Large-scale Assessments in Education

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Relationships among locus of control, learned helpless, and mathematical literacy in PISA 2012: focus on Korea and Finland

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Abstract

The purpose of this research is to gather empirical evidence for attribution theory (Weiner in J Educ Psychol 71(1):3–25. https://doi.org/10.1037/0022-0663.71.1.3, 1979) to explain students' feelings of helplessness when learning mathematics. The relationships between mathematics literacy in PISA 2012 and learned helplessness were also observed. Korean and Finnish students' responses were analyzed with ordinal and linear regression analyses. Similar patterns were found between the two countries when students attributed their failure to either ability or task difficulty, but different relationships were found for other attributions. The findings indicated necessity of cultural factors in addition to the attribution theory to understand students' helplessness in learning mathematics better.

Keywords: Motivation, Learned helplessness, Locus of control, PISA 2012

Introduction

Korean teachers and educators have recognized the issue that increasing numbers of students give up on mathematics. Korean public media have seriously discussed those students who avoid learning mathematics, calling them "su-hak po-gi-ja [mathematics abandoners]" in Korean (e.g., Jung 2015). Koreans' worries about mathematics abandoners require systematic investigations to understand why students do so. However, few studies have been conducted solely on how many Korean students could be labelled as mathematics abandoners (see Na et al. 2016). As seen in Jung's news article (2015), Koreans believe the main reasons for avoiding learning mathematics are difficult curriculum, preparation for college entrance exams, and traditional mathematics instruction. However, these factors do not fully describe the situation, which seems like a complex problem related to psychological (e.g., motivation and attitude toward mathematics), educational (e.g., curriculum, high-stakes tests, and instructional approach) and sociological factors (e.g., socioeconomic status) simultaneously. Therefore, it is still necessary to gather research evidence about why Korean students are discouraged in learning mathematics.

In this research, students' avoiding learning mathematics is considered as one of maladaptive behaviors causing a gap between their potential and actual achievement, referred as "learned helplessness" (McNabb 2003). Because of the complexity of this

issue in Korea, I recognize that the idea of learned helplessness may incompletely accounts for Korean students' feeling and behaviors. However, studies about learned helplessness can contribute to better understanding of the psychological factors related to avoiding learning mathematics. It is shown that Korean students have negative attitudes toward mathematics and low motivation in learning mathematics in international comparison studies (Mullis et al. 2012), which indicated possible impacts of psychological factors on giving up mathematics. Also, challenge avoidance, giving up, and lack of enjoyment characterized learned helplessness according to previous studies (McNabb 2003). Although most studies on learned helplessness did not focus on learning mathematics, observed behaviors of learned helplessness are very close to what Korean students reported.

Specifically, learned helplessness is adopted in this research for three reasons: (1) there are a large body of educational psychology research on learned helplessness which are fundamental for our study; (2) characteristics of mathematics abandoners are similar to what prior studies on learned helplessness have found. However, in Korean contexts, no research has been found to define "mathematics avoidance"; and (3) there is a collected, but not analyzed dataset, namely the Programme for International Student Assessment (PISA) 2012. The Organisation for Economic Co-operation and Development (OECD 2013) provides student questionnaire data on helplessness in learning mathematics for research purposes. Recently, the datasets of PISA 2015 and the Trends in International Mathematics and Science Study (TIMSS) 2015 have been released. However, these datasets do not include information about students' helplessness in learning mathematics. Particularly, the student questionnaires in PISA 2015 did not include questions about learned helplessness in mathematics because science is the focal subject of the PISA 2015.

Numerous studies have attempted to define conditions in which adaptive or maladaptive behaviors occur. Learned helplessness is one of the underlined maladaptive behaviors. To explain the conditions for learned helplessness, Rotter (1966) discussed social cognitive theories and Weiner (1979) developed attribution theory from Rotter's argument. The key idea in Rotter's and Weiner's arguments is *a locus of control* defined as "the tendency of people to perceive that outcomes in a particular arena were either within or outside of their control" (McNabb 2003, p. 418). Furthermore, Diener and Dweck (1978) claimed that students were likely to feel learned helplessness if they thought that the outcome was out of their control. Along with Diener and Dweck's claim, this research attempted to analyze who are likely to feel learned helplessness based on Weiner's (1979) attribution theory. Some researchers have also observed relationships between achievement and learned helplessness because learned helplessness has been studied in relation to underachievement (McNabb 2003).

