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Exploring Elementary School Students' Clusters in Blended Mathematics Learning

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Abstract: Blended learning is effective in enhancing meaningful learning in online and face-to-face learning environments. For adaptive learning supports, teachers should understand the diversity of students and identify student clusters with different educational needs in blended learning. This study explored the clusters of Korean students in a mathematics class, collecting blended learning data for one month. This study found three clusters: (1) students with the need for integrated support, (2) students with positive affective characteristics and high-level, self-regulated learning skills, and (3) students with high-level academic achievements and online learning participation. Thus, this study determined unique characteristics of Korean students that were typically overlooked by teachers.

Introduction

Blended learning can be effective to overcome the limitations of a traditional school system that does not sufficiently consider the diversity of students. Students have more autonomy in online learning activities because they can decide when, where, and how to learn, whereas teachers can provide adaptive support in face-to-face learning environments. To enhance the effectiveness of blended learning, teachers should understand the educational needs of students, which are the basis of differentiated instruction or personalized learning (Boelens et al., 2018). Learning analytics helps teachers effectively and timely identify the needs of students, using data collected from online learning platforms and digital devices. Teachers can explore student groups who share similar characteristics and behavior patterns to provide different learning tasks and adaptive support for each group (Han et al., 2021).

Although learning analytics is helpful for adaptive learning support in blended learning, previous studies have seldom explored clusters of elementary school students. Thus, it is necessary to investigate the diversity of elementary school students by analyzing multiple data sources such as academic achievements, online learning participation, affective characteristics, and self-regulated learning skills. In addition, there is a lack of research on East Asian students who may have different characteristics and educational needs from those in Western countries. To design personalized learning or differentiated instruction for Korean students, this study intended to explore clusters of elementary school students, using data collected from blended mathematics learning.

Methods

Participants

This study was conducted during the COVID-19 pandemic at a blended learning research school in Busan, South Korea. A total of 70 fourth-grade elementary school students participated in the study as part of their mathematics class, using the online learning platform MS Teams. All participants used a laptop provided by the government for online learning at school or home.

Data collection

This study collected data on mathematics learning (i.e., addition and subtraction of fractions) for four weeks. The data included academic achievements, subject interest (Sang et al., 2020), achievement emotion (Lichtenfeld et al., 2012), self-efficacy (Pintrich et al., 1991), self-regulated learning skills (Pintrich et al., 1991), and online learning participation. The surveys of affective characteristics and self-regulated learning skills had high reliabilities (Cronbach's alpha = .81 ~ .95). Data of online learning participation included the frequencies of submitted tasks, viewed tasks, and submitted quizzes.

Data analysis

The principal component analysis (PCA) was carried out to identify key components from data collected in blended learning. The PCA revealed four components: academic achievements, affective characteristics, self-regulated learning skills, and online learning participation. Using the four components, we conducted the two-

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stage cluster analysis including a hierarchical cluster analysis and a K-means cluster analysis. After finding three clusters, One-way ANOVAs and Kruskal-Wallis tests were carried out to investigate how the clusters were different from each other.

Findings

This study found three clusters of elementary school students regarding academic achievements, affective characteristics, self-regulated learning skills, and online learning participation. Cluster 1 (n = 35) had low grades (M = -.38, SD = .78), negative affective characteristics (M = -.63, SD = .7), low self-regulated learning skills (M = -.47, SD = .74), and low online learning participation (M = -.54, SD = .61). This cluster requires integrated support from an instructor because the students showed lower achievements in diverse aspects of blended learning than others. Cluster 2 (n = 20) had the highest academic achievements (M = .76, SD = .25) and actively participated in online learning activities (M = 1.14, SD = .63), but did not show high or positive results in affective characteristics (M = .15, SD = .78) and self-regulated learning skills (M = -.25, SD = .56). Cluster 3 (n = 15) had positive affective characteristics (M =1.26, SD = .43) and high self-regulated learning skills (M = 1.44, SD = .54), but their academic achievements (M = .37, SD = .64) and online learning participation (M = -.27, SD = .91) were not high. ANOVAs and Kruskal-Wallis tests showed that Cluster 1 had significantly lower academic achievements (H = 35.34, $p <$. 001) and more negative affective characteristics (F = 41.23, $p < .001$) than other clusters. Cluster 2 more actively participated in online learning than other clusters (H = 31.84, $p < .001$). Cluster 3 showed significantly higher self-regulated learning skills (F = 46.39, $p < .001$) and more positive affective characteristics (F = 41.23, $p < .001$) than other clusters.

Conclusion

This study determined three clusters of elementary school students in blended mathematics learning. The results indicated that students have different educational needs, requiring adaptive learning support and differentiated instruction. For Cluster 1, systematic support is necessary because students showed low achievements in diverse aspects of mathematics learning. Teachers and school counselors should collaborate to help students overcome the low achievements, which may be caused by instructional methods, mathematics curriculum, and family issues, as well as the COVID-19 pandemic. In addition, teachers should pay more attention to non-cognitive achievements of Cluster 2. The findings related to this cluster are consistent with the conclusion that Korean students show high achievements in mathematics but low confidence and interest (OECD, 2013). For Cluster 2, teachers should support their motivation by providing authentic tasks and enhancing their autonomy in blended mathematics learning. Teachers also need to explain and demonstrate self-regulated learning skills, such as how to plan, monitor, and control the learning process and environments. Lastly, teachers should encourage students in Cluster 3 to participate in online learning activities more actively. Teachers can provide feedback to prevent students from overestimating their participation and achievements, using the dashboard of an online learning platform. Future research is necessary to explore clusters of students in diverse contexts, to identify their educational needs and provide adaptive learning support.

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