LUMAT-B
International Journal on Math, Science and Technology Education

Research article

Comparing mathematics educational values of Turkish and South Korean students using a two-step cluster analysis

Yüksel DEDE[1], Hee-Jeong KIM[2] , Gürcan KAYA[3] and Veysel AKÇAKIN[4]

[1] Gazi University, Türkiye
[2] Korea University, Korea
[3] Afyon Kocatepe University, Türkiye
[4] Uşak University, Türkiye

Abstract: A part of a larger study, this study reports on a cultural comparison of mathematics educational values of Grade 9 students in Türkiye and Korea. Building on the premise that culture, on the one hand, shapes education and, on the other hand, is influenced by it, the study seeks to explore the differences and similarities in students' values concerning mathematics education in two somewhat different cultures, thus gaining a deeper understanding of these values from a sociocultural perspective. In this study, the mathematics educational values questionnaire of Dede and Barkatsas (2019)was used as a data collection tool. The data was analyzed using the two-step clustering analysis. The results showed that the Grade 9 students in both countries were divided into two groups regarding mathematics educational values. While the students in both countries were grouped, the practice value was the most important value when learning mathematics. In addition, it was also determined that, unlike students in Korea, the relevance value in Türkiye and the learning approach, feedback, and consolidating values in Korea were more important in grouping students. In addition, the information and communication technology [ICT] value was found to be equally important in determining the clusters of students in the two countries.

Keywords: cross-comparative study, mathematics educational values, Türkiye, Korea, grade 9 students, cluster analysis

Correspondence: ydede@gazi.edu.tr

1 Introduction

Culture is considered as ideas, communications, or behaviours that give a group of people a unique identity and are used to organize their own inner harmony and membership ties (Scollon et al., 2011). In this direction, education in all societies is not independent of culture, and each society aims to strengthen its members' ties with the society with an education system suitable for its own culture (Powe, 1993). Therefore, it can be said that this situation causes each society to have different socio-cultural elements. On the other

hand, learning mathematics in a country is a socio-cultural phenomenon, and mathematics learning and teaching activities are based on the common value system of that culture. In other words, students' mathematics learning may differ according to the socio-cultural context's shared values system. Therefore, understanding mathematics learning, academic achievement, and social and cultural approaches should be considered by students and society's culture. Therefore, it can be said that these different sociocultural approaches shape values, beliefs, goals, teaching methods, expectations, etc. This diversity of values and beliefs regarding mathematics education also causes education systems and expectations to differ according to country (An et al., 2006). In other words, mathematics values are important cognitive and affective factors that affect students' mathematics learning performance (Seah & Wong, 2012). In this context, the current study presented a small part of an extensive and ongoing project with cross-cultural comparison. In this context, the mathematics educational values of Grade 9 students in Türkiye and Korea, which differ considerably in factors such as culture, education system, language, and religion, were examined. Thus, it is aimed to reveal the possible similarities or differences between the mathematics educational values of the students in these two countries and to develop a rich and deep understanding of mathematics educational values from a sociocultural perspective.

1.1 Values, mathematics, and mathematics educational values

The concept of value is used with different meanings in different contexts (Seah & Bishop, 2000). Values are viewed as personal choices and decisions associated with individual standards for essential and valuable behaviours and preferences (Seah, 2003). Also, values might be considered "beliefs in action" (Clarkson et al., 2000). Seah (2003) also defined value as "an individual's internalization, 'cognitisation' and decontextualization of affective constructs (such as attitudes and beliefs) in his/her socio-cultural context" (p. 2). Bishop (1991), on the other hand, dealt with the values in mathematics classes in three categories: general educational values, mathematical values, and mathematics educational values. General educational values such as honesty, kindness, compassion, etc., help the development of individuals/students in society (FitzSimons et al., 2000). Mathematical values are classified as rationalism-objectivism, control-progress, and mystery-openness, which are related to the scientific discipline of mathematics, namely the nature of mathematical knowledge (Bishop, 1991). Finally, mathematics educational values refer to the values and norms arising from mathematics teaching and learning (Atweh & Seah, 2008). Although Bishop (1991) proposed the above classification for mathematical values, he did not make a classification for mathematics educational values because mathematics teaching can be differentiated between cultures (Seah & Wong, 2012). In this sense, in the current cross-cultural study, the mathematics educational values of students in both countries were compared with the mathematics educational values questionnaire developed by Dede and Barkatsas (2019). This questionnaire comprises six factors (relevance, practice, ICT, feedback, learning approach, and consolidating). Relevance is about any task in real-life mathematics; practice is about solving lots of math questions, examinations, and shortcuts of solutions; ICT is about the

use of technology in learning mathematics; feedback is about teachers' or peers'; learning approach is about the discussion in the learning environment; consolidating is about manipulatives and hands-on activities.