To examine Korean students' learned helplessness, I select Finland for binational comparison. A rationale for this selection is that international interest in Finnish mathematics education has grown due to Finnish students' success in the large-scale international comparison studies (Andrews et al. 2014). Results of TIMSS and PISA have indicated that the Finnish education system is internationally well known to function comparably, while remaining close to what mathematics educators find desirable (Seaberg 2015). For example, the Finnish education system emphasizes

local flexibility, diversity of school curricula, and individual growth (Kupiainen et al. 2009). However, as one of the East Asian countries with high achievement, Korea is known to have standardized, content-oriented, and examination-driven curricula (Leung 2001). Thus, comparisons between Korea and Finland merit further scrutiny.

As suggested by Clarke (2003), it is critical to understand that comparison studies contribute to articulating commonalities and differences among educational systems. Practices, policies, and school systems are dissimilar between Korea and Finland, which should be considered as variables rather than a constant (Keitel and Kilpatrick 1999). Therefore, the research on students' learning in relation with educational system requires consideration of the social and cultural factors that potentially affect students' learning behaviors. In this sense, these large-scale assessments might not fully address how students learn mathematics in the Korean and Finnish education systems. However, this research attempts to take a beginning step to explain how and why Korean students become mathematics abandoners by focusing on the psychological factors and by comparing the factors across countries. One should be very careful to infer how cultural differences is related to attribution theory, learned helplessness, and mathematics achievement, which should be answered in follow-up studies.

The purpose of the research is to gather empirical evidence for relationships between the four attributions in Fig. 1 and learned helplessness. Attribution theory will be discussed more in the literature review. This research also aims to link students' achievement in mathematics literacy to learned helplessness. The data analysis will examine probabilities that Korean or Finnish students feel learned helplessness for mathematics with respect to the attribution theory. Comparing Korea and Finland will show similarities and differences in the probabilities for learned helplessness and the relationships between learned helplessness and mathematics literacy. The questions guiding this research are: (1) What are the probabilities that Korean and Finnish students feel learned helplessness when they attribute academic outcomes to the following perceived causes via PISA 2012: academic ability, the effort spent in preparation, difficulty of tasks, and luck elements? And (2) what are the differences between Korean and Finnish students in the relationships between their feelings of learned helplessness and mathematic achievement?

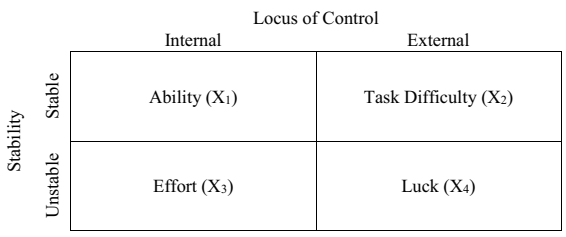

Fig. 1 Four attributions that explain academic outcomes (McNabb 2003, p. 419)

Literature review

To answer the research questions, I relied on literature about the following topics: (1) what learned helplessness is, (2) how it has been studied theoretically and empirically, and (3) how learned helplessness differs in various cultural contexts. It is important to understand the definition of learned helplessness because I want to eventually connect this concept to Korean students' behavior of avoiding learning mathematics. Theoretical and empirical studies on learned helplessness provide supportive evidence for attribution theory (Weiner 1979) to explain learned helplessness. Cross-cultural studies might help to show how the attribution theory can be applied to Korea. Lastly, we will discuss PISA because understanding of mathematical literacy is critical to interpreting and generalizing the findings in this research.

Learned helplessness

Learned helplessness involves the belief that nothing does matter as we can reason intuitively. In research with animals, learned helplessness is formally defined as "the probability of an important outcome (O) [...], given a response (R) is not different from the probability of (O) given the absence of that response (notR)" (Maier and Seligman 2016, p. 349). Helplessness is *learned* with pairing the above two conditional probabilities and generalizing them across all responses, which indicates that learned helplessness is cognitive. The animal must *identify* the lack of dependency and must *expect* that an important outcome and its response are independent (Maier and Seligman 2016).

Learned helplessness have been studied in human setting since 1970s. There are three directions of such studies: (a) replication in apparently analogous human settings (e.g., Hiroto and Seligman 1975); (b) explanations that people make for causes of their failure to escape in unescapable group (e.g., Alloy et al. 1984); and (c) a lavatory model of critical depression (e.g., Simson and Weiss 1989). Particularly, research in the second direction has shown that people would show long-term helplessness if they attribute their helplessness to permanent causes rather than temporary causes. In addition, learned helplessness in the laboratory could produce the eight symptoms of depressive disorder: sad mood, loss of interest, weight loss, sleep problems, psychomotor problems, fatigue, worthlessness, indecisiveness or poor concentration (Maier and Seligman 2016, p. 351).

