J. Korean Soc. Math. Ed. Ser. D. (2022) 25(1), 21–43 ISSN 1226-6191
https://doi.org/10.7468/jksmed.2022.25.1.21 Online ISSN 2287-9943

RESEARCH ARTICLE

Cultural Affordance, Motivation, and Affective Mathematics Engagement in Korea and the US

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Received: July 12, 2021 / Accepted: March 8, 2022 / Published online: March 23, 2022

Abstract

Investigating the relationship between intrinsic and extrinsic motivation and their effects on affective mathematics engagement in a cultural context is critical for determining which types of motivation promote affective mathematics engagement and the relationship with cultural affordance. The investigation in the current study is comprised of two dependent studies. The results from Phase 1 indicate that attitude and emotion are better explained by extrinsic motivation, while self-acknowledgment and value are better explained by intrinsic motivation. The results of Phase 2 indicate that the Korean sample has greater extrinsic motivation, attitude, and emotion, while the U.S. sample has greater intrinsic motivation, self-acknowledgment, and value. The key outcome for this research is that disentangling cultural affordance from the emotional and cognitive structures is impossible.

Keywords Cultural affordance, Motivation, Intrinsic motivation, Extrinsic motivation, Affective mathematics engagement

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I. INTRODUCTION

Affective mathematics engagement, which refers to the situational affective state that students feel during their mathematics learning process (Lee, Capraro, & Bicer, 2019), is a key outcome used for assessing the effectiveness of an educational system in a given country. Educational researchers have expressed an increased interest in affective mathematics engagement as a means to identify factors to improve students' mathematical academic achievement given its high correlation with students' affective domains (Hammouri, 2004). Teaching and learning in mathematics are formulated and maintained on the basis of affective mathematics engagement. In particular, effective learning encompasses curriculum or teaching methods as well as students' affective mathematics engagement (Fredricks, Blumenfeld, & Paris, 2004).

Motivation entails positive activation of affective mathematics engagement through directed attention and impulses to action. Affective mathematics engagement is the most direct link to motivation, since it is manifested either in positive or negative feelings, depending on how the student's learning situation aligns with their motivation (Hannula, 2006). In the process of salient affective-cognitive mathematical learning, students are constantly engaged with mathematical learning tasks through motivation. Motivation relates to the desire to engage with the tasks and is a key variable of students' affective state in their unique mathematical learning situation.

Affective mathematics engagement and motivation among students are heavily impacted by their cultural context, which is referred to as cultural affordance (Kitayama & Markus, 1999). Therefore, the current study investigates the relationship between motivation and affective mathematics engagement in the cultural context. Since most of the extant research comparing East Asian culture and Western culture has dealt with the cases of China or Japan (Lin, McKeachie, & Kim, 2003), it would also be useful to assess whether students' motivation and affective mathematics engagement in Korea is similar to that of U.S. students. This study includes two distinct phases: Phase 1 analyzes the hypothesized model about the correlation of motivation with affective mathematics engagement, and Phase 2 shows the differences between Korea and the US regarding students' motivation to learn mathematics and their affective mathematics engagement.

II. THEORETICAL FRAMEWORK

For the purposes of this study, we adopted the affective mathematics engagement framework proposed by Lee et al. (2019), which consists of (1) attitude, (2) emotion, (3) self-acknowledgment, and (4) value. The motivation framework proposed by Vallerand (1997) encompasses two components: (1) intrinsic motivation and (2) extrinsic motivation. These components are formed by social and cultural factors at the appropriate level of generality. In particular, the current study focuses on educational culture differences between Korea and the US.

Affective Mathematics Engagement

Attitude. Research concerning attitude may have the longest history within the field of affective mathematics engagement. Attitude has been defined as an emotional disposition in particular contexts (Debellis & Goldin, 2006; Hannula, 2006). The construct of attitude was initially developed within the context of social psychology as an individual’s behavior in a certain context. One’s attitude is organized through experience and is directly exerted on all objects and situations in mathematical learning (Pickens, 2005). Therefore, attitude has an explicit relationship with behavioral engagement (Hannula, 2006) and cognitive engagement (Majeed, Darmawan, & Lynch, 2013). Students who possess a positive attitude regarding mathematics might exhibit positive behavioral engagement, such as actively seeking solutions to mathematics problems, or cognitive engagement, such as through mental processes and openness (Majeed et al., 2013). Attitude represents aggregated measures of other constructs of affective mathematics engagement, such as emotion, value, and self-acknowledgment (Hannula, 2002; Iji, Abah, & Anyor, 2018; Lee et al., 2019; Rahmawati & Husain, 2017). For example, students who are aware of the value of mathematics for their future career choice might have a positive attitude towards learning mathematics, which is represented through their active communication with peers or efforts to solve problems. During students’ learning processes, mathematical self-acknowledgment related to a particular cognitive component leads them to recognize their emotion toward their mathematical understanding. This recognition of their own understanding and feeling influences their attitude. In turn, this manifestation of attitude dynamically encourages or discourages students during the learning process (Hannula, 2006; Zan & Di Martino, 2003).

Emotion. Emotion is defined as a rapidly changing feeling during an activity. Students’ interpretations and appraisals of specific situations are the basis of their emotion (De Bellis & Goldin, 2006; Op’t Eynde & Turner, 2006). Students vary in terms of personal factors, such as age, gender, and culture, as well as situational factors regarding mathematical activities and their teachers and peers. These personal and situational factors continuously develop and influence students’ emotion. Since emotion is contextualized based on students’ personal and situational factors, it can be unstable. In the same context, emotion is regarded as functional as it is critical for human coping, adaptation (Buck, 1999), and decision-making (De Bellis & Goldin, 2006). Emotion has been considered the most fundamental process among affective mathematics engagement constructs because it impacts the other constructs (i.e., attitude, self-acknowledgment, and value). Furthermore, emotion is an evaluation of a student’s goals in a mathematical learning situation (Hannula, 2002; Hannula, Evans, Philippou, & Zan, 2004). While students are engaged in mathematical activities, working towards achieving goals induces positive emotion while blocked progress induces negative emotion. These processes are called self-acknowledgment (DeBellis & Goldin, 2006). Mandler’s constructivist approach (1989) considers that emotion is initiated by attitude and value toward a discrepancy of an expected schema. Moreover, attitude and value about mathematics impact students’ evaluation about whether the mathematical learning is well accorded with their goals (Hannula, 2002).