1.2 Purpose and importance of the study

The education system in a country can be better understood when compared with the education systems in other countries. Moreover, international comparative studies can shed light on education in general and learning and teaching mathematics and provide data for diagnosing and making decisions about student learning (Cai, 2006). In addition, international comparative studies can provide valuable information on what can be learned from educational settings and practices in different countries and cultures (Cai, 2007). As mentioned, Türkiye and Korea significantly differ in culture, education system, language, and religion (Hofstede et al., 2010), and their students' Programme for International Student Assessment [PISA] achievements are also quite different (Organisation for Economic Co-operation and Development [OECD], 2019). In this context, comparing the mathematics educational values of Turkish and Korean students can offer a different perspective and a rich understanding of mathematics education in these two countries and values education and value studies in mathematics education globally. Moreover, considering that values are a conative variable (Goldin, 2019; Seah, 2019) and conation is a bridge between cognition, emotion, and behaviour (Seah, 2019), the importance of the present study is thought to increase even more. This is because "conation encompasses individuals' experienced needs, drives, desires, goals, choices, and meaningful purposes, and how these are (or are not) fulfilled." (Goldin, 2019). Moreover, values as a conative variable greatly influence students' decisions about engaging in a mathematics task (Bishop et al., 2006). In this vein, this cross-cultural comparison study may provide a broad and rich understanding of the possible similarities and differences of mathematics educational values of student groups in two different cultures and education systems from a sociocultural and conative perspective, and it may also form a good basis for further research on the subject. Based on these considerations, this study aims to determine the characteristics of these groups regarding the mathematics educational values of Grade 9 students in Türkiye and Korea.

2 Methodology

This study is part of a larger ongoing project using a sequential explanatory mixed-method design. Since explanatory mixed-method studies involve examining and explaining quantitative data in more depth with qualitative data (Creswell & Plano Clark, 2017), some of the findings obtained from the quantitative data of the project in question are presented in this study; in this context, quantitative data was gathered using the survey method. Data were collected from 1313 Grade 9 students (933 students from Türkiye and 380 students from Korea). The data from both countries were collected considering the PISA 2012 regions within each country. Since Grade 9 students are at the beginning of

their high school education, they were chosen as the sample because their mathematics educational values reflect the values they brought from middle school education. The mathematics educational values questionnaire in Dede and Barkatsas's (Dede & Barkatsas, 2019) study was used as a data collection tool. For this purpose, the six factors (relevance, practice, ICT, feedback, learning approach, consolidating) structure of the mathematics educational values questionnaire was examined and verified by considering the structural, metric, and scalar invariances for both countries (Dede, Kim, et al., 2023). The data were analyzed with a two-step cluster analysis. Two-step cluster analysis is a hybrid approach that sequentially combines objects based on distance measurement to create homogeneous clusters and then uses a modified hierarchical probabilistic procedure (Gelbard et al., 2007; Sarstedt & Mooi, 2018). In this context, two-step cluster analysis can be considered a tool rather than an analysis, as it identifies previously unknown groups (Amato et al., 2015). In the two-step clustering analysis, an algorithm similar to the k-means method is applied in the first step, and the hierarchical approach is applied in the second step (Sarstedt & Mooi, 2018). In this way, this analysis can identify the latent relationships between individuals with certain characteristics (Amato et al., 2015). In this respect, cluster analysis was conducted to determine homogeneous participant groups with different profiles of relevance, practice, ICT, feedback, learning approach, and consolidating mathematics educational values. Mathematics educational values (relevance, practice, ICT, feedback, learning approach, consolidating) were determined as clustering variables.

3 Findings

Two-step clustering analysis was applied to create profiles of Turkish and Korean Grade 9 students according to their mathematics educational values (relevance, practice, ICT, feedback, learning approach, consolidating) (see Table 1).

Table 1. Individual distribution of cluster analysis results in Türkiye

Clusters	**n**	**% of Combined**	**% of Total**
1	417	45.5	44.7
2	500	54.5	53.6
Combined	917	100	98.3
Excluded	16		1.7
Total	933		100

Grade 9 students in Türkiye are divided into two clusters according to their mathematics educational values (see Table 1). There are 417 students (45.5%) in the first cluster and 500 students (54.5%) in the second cluster. 16 students (1.7%) were excluded from the analysis due to missing data.