Differently from the psychological studies, prior educational research has explored learned helplessness as unpleasant emotion with a connection to a predictor of poor academic performance or underachievement. Educators have well recognized interactions between cognition and emotion and the effects of emotions in learning mathematics (Di Martino and Zan 2011). Although actual effects of emotions are difficult to examine, students emotional responses can shut down their problem solving entirely when faced with a lot of pressures in a situation (Hannula 2002). Particularly, some unpleasant emotions could cause students underachievement, which prompted research on students' various types of anxiety. While describing test anxiety and mathematics anxiety, Hembree (1990) referred anxiety as "the feelings of uncertainty and helplessness in face of

danger" (p. 33). This certainly showed that learned helpless is related to student's emotional status in specific situations like facing danger or pressures.

Prior studies have investigated students' behaviors which results from their emotions because emotions are difficult to investigate directly. According to McNabb (2003, p. 418), the followings have been considered as adaptive academic behaviors: challenge seeking, persistence, and task enjoyment. On the opposite side, challenge avoidance, giving up, and lack of enjoyment were regarded as maladaptive or *helpless* academic behaviors. Helplessness itself can be defined as an emotional status. However, McNabb's explanation showed that defining students with learned helplessness is practically more useful by observing their behaviors. To sum up, students who feeling learned helpless can be characterized with the three maladaptive behaviors, challenge avoidance, giving up, and lack of enjoyment.

Attribution theory

As mentioned in the second direction of research with people' being learned helpless, the majority of this research has attempted to answer who are likely to feel learned helplessness. Weiner (1979) established a foundation to examine learned helplessness by suggesting attribution theory. This theory is grounded on the claim that the way students attribute outcomes to perceived causes is connected to academic performance and learned helplessness (Marsh 1990). Weiner and his colleagues originally suggested the four attributions in Fig. 1: academic ability, effort spent in preparation, the difficulty of tasks, and luck elements in solving tasks.

Weiner's (1979) model was a good starting point to organize approximately 60 causes already revealed in interviews and surveys with two dimensions: locus of control (Rotter 1966) and stability. Locus of control was considered important even before attribution theory was proposed because it was broadly assumed that students felt helpless when outcomes are out of their control (Abramson et al. 1978). However, there have been critiques saying that these dimensions were ambiguous. For example, efforts could be stable when a person had the stable intent to work hard (Hau and Salili 1993) and ability may be unstable if a person believe that ability is not fixed, but changeable across time (McNabb 2003).

Weiner's (1979) also recognized that the two dimensions were not enough to categorize causes. With respond to those critiques, he suggested one more dimension: controllability, which should be distinguished from locus of control. Controllability is about whether or not students are able to deal with perceived causes, while locus of control is about whether perceived causes are external or internal. For example, sickness on the day of the exam is uncontrollable, internal, and unstable while a teacher's bias is controllable, but stable and external (Weiner 1986). Although three dimensions were established, I followed Weiner's original model with only the two dimensions. This is because a complex model is not always a better option for research. At the initial stage of research, a simpler model can provide insights to understand students' behaviors and provide more ideas about how to apply complex models if the behaviors are considerably unexplained with the simple model. Another rationale for using the original model is the structure of the PISA data. I selected some variables and reorganized the data about Korean and Finnish students from the PISA database. However, the PISA questionnaire

(OECD 2013) did not include questions for all three dimensions. The initial two dimensions, conversely, could be observable through the PISA database.

Empirical research and cross-cultural research

Prior studies based on attribution theory and learned helplessness has been conducted in the two main phases; development of instruments to measure students' attributions and investigation of the relationships among attributions measured by the instruments, helplessness, and academic achievement. Hau and Salili (1993) summarized instruments measuring specific causes developed before 1990 (see Hau and Salili 1993, pp. 382–383). Most of the instruments were developed based on the three dimensions of Weiner's (1979) models. One of the well-known instruments is the Sydney Attribution scale (SAS; Marsh et al. 1984). The 72 items on 24 scenarios in mathematics and reading were designed in the SAS to produce five-scale points for efforts, ability, and external causes. In the PISA assessment that I used, students' attributes were measured with simple questions in a questionnaire. Details will be presented in the method section to describe the variable selection process. The simple questions directly examining each attribution can be less reliable than instruments like the SAS, but this is the limitation of secondary analysis with an existing dataset.