Self-acknowledgment. Self-acknowledgment refers to affect toward cognition in a mathematical situation, and in this context, it is defined as an individual’s affective posture to acknowledge sufficiency or insufficiency of mathematical cognition (DeBellis & Goldin, 2006; Furinghetti & Morselli, 2007). Students develop their own feelings regarding cognition and cognitive processes in a mathematical situation by employing affective self-states. The students consider whether they can understand the problems, whether they are competent or incompetent problem solvers, whether they expect success or failure in solving problems, and their feelings about the problems and knowledge such as puzzlement, bewilderment, frustration, pleasure, elation, or satisfaction (Goldin, 2000). Self-acknowledgment is influenced by the other affective mathematics engagement constructs in several ways. For example, attitude, emotion, and value bias students’ attention and memory in their learning situation (Power & Dalgleish, 1997). Moreover, students who are aware of the value of mathematics and their attitude and emotion towards their goals while they are learning mathematics reflect on and activate their tendency to control cognitive processes (Hannula, 2002). Positive or negative attitude, emotion, or value often induce self-acknowledgment regarding students’ approach to their learning goals. As a result, strong relationships between self-acknowledgment and understanding of cognition can influence students’ academic success.

Value. Value refers to personal truth or commitment towards mathematics. From the macroscopic perspective, value is inherently present and pivotal in establishing a student’s sense of personal and social identity regarding mathematics (Bishop, 2008; Eccles & Wigfield, 2002). The Organization for Economic Cooperation and Development (OECD) has demonstrated the importance of value for students’ affective mathematics engagement below:

> Mathematical literacy is an individual’s capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of that individual’s life as a constructive, concerned and reflective citizen (OECD, 2003, p. 24).

From the microscopic perspective, value exerts a crucial impact on affective engagement in mathematics classrooms. Students’ value of mathematics encompasses a large portion of affective engagement and disengagement in mathematics activity (Bishop, 2008; Wigfield & Eccles, 2000). Therefore, to maintain positive affective mathematics engagement, students need to be encouraged to have positive value during a mathematical learning process. Furthermore, the affective mathematics engagement construct of value is related to the other constructs (i.e., attitude, emotion, and self-acknowledgment). Students who have a positive value towards mathematics focus on priorities and choices during mathematics learning processes. They define their priorities based on attitude, emotion, and self-acknowledgment during mathematical learning situations, and they make mathematical choices depending on their priorities (Op‘t Eynde & Turner, 2006). Value also helps students to set short- and long-term learning goals, and it motivates them to pursue such goals (Deci & Ryan, 1985). Therefore, to maintain value, students need to be exposed to positive attitude, emotion, and self-acknowledgment.

Motivation

Intrinsic motivation. Students' experience in their learning process impacts their intrinsic motivation. Intrinsic motivation is related to exploring and understanding mathematical concepts and having an intrinsic curiosity regarding mathematical learning and knowledge (Harter, 1981). Students' intrinsic motivation is developed when they attempt to create new connections between mathematical concepts or accomplish mathematical tasks (Vallerand, 1997). In particular, intrinsically motivated students were previously surrounded by an atmosphere in which they could freely investigate given tasks without competition or mastery (Matsumoto & Sanders, 1988). When students' tasks are based on intrinsic motivation, the results are positive psychological consequences.

Intrinsically motivated students tend to engage in their mathematical learning situation when they have an internal feeling of enjoyment and satisfaction. Such students positively and affectively engage in a mathematics learning process because they are interested in it and enjoy the mathematical knowledge itself (Eccles & Wigfield, 2002). Intrinsically motivated students may perceive pleasant experiences such as feeling free and relaxed as well as less pressure and tension regarding their mathematical learning. This positive affective mathematics engagement allows them to focus on the mathematical learning process and the value of mathematical learning (Matsumoto & Sanders 1988; Vallerand, 1997), creating a cycle that reinforces intrinsic motivation and mathematical learning.

Extrinsic motivation. Extrinsic motivation refers to behaving to achieve a separable outcome, such as to receive a reward or avoid punishment. For example, extrinsically motivated students may express that they intensely study for mathematics tests because their parents will be upset if they receive low scores. This consideration accounts for the ultimate state not for its own sake (Wigfield & Eccles, 2000). Cultural affordance often induces students' extrinsic motivation. Overall, some cultural affordances are more strongly associated or even predisposed to being extrinsically motivated in various contexts. Eventually, students experiencing these cultural affordances are extrinsically motivated to affectively engage in mathematical learning situations in the classroom. Since extrinsic motivation is associated with specific outcomes, it is sensitive to certain circumstances (Senko & Harackiewicz, 2005). For example, students who have been exposed to competitive settings in which students are rewarded for performance (e.g., achieving high test scores, entering a good university, securing a good job) based on their efforts (e.g., learning mathematics) are likely to have high extrinsic motivation. Therefore, extrinsic motivation induces situational affective consequences such as a high level of attention and positive attitude or emotion toward a particular mathematical task at a specific time (Vallerand, 1997). Extrinsic motivation entails consideration of the usefulness of affective mathematics engagement in the task.