Table 2. Individual distribution of cluster analysis results in Korea

Clusters	n	% of Combined	% of Total
1	129	35.9	33.9
2	230	64.1	60.5
Combined	359	100	94.5
Excluded	21		5.5
Total	380		100

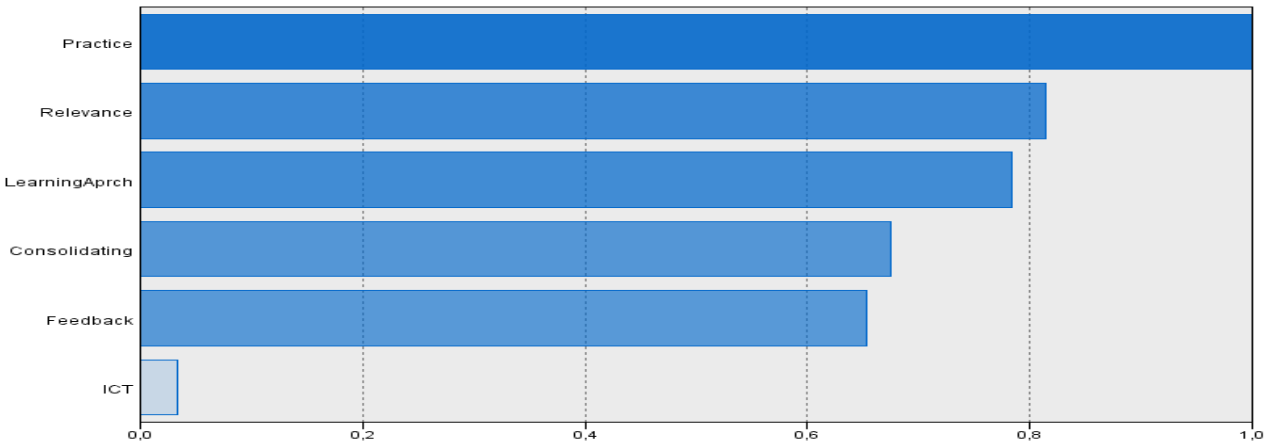
Grade 9 students in Korea were divided into two clusters according to their mathematics educational values (see Table 2). There are 129 students (35.9%) in the first cluster and 230 students (64.1%) in the second cluster. 21 students (5.5%) were excluded from the analysis due to missing data.

Table 3. Goodness-of-fit measure of Türkiye and Korea clusters

Clusters	Silhouette Measure of Cohesion and Separation	Cluster Quality
Türkiye	0.4	Fair
Korea	0.7	Good

The silhouette measure of fit and divergence, a general goodness-of-fit measure that indicates the solution quality of the clustering in the two-step cluster analysis, is given (Sarstedt & Mooi, 2018). Table 3 shows that the six independent variable cluster analyses in Türkiye and Korea are fair/good because the Silhouette measure of cohesion and separation measure indicates a fair value (0.4) for Türkiye and a good value (0.7) for Korea.

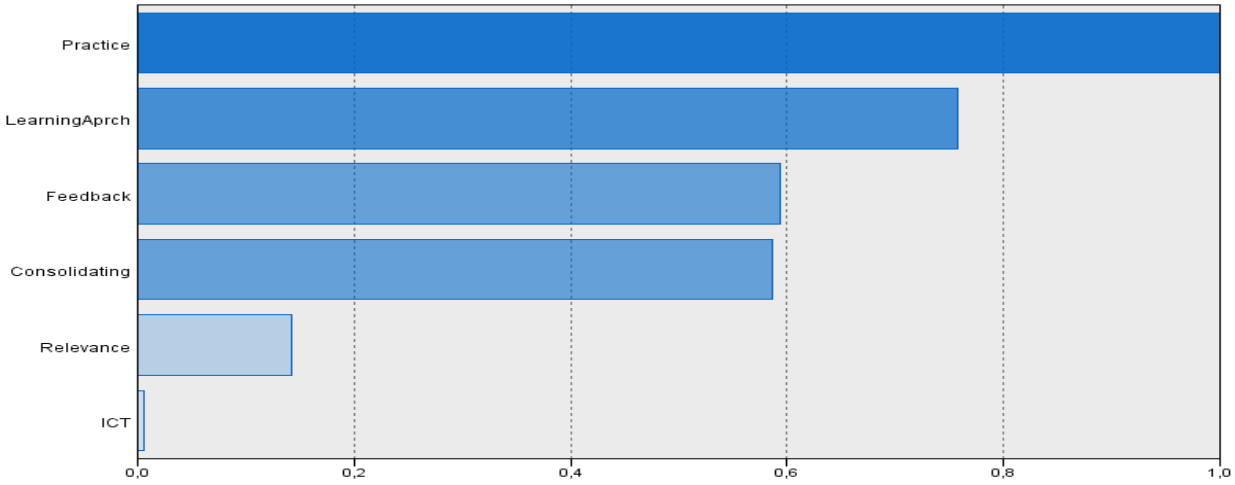
Figure 1. Important predictors of clusters of Türkiye about mathematics educational values