After development of instruments measuring specific attributions, research focus shifted to relationships between measured attributions (e.g., Marsh et al. 1984)/helplessness (e.g., Newman 1980) and achievement. Because learned helplessness has been considered problematic with a connection to underachievement, this shift can be somewhat expected. Recently the large-scale international comparison studies (PISA from 2000 and TIMSS from 1995) have provided opportunities to examine learned helplessness or students' attributions. However, only few studies can be found using these datasets (e.g., Hammouri 2004). This indicates the research opportunities given by the international comparison studies and the research gap in mathematics education.

Cross-cultural studies have mainly articulated similarity or difference between different educational systems in students' attributions or even their perceptions of attributions. Holloway (1988) summarized literature about differences in student perceptions on attributions between Japan and the United States at great length. In addition, Tuss et al. (1995) examined underachieving fourth graders to compare to what they attributed their academic outcomes. They found that controllable attributions had a more significant role in performance for the Asian students than for the American students. These cross-cultural studies can contribute to a better understanding of attribution theory in different contexts as well as cultural factors which play a role in learned helplessness and underachievement.

Interestingly, most of the cross-sectional studies were related to the United States, China, and Japan. This might indicate a lack of knowledge about Korean students' attributions and helplessness in learning mathematics. I argue that learned helplessness in Korea can be interesting because learned helplessness is generally emphasized in studies of underachievement, while Korea are one of the countries with the high mathematics achievement. Japan is also a high-achieving country, but Tuss et al. (1995) focused on Japanese underachievers. Considering Korean students' negative

attitude toward mathematics, research on Korean students could contribute to better understanding of other aspects of learned helplessness which are disconnected from low achievement.

Program for International Student Assessment (PISA)

It is important to understand what is measured in the PISA to interpret results about the relationships between learned helplessness and scores in mathematics literacy. The PISA is the international comparison study developed by OECD in order to evaluate student achievement as the outcome of educational system in participating countries. Students around the age of 15 participate in the PISA focusing on knowledge and skills in mathematics, science and reading. Particularly, the PISA assesses student's ability to reproduce subject matter knowledge as well as extrapolation and application of their knowledge based on their understanding of concepts and various situations (OECD 2009).

To assess students' achievement, the OECD (2013) defined *mathematics literacy* as individuals' ability to not only understand the role and need of mathematics in the world but also to use and engage with mathematics in the ways which meet the role and requirement. Mathematics literacy served as the foundation of the assessment framework. Furthermore, the OECD (2013) integrated mathematical modeling (Lesh and Fennewald 2013) into the previous definition of mathematics literacy. Students' use of mathematics and mathematical tools underwent four stages sequentially with different cognitive skills as seen in Fig. 2: *formulate, employ, interpret*, and *evaluate*. By the definition of mathematics literacy, scores in the PISA 2012 represented students' overall achievement in performing the four suggested stages of problem solving. the OECD (2013) provided details on the four stages as follows;

> *Formulating situations mathematically involves identifying opportunities to apply and use mathematics—seeing that mathematics can be applied to understand or*

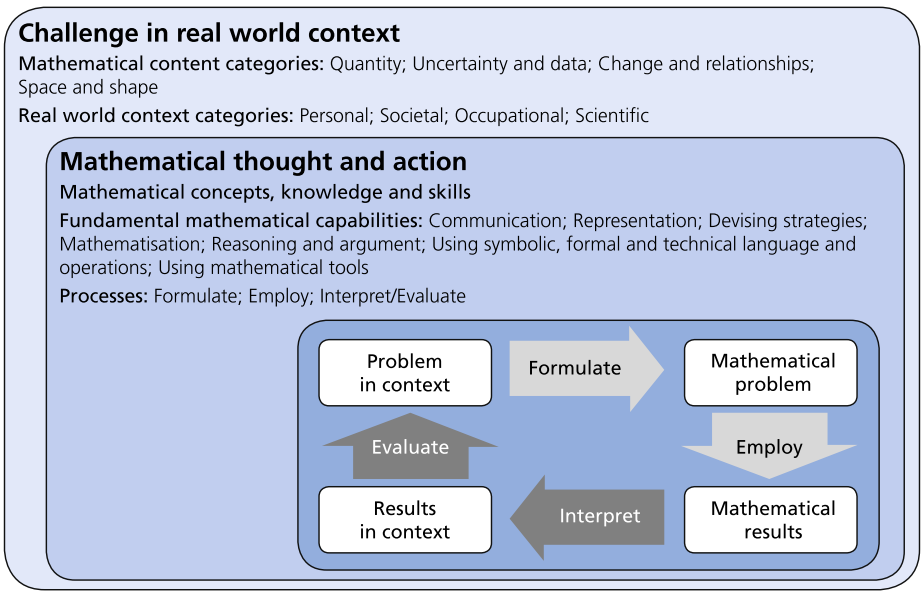

Fig. 2 A model of mathematical literacy in practice (OECD 2013, p. 26)