Educational Culture Differences Between Korea and the US

Korean culture may be described as interdependent. Concepts related to interdependence, such as social harmony, duty to groups, adjustment and fitting in, and sympathy, have been historically salient in East Asian countries, such as Korea, Japan, and China (Kitayama, Mesquita, & Karasawa, 2006). The impact of cultural affordance on educational cultures in Korea is related to students having the same educational opportunities. Korea also employs a national standardized curriculum and examination (Byun, Schofer, & Kim, 2012). Mathematical formal instruction has been preferred to adopting a whole-class teaching approach (Leung, 2002). Due to the standardized educational system, extrinsic motivation has assumed a more important position in respect to the success of students' mathematical learning (Shin, Lee, & Kim, 2009). For example, the education system in Korea has been characterized by highly competitive examinations, which are considered the only means to enter a postsecondary-level school, which is also related to students' future success. Given the importance of the examination, mathematics instruction has been oriented to encourage a focus on effort in competitive settings, and Korea has emphasized effort-based learning, regardless of the individual student's interest in mathematical tasks (Kang, Scharmann, Kang, & Noh, 2010; Shin et al., 2009). Such effort-based learning in Eastern Asian countries is characterized by the term, "Confucian heritage culture" (Watkins & Biggs, 1996). In Korean culture, enjoyment of mathematics is derived from having exerted concerted effort and achieving a deep knowledge of the subject matter.

In contrast, U.S. culture is described as more independent and individualistic. Ideas related to independence, such as personal achievement, the pursuit of goals, free choice, and personal rights, are highlighted in Western countries such as the US, Canada, and the United Kingdom (Kitayama et al., 2006). These Western cultural affordances have produced educational cultures in these countries that prioritize interest-based learning (Kang et al., 2010; Schiefele, 1991). Educators in the US assert that the most effective means of motivating students to learn mathematics is by increasing students' interest in what they are studying in the mathematics classroom (Kitayama et al., 2006; Leung, 2001). Furthermore, students' interest in mathematics has been positively correlated with affective mathematics engagement (Schiefele, 1991).

While intrinsic motivation has been valued more highly in the US to ensure the success of students' mathematical learning, extrinsic motivation is even regarded as harmful to learning (Leung, 2001, 2002). In this motivational paradigm, an individual with intrinsic motivation is assumed to be capable of changing features of the external learning environment (Kitayama, Markus, Matsumoto, & Norasakkunkit, 1997). Students' affective mathematics engagement has a deeper cultural milieu. Students' cultural environments can evoke highly different sets of affective engagement in their mathematical learning process (Kitayama et al., 2006). Therefore, it is important to investigate students' affective mathematics engagement to understand whether their actual learning processes are successful. In addition, comparing different statuses of affective mathematics engagement from different cultures can help educators illuminate fruitful implications in many countries.

The present study investigates how intrinsic and extrinsic motivation, which are intertwined and complicated by cultural milieu, impact students' affective mathematics engagement (Phase 2). The results of Phase 2 enable us to associate the employed operational measure of motivation with the conceptual definition in the literature regarding the perceived reasons (intrinsic or extrinsic motivation) for affective mathematics engagement (Phase 1). In particular, Phase 1 is situated within the U.S. sample and provides theoretical support for the measurement of intrinsic and extrinsic motivation used for Phase 2. The research questions are the following:

1. Phase 1: How do intrinsic and extrinsic motivators influence affective mathematics engagement?
2. Phase 2: Do students differ in terms of intrinsic and extrinsic motivation in affective mathematics engagement (i.e., attitude, emotion, self-acknowledgment, and value) by country (Korea as opposed to the US)?

III. PHASE 1

Methodology

Participants. The sample size for Phase 1 is 127. The participants for this phase do not overlap with the participants for Phase 2. The theoretical model includes six measured variables and nine estimated paths. A sufficient sample size for structural equation modeling (SEM) analysis is suggested to be 10–20 participants per estimated parameter (Kline, 2005). Based on this, a minimum of 10 × 9 = 90 participants were needed to test the model in this study. Therefore, the sample size was sufficient to provide robust results. This sample included two students in 7th grade, 13 in 8th grade, 11 in 9th grade, 15 in 10th grade, 74 in 11th grade, and 11 in 12th grade (missing = 1). The sample included 80 female students and 45 male students (missing = 2). In terms of ethnicity, the participants included 24 African-American, 18 Asian, 49 Caucasian, and 31 Hispanic students, with two students from other ethnic backgrounds (missing = 4). Using SPSS 24, these U.S. students were randomly selected with an equally likely possibility of selection from a total population of 606, who agreed to complete two instruments.

Instruments. Two instruments were used for this study. To measure motivation, the Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich, Smith, Garcia, and McKeachie (1991) was administered. The instrument consists of eight items within the two frameworks: four items for intrinsic motivation (Cronbach's $\alpha = .89$) and four items for extrinsic motivation (Cronbach's $\alpha = .85$). The items of the MSLQ are scored on a seven-point Likert-type scale, from 1 (not at all true of me) to 7 (very true of me). The second instrument of this study was to measure affective mathematics engagement, and for this purpose the Measurement of Affective Mathematics Engagement (MAME) by Lee et al. (2019) was administered. The instrument consists of 37 items within four frameworks: seven items for attitude, 11 for emotion, seven for self-acknowledgment, and 12 for value. The Cronbach's α was .91, and the construct validity was .89. Students were asked to indicate the extent of their agreement with each statement on a five-point Likert-type scale, from "This statement greatly represents how I felt in class today" to "This statement does not represent how I felt in class today" (scored from 5 to 1).

Analysis. Stata 15.1 was used to conduct the analyses in this study. To test the theoretical model (see Figure 1), the SEM technique was employed to estimate the fit of the hypothesized model that determines how students' motivation influences their affective mathematics engagement. In line with the theoretical assumptions, we hypothesized that students' intrinsic and extrinsic motivation will uniquely influence their attitude, emotion, self-acknowledgment, and value. Therefore, we tested whether endogenous variables (i.e., intrinsic and extrinsic motivation) statistically and significantly predicted the exogenous variables (i.e., attitude, emotion, self-acknowledgment, and value) based on the data from this study. Intrinsic and extrinsic motivation are connected with a two-headed arrow. No data were missing for the SEM analysis, and measured variables were mean-centered. We used six measured variables and estimated nine paths for the theoretical model.