In Figure 1, the predictors of clustering solutions that emerged due to Türkiye's two-step clustering analysis are given in order of importance. According to the two-step clustering analysis results, the practice value emerged as the most important mathematics

education value while determining the clusters belonging to Türkiye's data. Other important values include relevance, learning approach, consolidating, and feedback values. The ICT value was determined to be the least important value in determining the groups.

Figure 2. Important predictors of clusters of Korea about mathematics educational values



In Figure 2, the predictors of clustering solutions resulting from Korea's two-step clustering analysis are given in order of importance. According to the results of the two-step clustering analysis, it was determined that the most important value of mathematics education was the value of practice while determining the clusters of Korean data. Learning approach, feedback, and consolidating values are other important predictive values. Relevance and ICT values were determined to be the least important values when grouping Korean students.

Figure 3. Mathematics educational values importance predictor levels of clusters of Türkiye and Korea

Turkey		
Clusters	1	2
Value predictors	Practice 2.01	Practice 1,31
	Relevance 2.93	Relevance 1.96
	LearningAprch 2.36	LearningAprch 1.60
	Consolidating 2.49	Consolidating 1.52
	Feedback 2.46	Feedback 1.44
	ICT 2.90	ICT 2.69

Korea		
Clusters	1	2
Value predictors	Practice 1.85	Practice 4.22
	LearningAprch 2.06	LearningAprch 4.03
	Feedback 1.99	Feedback 4.17
	Consolidating 2.08	Consolidating 3.95
	Relevance 2.60	Relevance 3.45
	ICT 2.73	ICT 2.86

In order of importance, the mathematics educational values used in determining the clusters within Türkiye and Korea according to the two-way clustering analysis are given in Figure 3 to allow for comparison between countries. Accordingly, students in Türkiye and Korea were divided into two clusters according to their mathematics educational values. As can be seen in Figure 3, it has been determined that the most important value of mathematics education in dividing students in both countries into two clusters is the value of practice. In addition, it has been determined that practice value is a more important predictor of the grouping of students in Korea than their Turkish partners. In other words, students in Korea want more practice in learning mathematics than students in Türkiye. In addition, learning approach, feedback, and consolidating values were important predictors of mathematics educational values for both countries. On the contrary, relevance value was found to be a less significant predictor in grouping students in Korea than in Türkiye. On the other hand, while the relevance value is more important in the grouping of students in Türkiye, the feedback value has emerged as a less important predictor. In other words, students in Korea expect more feedback from their teachers or peers in mathematics teaching than students in Türkiye. In addition, students in Türkiye want to see their lessons more related to daily life. In this context, practice value is more important in grouping students, and relevance value is less important for Korean students than Turkish partners. Also, it can be seen in Figure 3 that students in both countries give equal importance to ICT value.

4 Discussion

The results of this study showed that Grade 9 students in Türkiye and Korea were divided into two homogeneous groups according to their mathematics educational values. In this context, practice value emerged as the most important predictor for the Grade 9 students of both countries to be divided into two homogeneous groups. Similar results have been observed in various studies (Aktaş et al., 2021; Dede, 2019; Dede, et al., 2023; Dede & Barkatsas, 2019). In these studies, Turkish students generally see the practice value as the most important value among mathematics educational values. Compared to Türkiye, the practice value is a more important predictor in Korea. However, mathematics education in Korea focuses on teacher-centred mathematics content and emphasizes practice (Pang, 2009). Moreover, since students in Türkiye take high school and university exams, they prepare for these exams by solving as many mathematics questions as possible. As a reflection of this, it can be said that students in Türkiye want to practice less in mathematics lessons than their Korean counterparts. As a consequence of this situation, it can be said that practice value is a less important discriminator for Turkish students than for their Korean counterparts. On the other hand, the relevance value was a more important predictor than the learning approach, feedback, and consolidating values in grouping students in Türkiye. In parallel with this study, in the study of (Pang & Seah, 2021), it was determined that Korean students attach importance to the fact that mathematics is related to daily life. In the current study, the relevance value emerged as a less significant predictor than Turkish students for dividing Korean students into two

homogeneous groups. In other words, most Korean students see mathematics as a connection with daily life compared to their Turkish partners. One of the reasons for this, seen from the PISA results, is that teaching mathematics in Korea supports meaningful learning, so students learn mathematics by making connections (Pang & Seah, 2021). On the contrary, in Türkiye since 2005, although a particular emphasis has been placed on teaching mathematics interdisciplinary, connecting it with daily life and in mathematics curricula, and although there have been some positive developments in recent years, as can be seen from the PISA results, meaningful and relational learning can be said not to have been fully achieved. Despite the strong emphasis on learner-centred learning in the Turkish curriculum since 2005, one reason why students may want to see maths more related to everyday life may be that teachers tend to focus on test preparation due to the competitive examinations for which students are preparing.