> *resolve a particular problem or challenge presented. [...] Employing mathematics involves applying mathematical reasoning and using mathematical concepts, procedures, facts and tools to derive a mathematical solution. [...] Interpreting mathematics involves reflecting upon mathematical solutions or results and interpreting them in the context of a problem or challenge. It includes evaluating mathematical solutions or reasoning in relation to the context of the problem and determining whether the results are reasonable and make sense in the situation. (p. 6)*

Method

Korean and Finnish data in the PISA 2012 are analyzed. Students' responses in a questionnaire are collected in the dataset. To answer the research questions, the data analysis consists of two steps. First, ordinal regression analyses are applied to produce the probability that students feel learned helplessness in connections to the degree of agreement to each attribution. Second, a linear regression analysis is employed to test whether Korea shows significantly different relationships between mathematics literacy and learned helplessness than Finland.

Data description

I select Korean and Finnish data from the PISA 2012 database and collect students' achievement scores and responses from the student questionnaire. The total number of students in the PISA 2012 database is 8829 for Finland and 5033 for Korea. However, I am able to utilize about a third of the students in both countries because the design of the PISA 2012 student context questionnaires was "a rotation with constructs being asked in two of the third of the three forms to allow joint analyses of these constructs" (OECD 2014, p. 59). Based on the variable selection that will be discussed later, this rotation design allowed me to examine the students taking the form B (see Figure 3.9 in OECD 2014, p. 61); All of the questions used in this research were included in the form B). Thus, I collect and analyze only data from these students who completed the student questionnaire. Deleting the missing data is due to the questionnaire design, which could lead to the conclusion that the sample is still representative of the population in each country. My final sample sizes are 2812 for Finland and 1684 for Korea.

Variable selection

First of all, students' overall achievement scores in the PISA 2012 are collected to investigate the relationships between learned helplessness and mathematical literacy. I utilize all five plausible values for mathematical literacy which the PISA 2012 provided (PV1MATH to PV5MATH). The plausible values as a set are more appropriate to describe the performance of the Korean and Finnish student populations (OECD 2014, p. 147). In addition, Mullis et al. (2012) stated that "by including all available background data in the model, a process known as 'conditioning', relationships between these background variables and the estimated proficiencies will be appropriately accounted for in the plausible values. Because of this, analyses conducted using plausible values will provide an accurate representation of these underlying relationships" (p. 3).

Table 1 Five questions for learned helplessness and locus of control

PISA variable	Variable code		Question	Coding
ST42Q08	Learned helplessness	Y	I feel helplessness when doing mathematics problem	1 Strongly agree 2 Agree 3 Disagree 4 Strongly disagree
ST43Q01	Effort	X_3	If I put in enough effort I can succeed in mathematics	
ST44Q01	Ability	X_1	I'm not very good at solving mathematics problems	
ST44Q04	Task difficulty	X_2	Sometimes the course material is too hard	
ST44Q06	Luck	X_4	Sometimes I am just unlucky	

Table 2 The number of Korean and Finnish students for each response to the five questions

	Variable	Strongly agree	Agree	Disagree	Strongly disagree	Total valid cases
Finland	Learned helplessness	198 (7.1%)	619 (22.2%)	1363 (48.9%)	609 (21.8%)	–
	Effort	1066 (37.9%)	1491 (53.0%)	226 (8.0%)	29 (1.0%)	2812
	Ability	396 (14.2%)	1222 (43.8%)	839 (30.1%)	332 (11.9%)	2789
	Task difficulty	542 (19.5%)	1413 (50.9%)	634 (23.1%)	180 (6.5%)	2778
	Luck	346 (12.4%)	936 (33.6%)	951 (34.1%)	553 (19.8%)	2786
Korea	Learned helplessness	171 (10.2%)	537 (31.9%)	721 (42.9%)	252 (15.0%)	–
	Effort	545 (32.4%)	919 (54.6%)	180 (10.7%)	40 (2.4%)	1684
	Ability	213 (12.7%)	611 (36.3%)	661 (39.3%)	196 (11.7%)	1681
	Task difficulty	182 (10.9%)	649 (31.9%)	607 (36.2%)	239 (14.3%)	1677
	Luck	206 (12.3%)	461 (27.5%)	611 (36.4%)	401 (23.9%)	1679

It should be noted that "Plausible values are not test scores and should not be treated as such" (OECD 2014, p. 147). Furthermore, averaging plausible values is not an option for analysis because that leads to biased estimates (von Davier et al. 2009). Rather, I apply formulas and recommendations provided by the National Center for Education Statistics (Chaney et al. 2001) to estimate parameters and compute the standard errors for calculated estimates.