All fit indices were accounted for to determine whether the theoretical model fits the given data. The fit indices that were used for this study included the comparative fit index (CFI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR). greater than 0.90 for CFI are indicative of an adequate model fit, although values approaching 0.95 are preferable. Values smaller than 0.08 for the RMSEA also support a good model fit. Traditional fit indices (CFI, RMSEA) perform well under weighted least squares mean and variance adjusted (WLSMV) estimation (Beauducel & Herzberg, 2006). Furthermore, the SRMR index is based on covariance residuals, which indicate the degree of difference that exists between the measured data and the model (Bentler, 1995). Values smaller than .08 for SRMR are regarded as a good model fit (Hooper, Coughlan, & Mullen, 2008).

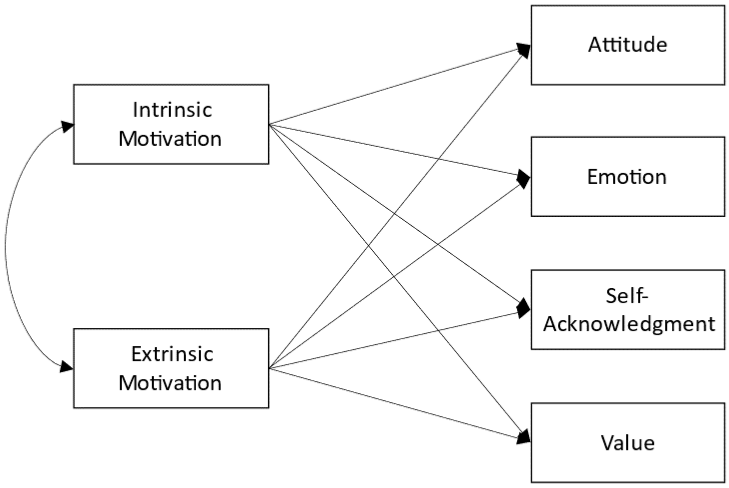

Figure 1. Theoretical model with measured variables and parameters.

Results

Preliminary analysis. In this study, students' motivation was categorized as either intrinsic or extrinsic motivation. Students' affective mathematics engagement was classified into four components: attitude, emotion, self-acknowledgment, and value. Initially, descriptive statistics were conducted to determine the means (Ms) and standard deviations (SDs) of these six components (see Table 1). The results indicate that students' extrinsic motivation (M = 19.441, SD = 7.269) was higher than their intrinsic motivation (M = 17.913, SD = 7.195). The comparison between the component of affective mathematics engagement should be conducted cautiously, because the number of items of each component differs. Therefore, Table 1 indicates the ranges, which encompass the actual minimum and maximum scores for each component. This is reported because the scales of components and the number of items within each component differ. The range also assists in the interpretation of the reported means.

Table 1. Descriptive statistics of measured variables

Variables	M	SD	Min	Max	95% CIs
Intrinsic motivation	17.913	7.195	4	28	[16.650, 19.177]
Extrinsic motivation	19.441	7.269	4	28	[18.164, 20.717]
Attitude	24.480	6.051	7	35	[23.418, 25.543]
Emotion	32.677	9.018	12	55	[31.093, 34.261]
Self-acknowledgment	23.850	7.884	9	35	[22.466, 25.239]
Value	39.126	14.124	12	60	[36.466, 41.606]

Table 2. Correlation matrix of all components (Phase 1)

	(1)	(2)	(3)	(4)	(5)	(6)
(1) Intrinsic Motivation	1					
(2) Extrinsic Motivation	.746	1				
(3) Attitude	.608	.655	1			
(4) Emotion	.582	.632	.821	1		
(5) Self-acknowledgment	.754	.694	.712	.722	1	
(6) Value	.762	.753	.600	.709	.778	1

Note. All correlations are statistically significant (*p* < .001).

Table 2 presents the correlations among the variables. Motivation components (i. e., intrinsic and extrinsic motivation) were statistically significantly and positively correlated to affective mathematics engagement components (i.e., attitude, emotion, self-acknow ledgment, and value). The bivariate correlations can indicate the effect sizes associated with the key variables (Cohen, 1988). The Pearson’s r correlations between these variables were moderate or high, ranging from .582 to .821, $p < .001$. In particular, motivational subscales were mostly related to affective mathematics engagement subscales. These correlations appear to adhere to the expected pattern based on the theoretical expectations.

Structural equation modeling. The goodness-of-fit indices for the hypothesized model indicate a good fit with the data. According to the t-rule, the number of estimated parameters (= 15) for this SEM analysis is smaller than half the number of measured variables multiplied by the number of measured variables plus 1:

$$\frac{n(n+1)}{2} = \frac{6 \times 7}{2} = 21$$

This model was identified (Bollen, 1989). The chi-square test results are $\chi 2 = 1.922$, df = 1, $p = .166$, which indicate a good fit. The value of RMSEA was .085, which indicates a relatively moderate fit of the model that is exceptionally close to being a good fit. Both CFI (= .998) and SRMR (= .018) values suggest a good fit. The explained variance (R^2 = 1 – “error variance”) of attitude was $R^2 = .461$, emotion was $R^2 = .427$, self-acknowledgment was $R^2 = .608$, and value was $R^2 = .657$ (by intrinsic and extrinsic motivation). Intrinsic and extrinsic motivation were allowed to be freely correlated. Error terms for affective mathematics engagement were allowed to be correlated with each other due to the high modification index found. When the modification indices were run, all of the modification indices were less than 3.841, which suggests no changes in the covariance of error terms. Therefore, the model fits the data, and no specific sources were found to indicate a lack of fit in this model.