If the values for practice and relevance are considered together, it can be said that this situation is in line with the results of international competitive examinations (PISA, Trends in International Mathematics and Science Study [TIMMS]). Considering the nature of PISA and TIMMS questions related to daily life and the high success of South Korean students and the low success of Turkish students in these exams, one reason why South Korean students want more practice and Turkish students want the relevance of maths to daily life to be included in their maths lessons may be that South Korean students' maths lessons are mostly related to daily life and, as noted above, maths lessons in Turkey are mostly about practice.

Learning approach, feedback, and consolidating values were more important predictors for students in Korea than for students in Türkiye. A reason for this might be that students in Korea have a high tendency to accept teachers' authority in classrooms (Pang & Seah, 2021), given that Korea attaches importance to the power distance index (Hofstede et al., 2010) and cultural factors that shape values (Seah, 2019). In addition, Xiaoqing, Sichang, and Daejung (2015) stated in their study that students in Korea are affected by extrinsic motivation. Considering that teachers are one of the most important sources of external motivation for students and who give feedback to students in the classroom, this result may be a reason for some students in Korea to put more emphasis on the feedback, learning approach, and consolidating values, which are also related to teachers. The ICT value in both countries emerged as the least practice value in dividing the countries into two homogeneous groups. One of the reasons for this may be that students do not have difficulty accessing technology due to the rapid spread of technology worldwide. Therefore, ICT value is not distinctive among students in both countries.

5 Conclusion

On the other hand, the current study was carried out with a two-way cluster analysis, considering the six value dimensions in the mathematics education values questionnaire of Dede and Barkatsas (2019). In this regard, cross-cultural qualitative studies that can reveal the possible reasons underlying these values (which can reveal different mathematics educational values, if any) and use different analysis methods can be recom-

mended here for further research. However, Clarke (2013) stated that there are some dilemmas in international comparative studies, such as overlooking some details specific to cultures to make comparisons. In this context, ensuring measurement invariance for both countries in the mathematics educational values questionnaire in this study can be said to be shown that the questionnaire items are culturally understood in the same way by the students of the two countries. In addition, the fact that the scale items are understood from the same perspective by students in both countries can be said to be indicated that the linguistic and measurement dilemmas mentioned by Clarke (2013) have been overcome. Since this study is a small part of a large ongoing study, it is thought that artificial differences that may arise under the compulsion of comparability can be overcome since the situations that reflect the characteristic differences of cultures in values, even if small, will emerge with the qualitative data obtained from both countries. In addition, the current study is limited to identifying and comparing the groups of mathematics educational values of only Grade 9 students in both countries. In this context, it is thought that further research that will reveal how the mathematics educational values of students at different grade levels in the same culture are grouped may offer a different perspective to the relevant literature.

Research ethics

Author contributions

Yüksel Dede: Conceptualization, investigation, methodology, project administration, supervision, writing—original draft preparation, writing—review and editing

Hee-Jeong Kim: Conceptualization, investigation, methodology, project administration, supervision, writing—original draft preparation

Gürcan Kaya: Investigation, data curation, formal analysis, writing—original draft preparation, writing—review and editing

Veysel Akçakın: Visualization

All authors have read and agreed to the published version of the manuscript.

Funding

The study was supported by grants from the Scientific and Technological Research Council of Türkiye [TÜBİTAK] and the National Research Foundation of Korea [NRF] bilateral project (Grant No: 221N088). Any opinions expressed herein are those of the author and do not necessarily represent the views of the TÜBİTAK and the NRF.

Informed consent statement

Informed consent was obtained from all research participants.

Data availability statement

The data is unavailable due to privacy or ethical restrictions.

Acknowledgements

The study was supported by grants from the Scientific and Technological Research Council of Türkiye [TÜBİTAK] and the National Research Foundation of Korea [NRF] bilateral project (Grant No: 221N088). Any opinions expressed herein are those of the author and do not necessarily represent the views of the TÜBİTAK and the NRF.

Conflicts of Interest

The authors declare no conflicts of interest.

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