Specific five variables/questions with a four-level Likert scale are selected corresponding to attribution theory. Table 1 shows details about those questions. Students' answer "1" indicates strong agreement with a given question while "4" shows strong disagreement. Also, Table 2 provides the number of Korean and Finnish students for each response to the five questions. Although hypothesis tests like Chi square tests are not conducted to compare differences, the two tables show that a larger portion of Finnish students strongly and moderately agreed to the question about each attribution. At the same time, a larger percentage of Korean students feel learned helplessness than Finnish students (42.1% for Korea and 29.3% for Finland). Lastly, the total valid cases indicate the sample sizes for the analyses no the relationships between locus of control and learned helplessness.

Table 3 Weighted means and standard deviations of mathematical literacy

Country	Mathematical literacy	Learned helplessness				Total
		Strongly agree	Agree	Disagree	Strongly disagree	
Finland	PV1MATH	454.40 (63.57)	483.15 (66.68)	524.24 (77.93)	573.35 (78.98)	523.09 (82.96)
	PV2MATH	456.06 (62.93)	481.30 (66.60)	524.26 (77.40)	573.22 (79.39)	522.78 (82.86)
	PV3MATH	456.99 (61.90)	482.84 (66.57)	525.25 (76.80)	572.83 (78.21)	523.55 (82.01)
	PV4MATH	455.44 (61.84)	483.95 (66.90)	523.16 (76.17)	571.90 (79.45)	522.44 (81.88)
	PV5MATH	455.84 (62.30)	481.74 (66.30)	524.05 (77.07)	573.32 (79.56)	522.78 (82.64)
Korea	PV1MATH	498.31 (86.48)	535.19 (87.50)	571.00 (93.08)	591.09 (108.49)	555.23 (97.88)
	PV2MATH	496.82 (87.29)	534.23 (88.33)	569.36 (92.74)	588.76 (108.51)	553.69 (97.96)
	PV3MATH	496.18 (84.58)	533.62 (88.14)	570.28 (93.42)	587.70 (109.69)	553.62 (98.20)
	PV4MATH	495.95 (86.35)	535.81 (88.39)	569.50 (94.58)	588.15 (108.56)	554.03 (98.54)
	PV5MATH	496.64 (86.97)	536.37 (88.60)	571.04 (93.41)	589.36 (108.46)	555.12 (98.29)

Table 3 shows the descriptive statistics of mathematical literacy by degree of agreement to learned helplessness. The weighted average score of the Finnish students are approximately 523 while those of the Korean students are approximately 554. In addition, Finnish students have less standard deviations compared to Korean students. Considering learned helplessness and mathematical literacy together, it is notable that students are likely to have higher scores and less variances of mathematical literacy in both countries as students more strongly agree that they felt learned helplessness.

Data analysis

This research has two focuses in the binational comparison: the relationships (a) between each attribution and learned helplessness and (b) between learned helplessness and mathematical literacy. In other words, this research attempts to examine who is likely to feel learned helplessness with a connection to locus of control, and then, what is their achievement in mathematical literacy.

Locus of control and learned helplessness

For the first focus, ordinal regression analyses are employed with the R package MASS (Ripley et al. 2018). These regression analyses are appropriate because all questions related to a locus of control and learned helplessness have four-level Likert scale, which produces ordinal variables. It should be noted that real distances between adjacent categories are unknown. Thus, I focus on describing the relationships between attributions and learned helplessness rather than conducting hypothesis tests for statistically significant differences between the ordinal regression models for Korea and Finland. This is also because differences between the two countries may be evident, but not revealed.

A proportional odds logistic regression (also sometimes called ordinal logit models; Kleinbaum et al. 2014) is applied with one independent variable and one dependent variable. Using dummy variables could be another option for researchers to include ordinal variables in linear regression models. However, I disregard this option because the weakness of using dummy variables is ignoring the ordering of the values, that is, ignoring the key characteristics of the variables. Students' answers for learned helplessness are considered as a dependent variable and answers for each question about locus of control are

included in the regression model as an independent variable. Then based on the following equation I predict the probability of students' answers about learned helplessness:

$$\ln \frac{P(y \leq j|X)}{P(y > j|X)} = \tau_j + \beta x$$

where $P(y \leq j|X)$ represents the probability to answer j-th or lower categories for learned helplessness when students answer X for an independent variable; τ_j is a threshold parameter for the j-th category of learned helplessness; and β is a location parameter for a category of X for an independent variable. Using estimated threshold and location parameters, the probability to answer each level of learned helplessness are calculated. Moreover, I include the final student weight labeled with W_FSTUWT in the dataset.