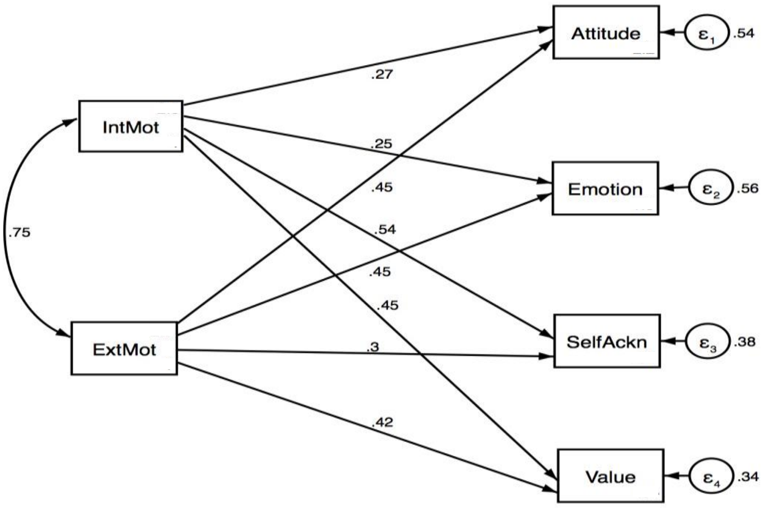

Figure 2. Standardized parameter values of the model. Note. IntMot = intrinsic motivation; ExtMot = extrinsic motivation; SelfAckn = self-acknowledgment. All paths are statistically significant ($p < .05$).

Figure 2 illustrates the results of the reciprocal effects SEM. The standardized robust maximum likelihood parameter was estimated. The error variance (i.e., residual variance component) indicates the degree of unexplained variance. All loading (path coefficients) estimates were statistically significant, which supports the relationships between the measured variables. There were statistically significant relationships between endogenous variables (i.e., intrinsic and extrinsic motivation) and exogenous variables (i.e., attitude, emotion, self-acknowledgment, and value; $p < .05$), and each path was positively estimated, as indicated in Figure 2.

Table 3 presents more detailed estimations, significance, and relationships for variables of each path in the hypothesized model. Attitude and emotion are explained more effectively by extrinsic motivation (attitude: $\beta = .454$, $p < .001$; emotion: $\beta = .446$, $p < .001$) than intrinsic motivation (attitude: $\beta = .269$, $p < .05$; emotion: $\beta = .246$, $p < .05$), while self-acknowledgment and value were better explained by intrinsic motivation (self-acknowledgment: $\beta = .532$, $p < .001$; value: $\beta = .450$, $p < .001$) than extrinsic motivation (self-acknowledgment: $\beta = .298$, $p < .001$; value: $\beta = .417$, $p < .001$). For example, on average, one standard deviation increase in intrinsic motivation would result in a .532 standard deviation increase in self-acknowledgment; conversely, on average, one standard deviation increase in extrinsic motivation would result in only a .298 standard deviation increase in self-acknowledgment. The results of this analysis demonstrate a strong relationship between motivation and affective mathematics engagement. The results confirm the hypothesis: motivation positively predicts affective mathematics engagement. In particular, intrinsic and extrinsic motivation statistically positively predict attitude, emotion, self-acknowledgment, and value.

Table 3. Standardized parameter estimates, standard errors, z-values, and *p*-values

Variables		**Standardized Coefficient (β)**	***SE***	***z***	***p***
Attitude on	Intrinsic Motivation	.269	.094	2.79	.005
	Extrinsic Motivation	.454	.093	4.86	< .001
Emotion on	Intrinsic Motivation	.249	.100	2.50	.012
	Extrinsic Motivation	.446	.096	4.62	< .001
Self-acknowledgment on	Intrinsic Motivation	.532	.079	6.77	< .001
	Extrinsic Motivation	.298	.082	3.62	< .001
Value on	Intrinsic Motivation	.450	.075	5.99	< .001
	Extrinsic Motivation	.417	.076	5.51	< .001

Another model was tested to investigate if a better model fit exists between motivation and affective mathematics engagement. This model included motivation—a combination of intrinsic and extrinsic motivation—as one endogenous variable and four components of affective mathematics engagement (i.e., attitude, emotion, self-acknowledgment, and value). The results of the model fit test do not indicate a good model fit. The CFI value was .884, and the SRMR value was .082, which indicates a moderate fit. However, the chi-square test results are $\chi2 = 56.320$, df = 6, $p < .001$, and the value of RMSEA is .267, which indicates that the data does not fit the model. This result supports the theoretical separation of intrinsic motivation and extrinsic motivation.

Discussion of Phase 1

In Phase 1, we examined the effects of motivation on affective mathematics engagement, particularly the relationships between intrinsic and extrinsic motivation with attitude, emotion, self-acknowledgment, and value. The results from the SEM analysis suggest that affective mathematics engagement variables are directly correlated with motivation variables. In the hypothesized model, attitude and emotion are more thoroughly explained by extrinsic motivation than intrinsic motivation, while self-acknowledgment and value are better explained by intrinsic motivation than extrinsic motivation. These findings suggest that students' motivation is associated with affective mathematics engagement. In line with the hypotheses, students with high motivation are also more likely to report being affectively engaged in mathematics.

In particular, distinguishing between intrinsic and extrinsic motivation for this study provides a deeper and more detailed understanding about the relationships between students' motivation and affective mathematics engagement. Furthermore, the model fit using motivation (i.e., a combination of intrinsic and extrinsic motivation) as one endogenous variable and four components of affective mathematics engagement does not indicate a good model fit. This result supports the theoretical separation of intrinsic and extrinsic motivation.

The positive relationship between students' intrinsic motivation and their learning engagement has been supported by several researchers (e.g., Cokley, Bernard, Cunningham, & Motoike, 2001; Fan & Williams, 2010; Moneta & Siu, 2002). Students with high intrinsic motivation are likely to notice the importance of learning and understanding mathematical concepts, which encourages them to deeply engage in their learning process. For example, students who believe that the mathematical concept they are learning is important for personal reasons might be more focused on the mathematical learning situation in which they are engaging. Since intrinsically motivated students enjoy mathematics activities and learning itself, they are likely to have high engagement in terms of self-acknowledgment, which encompasses feelings about mathematical cognition (DeBellis & Goldin, 2006) and value, which refers to students' capacity to identify and understand the role that mathematics plays (Bishop, 2008). Therefore, students' positive experience in mathematical learning processes based on intrinsic motivation encourages them to improve their affective mathematics engagement.

