveness of the GPS mindset interventions introduced in the courses during the later semesters (Fall 2022 and Spring 2023).

Intervention

The GPS mindset intervention was implemented in the asynchronous mathematics courses during the Fall 2022 and Spring 2023 semesters. The intervention consisted of online modules and activities designed to promote the GPS mindset. The intervention materials were integrated into the regular course content and were accessible to students throughout the semester. Some samples and examples will be provided later in the article. The intervention was divided into three main components:

1. Growth Mindset (G).

- 2. Purpose (P).
- 3. Sense of belonging (S).

Various strategies were employed to address each component. Some examples are shown below.

Examples of GPS Interventions

Growth (G).

1. Throughout the semester, I carefully chose words to encourage a growth mindset in students. I avoided saying things like, "This course will be difficult." Instead, I used positive phrases such as "All students have the potential to succeed" and "At first, new topics can seem hard to everyone. But with enough practice, they become easier."

 Personal experiences were shared with students to encourage resilience in facing challenges. This included discussions about difficulties I faced as a student and strategies I used to overcome them.

3. The discussion forum was set up to create a welcoming space for students to freely talk about their struggles with tough courses in the past and share how they managed to succeed. I joined in these discussions, offering advice and support to the students.

 Throughout the semester, I identified different campus resources like the Academic Learning Center, the Black Male Initiative, and Accelerated Study in Associate Programs (ASAP). These offer free tutoring and extra support to students.

Purpose (P).

1. I created new lesson plans for each course, highlighting how the material applies in real life. Below are a few examples of these topics and applications. These examples show the variety of applications we used during the semester. Many of these real-world problems were turned into projects, playing a big part in the students' final grades.

Calculus III.

a) Utilizing polar equations to design artistic patterns and create visual art.

b) Employing cross and dot products in practical situations, such as calculating torque.

c) Applying geometry of space in computer graphics. Provides hands-on experience in using computers for three-dimensional graphing.

Linear Algebra.

a) Implementing linear algebra techniques in computer graphics.

b) Using linear algebra for image morphing applications.

c) Applying Singular Value Decomposition for image compression techniques.

Differential Equations.

a) Analyzing mixing problems and modeling pollution scenarios.

- b) Investigating logistic population growth patterns.
- c) Exploring the harvesting of fish populations to maintain ecological balance.

2. Students were urged to attend math and science events like seminars, Math Day, career events, and club meetings. These activities helped them learn and understand how math applies to the broader world.

Sense of Belonging (S).

1. We encouraged a welcoming and positive atmosphere during the semester. Students learned how to behave on discussion boards and how to give feedback. The board was regularly checked, and we stepped in when needed to keep things friendly.

2. Stereotypes and biases that emerged in discussions were addressed, ensuring that hidden prejudices were not left unchallenged.

3. Positive and constructive feedback was provided to students throughout the online modules. Students who exceeded the required minimum were recognized with extra credit, special mentions in the Learning Management System (LMS), and, in some cases, certificates of achievement.

The regular teaching approach without the GPS mindset intervention focused mainly on traditional methods, emphasizing algebra and mechanical calculations, and limited real-life applications and extracurricular activities.

Measures

Student retention rates were compared between the academic years Fall 2018 and Spring 2019, where no GPS mindset intervention was infused, and the academic years Fall 2022 and Spring 2023, where the GPS mindset intervention was implemented. Retention

rates were calculated for each course (Calculus III, Differential Equations, and Linear Algebra) in each semester.

Professional Development Training

Before implementing the GPS mindset intervention, the instructor received three months of professional development training during the summer of 2022 on infusing and implementing a GPS mindset in teaching. The intervention was then implemented during the Fall 2022 and Spring 2023 semesters.

Data Analysis

The provided data (Table 1 through Table 4) compares the student retention rates in asynchronous mathematics courses before and after implementing a GPS intervention. A more detailed statistical analysis is given below.

Table 1

Before GPS Intervention

Course	Semester	Retention
		Rate
Calculus III	Fall 2018	75%
Calculus III	Spring 2019	82%
Differential Equations	Fall 2018	46%
Differential Equations	Spring 2019	52%
Linear Algebra	Fall 2018	66%
Linear Algebra	Spring 2019	62%

Table 2

Statistics for Table 1

Statistics	Scores
Mean	0.638333
Standard Error	0.055403
Median	0.64
Standard Deviation	0.135708
Sample Variance	0.018417
Kurtosis	-1.18844
Skewness	0.007615
Range	0.36
Minimum	0.46
Maximum	0.82
Sum	3.83
Count	6
Confidence Level (95.0%)	0.142417