I report pseudo R-squared to evaluate the ordinal regression models. Particularly, McFadden's R^2, which has been preferred to other types of pseudo R^2 (Menard 2000), is informed in Table 4. Goodness of fit is important in a regression analysis and pseudo R-squared can help to evaluate the ordinal regression models in this research at some degree. Chi square tests for goodness of fit are not proper because of the large sample sizes. Thus, those tests are overpowered, which means that it is very likely to reject the regression model not because of poor fit of models. I also recognize a weakness of using pseudo R-squared. There are no clear recommendations about how to use pseudo R-squared and how to interpret those (Long 1997). It is possible to notice that there is no difference between the target regression model and the model with only intercept if McFadden's R^2 is equal to zero. McFadden's R^2 is estimated considering each attribute variable as a numeric value because of some technical issues. McFadden's R^2 coefficients in Table 4 shows that the regression model for the relationship between ability and learned helplessness shows the best model fit among the variables for locus of control. The regression model for luck and learned helplessness had relatively worst model fit in both Korean and Finnish. Again, there is no clear criteria to evaluate McFadden's R^2 greater than 0 as well as it would be cautious to make a strong conclusion with a single index about goodness of fit.

Learned helplessness and mathematical literacy

A linear regression model is employed to compare Korean and Finnish students in terms of the relationships between learned helplessness on mathematical literacy in Korea and Finland. The full regression equation was: $Y = B_0 + B_1D_1 + B_2D_2 + B_3D_3$ where Y is the first plausible value for mathematical literacy, B_i are regression weights, and e is the error term. I use the R package intsvy (Caro and Biecek 2018) to build the two distinct linear models from all plausible values. As with the ordinal regression analysis above, the final student weight is also used in this linear regression analysis. Then expected scores calculated by the two regression models are mainly observed to compare Korean and

Table 4 McFadden's R^2 for each ordinal regression model

Independent variable	Ability	Effort	Task difficulty	Luck
Korea	0.55	0.54	0.53	0.52
Finland	0.56	0.54	0.54	0.52

Table 5 Dummy variables for learned helplessness

Learned helplessness	Dummy variables		
	D_1	D_2	D_3
Strongly agree	0	0	0
Agree	1	0	0
Disagree	0	1	0
Strongly disagree	0	0	1

Finnish students in terms of relationships between learned helplessness and mathematics literacy.

Differently from the ordinal regression analysis, three dummy variables, D_1, D_2, and D_3, are constructed for the ordinal variable of learned helplessness as seen in Table 5. This is because my emphasis on the fact that distances between the adjacent categories are uncertain, which can lead to inappropriate interpretations of the linear model. Instead, when students strongly agree that they feel learned helplessness, $(D_1, D_2, D_3) = (0\ 0\ 0)$ is assigned to them. This approach means that regression weights, particularly B_1, B_2, and B_3 indicate how scores for mathematical literacy are expected to be changed as students less felt learned helplessness.

Results

Locus of control and learned helplessness

The analysis results showed that Korean students are likely to feel learned helplessness in the following cases: (1) students agree that their failure was due to their abilities; (2) students disagree that they are able to succeed in mathematics with enough effort; (3) students strongly agree that course materials are difficult; and (4) students strongly agree that students' failure in mathematics is because of misfortune. In those cases, the probability to agree or strongly agree with learned helplessness is greater than 0.5, as seen in Table 6.

Korean students show a high possibility of learned helplessness when they strongly agreed that their failure is due to their ability (the probability is 0.84), task difficulty (the probability is 0.77), or even misfortune (the probability is 0.63). However, if students report any degrees of disagreement that they could succeed in mathematics with sufficient effort, they report high probabilities of learned helplessness (the probability is 0.67 for "disagree" while 0.80 for "strongly disagree"). In addition, students' answers about their ability make the widest range of probabilities of learned helplessness (from 0.11 to 0.84) while those about luck have the narrowest range (from 0.35 to 0.63).