Some researchers implicitly assume that extrinsic motivation cannot positively influence students' affective mathematics engagement (e.g., Jang, 2008; Joussemet, Koestner, Lekes, & Landry, 2005). The results of the present study and prior research supporting these results (e.g., Lee, Capraro, & Viruru, 2018; Saeed & Zyngier, 2012) indicate that extrinsic motivation fosters positive affective mathematics engagement. In particular, extrinsically motivated students care about receiving rewards or avoiding punishment based on their engagement (Eccles & Wigfield, 2002); therefore, they are likely to mediate their attitude and emotion regarding mathematics during their learning process. This occurrence is because they understand that if they can fully engage by harboring positive attitude and emotion toward mathematical learning situations, they may achieve in the mathematics classroom and eventually in their future careers. For example, some items about attitude in the affective mathematics engagement survey are related to the student's relationship with their peers or teachers during mathematics activity. Students with high extrinsic motivation might demonstrate that they attempt to have a good relationship with others or to avoid conflicts when they communicate during mathematics classes. This approach might be because their attitude impacts their reputation, reward, or punishment.

In summary, intrinsic and extrinsic motivation are important variables that can increase students' affective mathematics engagement. This finding suggests that educators and stakeholders must focus on students' development of mathematical motivation. If students formulate positive motivation in society, at home, and in school, then their positive affective mathematics engagement will also increase, which in turn can influence their academic performance, achievement, and eventually their future major and career choices.

The results from this study suggest that in countries where students are likely to experience intrinsic motivation, students may also experience greater self-acknowledgment and value. However, in countries where students are more likely to experience extrinsic motivation, they may experience a better attitude and emotion toward mathematics. According to the literature review, students in Korea exhibit relatively higher extrinsic motivation than intrinsic motivation, and students in the US display relatively higher intrinsic motivation than extrinsic motivation (e.g., Kitayama et al., 1997, 2006; Leung, 2001; Schiefele, 1991). Therefore, students in Korea may exhibit relatively higher attitude and emotion, and students in the US may express relatively higher self-acknowledgment and value. The empirical study in Phase 2 explores if these hypotheses are supported.

Ⅳ. PHASE 2

The results of Phase 1 indicate the strong relationship between motivation and affective mathematics engagement. Based on these results, Phase 2 explored the country-differences in terms of students' motivation and affective mathematics engagement.

Methodology

Participants. The sample consists of 33 students in Korea and 30 students in the US. Table 4 presents the demographics. This sample size was enough for our inquiry because t-tests, which were adopted for analysis, are preferable when the sample size amounts to approximately 60 or less (Campbell, 1997). The sample for Korea was collected from a high school (10th and 11th grade) in Seoul, and the sample for the US was randomly selected from 606 students from several schools in Texas. This random sampling was conducted using SPSS 24. The Korean sample includes 18 male and 15 female students, and the U.S. sample includes nine male and 21 female students. In terms of ethnicity, the participants in Korea were all Asians, and the participants in the US included three African-American, 19 Caucasian, seven Hispanic, and no Asian students (missing = 1).

Table 4. Demographics for students participating in Phase 2

		Korea	**US**
Gender	Female	18	9
	Male	15	21
Grade	8th	-	2
	9th	-	6
	10th	13	5
	11th	20	5
	12th	-	10
	Missing	-	2
Ethnicity	African-American	-	3
	Asian	33	-
	Caucasian	-	19
	Hispanic	-	7
	Missing	-	1
Total		33 (100%)	30 (100%)

Instruments. Students' motivation and affective mathematics engagement were measured with the same instruments as those used in Phase 1. Participants were asked to answer the MSLQ and MAME. All of the questionnaires used for this study were originally developed in English, and then they were translated into Korean for the participants in Korea. The back-translation method ensured the standardization of questions. The instruments were implemented in the middle of the semester. Each instrument required 10 to 15 minutes to complete.

Analysis. For the statistical analyses, SPSS 24 was used. To determine the mean differences in students' affective mathematics engagement between Korea and the US, independent t-tests were used. Moreover, descriptive statistics including Hedges' g effect sizes were reported. An effect size is more robust to sample size because it is independent of sample size. Hedges' g was chosen for this study because it provides a more conservative estimate of the effect when the sample size changes (Capraro, Bicer, Lee, & Vela, 2019).

Results

Table 5 presents the descriptive statistics, which include the means, standard deviations (SDs), and 95% confidence intervals (CIs; lower and upper limits), of the performance of students in Korea and in the US. In addition, the range of scores, which were the minimum and maximum scores for each framework, are reported because the number of items within each subscale differs.

Table 5. Descriptive statistics and t-value in subscales of motivation and affective mathematics engagement

Framework	**Korea**			**US**			**Range**		***t*-value**
	Mean	***SD***	***95% CIs***	***Mean***	***SD***	***95% CIs***	***Min***	***Max***	
Intrinsic Motivation	11.121	3.594	[9.895, 12.347]	24.200	3.488	[22.952, 25.448]	5	28	-14.628**
Extrinsic Motivation	21.667	4.392	[20.169, 23.165]	18.767	5.437	[16.821, 20.713]	7	28	2.338*
Attitude	25.733	3.991	[24.411, 27.135]	24.576	4.078	[23.117, 26.035]	16	34	1.137
Emotion	34.800	6.494	[32.584, 37.016]	30.333	7.330	[27.710, 32.956]	11	51	2.550*
Self-Acknowledgement	22.091	4.397	[20.591, 23.591]	29.800	6.494	[27.276, 32.124]	14	35	-6.779**
Value	35.455	8.584	[32.526, 38.384]	42.567	8.024	[39.696, 45.438]	16	59	-3.223**