Table 3

After GPS Intervention

Course	Semester	Retention
		Rate
Calculus III	Fall 2022	90%
Calculus III	Spring 2023	100%
Differential Equations	Fall 2022	85%
Differential Equations	Spring 2023	80%
Linear Algebra	Fall 2022	90%
Linear Algebra	Spring 2023	95%

Table 4

Statistics for Table 3

Statistics	Scores
Mean	0.9
Standard Error	0.028868
Median	0.9

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Mode	0.9
Standard Deviation	0.070711
Sample Variance	0.005
Kurtosis	-0.3
Skewness	-8.3E-16
Range	0.2
Minimum	0.8
Maximum	1
Sum	5.4
Count	6
Confidence Level (95.0%)	0.074206

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Before implementing the GPS intervention (Table 1 and Table 2), the mean retention rate across all courses was approximately 64% (0.638333). The range, or the difference between the maximum (82%) and the minimum (46%) retention rates, was 36%. This indicates a substantial variability in retention rates among different courses. The standard deviation, another measure of variability, was around 13.6% (0.135708). This relatively large standard deviation suggests significant dispersion in retention rates around the mean. The skewness, a measure of the asymmetry of the probability distribution, was near zero (0.007615), indicating the data was fairly symmetrical. The kurtosis, a measure of the "tailedness" of the distribution, was -1.18844, suggesting a flatter distribution than a normal distribution. This means there were fewer extreme values than expected in a normally distributed dataset.

After the GPS intervention (Table 3 and Table 4), the mean retention rate was 90% (0.9), demonstrating a significant increase from the pre-intervention mean. The range of retention rates decreased to 20% (0.2), and the standard deviation reduced to around 7.1% (0.070711), suggesting a lower retention rate variability after the GPS intervention. The

skewness was effectively zero (-8.3E-16), showing that the data distribution remained symmetrical. However, the kurtosis increased to -0.3, indicating the distribution became less flat or more "normal," with the retention rates more clustered around the mean.

This statistical data supports the hypothesis that implementing a GPS mindset intervention in asynchronous mathematics courses significantly increases student retention rates. The mean retention rate significantly increased, the variability of retention rates decreased, and the precision of the estimated mean improved. These changes are consistent with the positive impact of the GPS intervention on student retention rates.

It is important to note that the observed improvements cannot be solely attributed to the GPS mindset intervention, as other factors may have influenced the outcomes. However, the consistent increase in retention rates across multiple courses and semesters strongly supports the conclusion that the GPS mindset intervention significantly enhanced student retention.

Limitations and Future Directions

Limitations:

Despite this study's promising results and contributions, it is essential to acknowledge certain limitations that should be considered when interpreting the findings.

1. Generalizability: This research was about online math courses at one school. The results might not apply to other places or subjects. We need more studies at different schools with various students to see if the findings hold elsewhere.

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2. Sample Size: The study had a small number of courses and participants. Although we tried to make it representative, having more participants and courses would make the results stronger and more widely applicable. Future research should aim for a broader selection of courses and more participants.

Future Directions:

1. Long-Term Studies: This study spanned four semesters, which might not fully capture the long-term effects of the GPS on student performance. Tracking progress was hard as some students took Calculus III, then Linear Algebra and Differential Equations in order, and many moved on to other universities after graduation. This made it tough to see their long-term retention. Thus, we need an experiment designed to understand better the lasting impacts of GPS on student retention rates.

2. Comparative Analysis of Various Teaching Modalities: This study didn't compare GPS interventions with other methods like online synchronous learning, hybrid models (mixing online and in-person teaching), or traditional classroom learning. Understanding how GPS impacts student outcomes differently across these teaching styles is important.

 Qualitative Research: Adding interviews or focus groups to the data would give us a better understanding of how students feel and think about the GPS mindset intervention. This approach can reveal how the intervention affects student retention and engagement.

4. Extension to Other Disciplines: Although this study looked at math education, future research should see how the GPS mindset works in other subjects. This would expand our knowledge of its benefits and help us understand its effects better.

Conclusion

In conclusion, the findings of this study provide strong evidence to support the hypothesis that implementing a GPS mindset intervention in asynchronous mathematics courses significantly increases student retention rates. The data analysis before and after the intervention demonstrates the positive impact of incorporating GPS elements into the teaching and learning process.

Thus, this paper contributes to the growing research on practical pedagogical approaches in online mathematics education, particularly for asynchronous courses. The results underscore the importance of integrating psychological factors, such as GPS mindset, into teaching practices to enhance student retention and success.

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