Note. **p* < .05, ***p* < .001

The results from the independent t-tests reveal that the difference between Korea and the US in terms of intrinsic motivation is statistically significant (t = -14.628, df = 61, *p* < .001). The mean of students in the US is higher than the mean of those in Korea, indicating that the former has more intrinsic motivation than the latter. The Hedges' g effect size for this difference is 3.645. Furthermore, the difference in extrinsic motivation between Korea and the US is also statistically significant (t = 2.338, df = 61, *p* < .001). The mean of students in Korea is higher than the mean among students in the US, indicating that students in Korea possess more extrinsic motivation than those in the US. The Hedges' g effect size for this difference is .583. The results of these analyses suggest that students in Korea harbor more extrinsic motivation, while students in the US have more intrinsic motivation. Figure 3 represents the means and 95% CIs of intrinsic and extrinsic motivation in Korea and in the US.

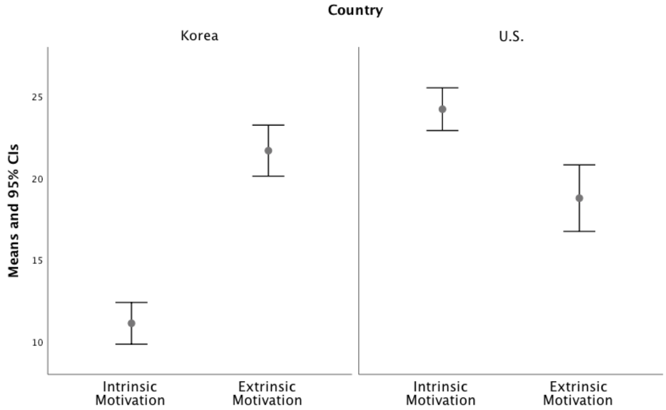

Figure 3. Intrinsic and extrinsic motivation in Korea and in the US

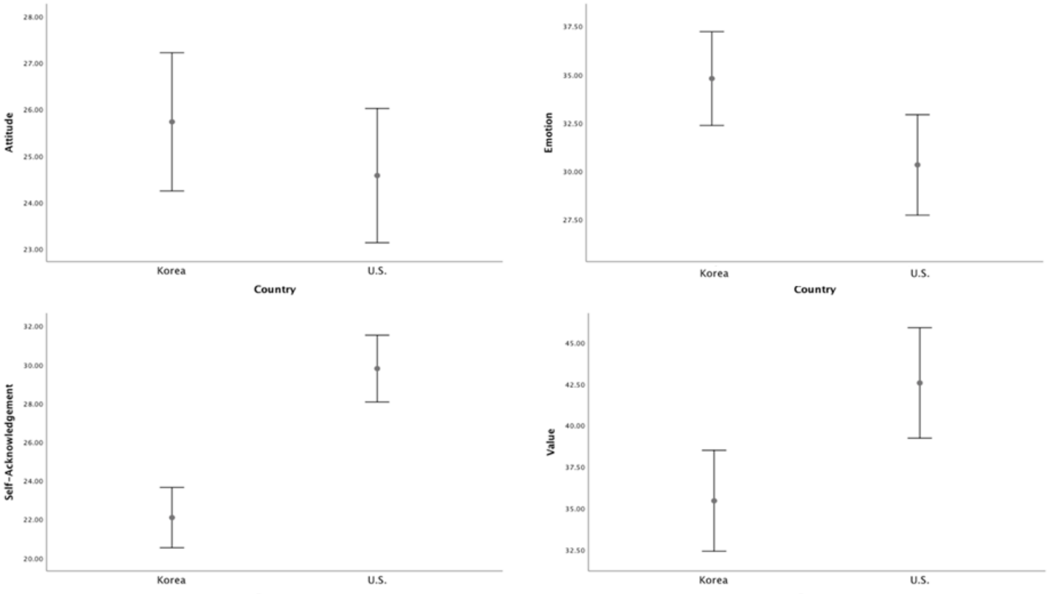

Figure 4. Means and 95% confidence intervals of attitude, emotion, self-acknowledgment, and value in Korea and in the US

Affective mathematics engagement was disaggregated by frameworks such as attitude, emotion, self-acknowledgment, and value (see Figure 4). The means of the students in Korea are higher than the means of the students in the US on attitude (t = 1.137, df = 61), but this finding is not statistically significant (*p* = .260). Furthermore, the mean of the students in Korea is statistically significantly higher than the mean of the students in the US regarding emotion (t = 2.550, df = 61, $p < .05$). The Hedges' g effect sizes are .283 for attitude and .637 for emotion. The means for self-acknowledgment (t = -6.779, df = 61, $p < .001$) and value (t = -3.223, df = 61, $p < .001$) are higher for the students in the US than for students in Korea. The Hedges' g effect sizes are 1.372 for self-acknowledgment and .844 for value.

Discussion of Phase 2

Phase 2 calculated the differences in students' motivation to learn mathematics and affective mathematics engagement between Korea and the US. The results of this study reveal that students in Korea exhibit more extrinsic motivation in mathematics than those in the US, while students in the US display more intrinsic motivation in mathematics than those in Korea. In addition, students in Korea demonstrate more positive mathematical attitude and emotion than students in the US, and students in the US exhibit more positive mathematical self-acknowledgment and value than students in Korea.

Country differences in terms of intrinsic and extrinsic motivation and their relationships with affective mathematics engagement are supported by much of the literature. The standardized educational system in Korea causes teachers to prefer to implement traditional instruction (Byun et al., 2012; Leung, 2002) and encourages students to focus on their academic outcomes, such as test scores, college entrance exams, and extrinsic rewards. The success of learning in mathematics has assumed a more important position, which is represented by extrinsic motivation. Traditional instruction is intended to provide highly structured, teacher-centered instruction (Ewing, 2011). Therefore, students may focus more on the outcome of their learning process rather than the process itself, and as a result, they may feel less pressure during their learning process (Lee et al., 2019). This tendency has been demonstrated to result in relatively positive attitude and emotion.

Based on their higher extrinsic motivation, students in Korea are more encouraged by the rewards for their success in mathematical learning rather than an interest or enjoyment of mathematical learning itself. These students are even likely to suppress their intrinsic motivation to learn mathematics (Lin et al., 2003). For example, although the students enjoy mathematics classes and implement collaborative mathematics learning, they attempt to avoid engagement if they believe that the activity requires more time to learn concepts through traditional instruction. Traditional instruction has typically been shown to be more effective for learning mathematical concepts that are necessary for passing a test or demonstrating rote knowledge. Extrinsically motivated students may comment, “I cannot afford to get interested in this course because I have to get a good grade” (Lin et al., 2003). In this case, affective mathematics engagement indicated by the student may be pseudo engagement.

Alternatively, students in the US place a greater value on intrinsic motivation. Teaching and learning in mathematics classes in the US are more student-centric than traditional, teacher-centered instruction. Through this approach, students can enjoy mathematical learning. This interest-based learning has been assumed to be crucial for students' success in their mathematical learning (Kang et al., 2010; Kitayama et al., 2006; Schiefele, 1991; Leung, 2001). Focusing on the learning process itself and student-centered instruction encourages students to focus on the mathematical learning process. By focusing on their own interests and being intrinsically motivated, students may enjoy the exploration of mathematical concepts. Therefore, intrinsic motivation may cause students to increase their mathematical self-acknowledgment and value.

In this study, the mean difference between Korea and the US in terms of mathematical attitude was not statistically significant. One possible reason is a measurement error. The Cronbach's α reliability of the items of attitude is .57, which is not relatively large. When reliability decreases, the measurement error increases (Wells & Wollack, 2003), which in turn increases the statistical significance (*p*-value) of a study (Jacobson, Roberts, Berns, & McGlinchey, 1999). Although the t-test reveals a non-statistically significant result, an apparent difference exists between the two countries in terms of attitude, as demonstrated in Figure 4 and the result of Hedges' g (= .283), even though the difference is small.

V. CONCLUSIONS

Cultural differences account for important variation in students' perceptions of motivation and affective mathematics engagement. The findings of Phases 1 and 2 provide supporting evidence that the instructional environment present in Korean and U.S. culture has influenced both motivation and affective mathematics engagement. The results of Phase 1 indicate that intrinsic motivation effectively explains students' self-acknowledgment and value, and the results of Phase 2 support these findings because students in the US show higher intrinsic motivation and exhibit higher self-acknowledgment and value in comparison to students in Korea. In addition, the results of Phase 1 indicate that extrinsic motivation effectively explains students' attitude and emotion. These findings are in turn supported by the results of Phase 2: students in Korea are influenced by extrinsic motivation factors, and those who have higher extrinsic motivation display higher attitude and emotion relative to the students in the US.

According to the results of the present study, motivation and affective mathematics engagement are not isolated but dynamically interrelated within the student. This assessment of students' motivation and affective mathematics engagement offers an enhanced understanding of students' learning situations rather than single components. While the components of motivation and affective mathematics engagement have been studied independently, it is unknown how these components combine or interact to determine students' academic performance. In particular, applying both theoretical (i.e., Phase 1) and empirical (i.e., Phase 2) studies enables the determination of when motivation produces affective mathematics engagement consequences. This study also allows a comparison between the impact of intrinsic and extrinsic motivation based on cultural affordance for various types of affective mathematics engagement (i.e., attitude, emotion, self-acknowledgment, and value).

The results of this study suggest the importance of considering relationships when generalizing the effects of different motivations on affective mathematics engagement. Although motivation is based on cultural backgrounds, it is activated by cues in the current environment (Lin et al., 2003). Therefore, future research should explore how educational paradigms situated in countries can be overcome. For example, sharing educational learning contexts and cultures across two countries provides opportunities for students in Korea to be exposed to intrinsic motivation through student-centered instruction. This approach may positively impact students' positive self-acknowledgment and value toward mathematical learning. Likewise, students in the US may benefit from increased emphasis on mathematical proficiency and effort-based learning, which were prioritized in Confucian heritage culture. These findings provide the context for assessing learning opportunities in different international learning environments that influence students' learning experiences.

VI. LIMITATIONS

The current study includes sample sizes of 127 for Phase 1 and 63 (33 in Korea and 30 in the US) for Phase 2. These sample sizes are appropriate to provide robust results based on numerous studies (e.g., Campbell, 1997; Kline, 2005). However, larger sample sizes would strengthen the results of this study. Some researchers have recommended the sample size for SEM to be approximately 300 or more (e.g., Tabachnick, Fidell, & Ullman, 2007; Siddiqui, 2013), and others have recommended using a power analysis such as the Monte Carlo simulation (Muthén & Muthén, 2002) to calculate the required minimum sample size to detect effect. This low sample size could also cause multicollinearity between intrinsic and extrinsic motivation (β=.746). In this regard, future studies with a larger sample size are needed to secure more stable estimates of the correlations or covariances. In addition, including a larger sample size would provide more sophisticated results of hypothesis testing by reducing possible sampling errors and bringing more statistical power.

Last, another limitation is linked to the representativeness of the sample. The samples from Korea and the US were chosen because of a lack of research that directly compares these two countries in a similar context. We assumed that Korea and the US were sample groups which represent general Eastern and Western cultures in terms of students' motivational characteristics. This assumption is generally consistent with numerous findings that demonstrate cultural affordance in motivation. However, we cannot ignore the possibility that national culture in each country might have influenced the data. Therefore, overgeneralization of the results of this study to all Eastern and Western countries should be avoided. Avenues for further investigation include assessing additional countries and considering both between- and within-group differences.

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