Finnish students show different patterns in the relationships between learned helplessness and attributions than Korean students (see Table 7). Finnish students are likely to feel learned helplessness in the two following cases: (1) students strongly agree that they are not good at mathematics; (2) students disagree, but not strongly, that they can succeed in mathematics with enough effort; and (3) students strongly agree that course materials are difficult. These three cases of Finnish students show higher probabilities than 0.6.

Table 6 Korean students' probability to agree/disagree with learned helplessness by attribution

	Learned helplessness					
	Strongly disagree	Disagree	Agree	Strongly agree	Total	
					Positive	Negative
Ability						
Strongly disagree	0.43	0.46	0.10	0.01	0.11	0.89
Disagree	0.17	0.51	0.27	0.05	0.32	0.68
Agree	0.08	0.40	0.41	0.11	0.52	0.48
Strongly agree	0.02	0.15	0.47	0.36	0.83	0.17
Effort						
Strongly disagree	0.03	0.18	0.45	0.35	0.80	0.20
Disagree	0.05	0.28	0.46	0.22	0.67	0.33
Agree	0.11	0.42	0.37	0.11	0.47	0.53
Strongly agree	0.27	0.51	0.19	0.04	0.23	0.77
Task difficulty						
Strongly disagree	0.29	0.50	0.18	0.04	0.22	0.78
Disagree	0.18	0.48	0.28	0.06	0.34	0.66
Agree	0.11	0.41	0.37	0.11	0.48	0.52
Strongly agree	0.03	0.20	0.46	0.31	0.77	0.23
Luck						
Strongly disagree	0.19	0.46	0.27	0.07	0.35	0.65
Disagree	0.15	0.44	0.32	0.10	0.42	0.58
Agree	0.15	0.44	0.32	0.10	0.42	0.58
Strongly agree	0.07	0.30	0.43	0.20	0.63	0.37

P(*Positive*) = P(*strongly agree*) + P(*agree*) and P(*Negative*) = P(*strongly disagree*) + P(dis*agree*)

The most interesting finding is the relationships between effort and learned helplessness. Finnish students have a high probability (0.60) of learned helplessness when they agree that they can succeed with effort. However, if students *strongly* agree with that statement, the probability decreases to 0.34. Furthermore, students' answers about luck are independent from learned helplessness. Unless students strongly believe that course materials are difficult, students are unlikely to feel learned helplessness. Even when students strongly agree, the chance to feel learned helplessness is around a half (0.52).

In all cases, Korean students have higher probabilities to feel learned helplessness than Finnish students. Figure 3 shows probabilities that Korean or Finnish students agree or strongly agree to feeling learned helplessness in learning mathematics. Whatever Korean students answer about their attributions, they have greater chances for learned helplessness than peers in Finland. Most cases for the Finnish students show probabilities less than 0.5 to feeling learned helplessness while Korean students are very likely to do with strong beliefs about attributions.

Similar patterns between the two countries are found in the relationships of ability or task difficulty to learned helplessness. As students' responses shift from agreement to disagreement, the probabilities decrease. In both countries, it is reasonable to assume a monotonic relationship between students' learned helplessness and strength of agreement that ability/task difficulty attributes to failure. The ranges of probabilities from strong agreement to strong disagreement are greater in Korea. In other words, Korean

Table 7 Finnish students' probability to agree/disagree with learned helplessness by attribution

	Learned helplessness					
	Strongly disagree	Disagree	Agree	Strongly agree	Total	
					Positive	Negative
Ability						
Strongly disagree	0.59	0.37	0.04	0.01	0.05	0.95
Disagree	0.25	0.57	0.15	0.03	0.18	0.82
Agree	0.13	0.54	0.28	0.06	0.33	0.67
Strongly agree	0.03	0.27	0.48	0.21	0.69	0.01
Effort						
Strongly disagree	0.13	0.53	0.27	0.07	0.34	0.66
Disagree	0.05	0.35	0.43	0.17	0.60	0.40
Agree	0.13	0.52	0.28	0.07	0.35	0.65
Strongly agree	0.39	0.50	0.09	0.02	0.11	0.89
Task difficulty						
Strongly disagree	0.62	0.33	0.04	0.01	0.05	0.95
Disagree	0.29	0.54	0.15	0.03	0.18	0.82
Agree	0.17	0.53	0.25	0.06	0.30	0.70
Strongly agree	0.07	0.41	0.39	0.13	0.52	0.48
Luck						
Strongly disagree	0.30	0.50	0.16	0.04	0.20	0.80
Disagree	0.20	0.50	0.24	0.06	0.30	0.70
Agree	0.19	0.50	0.24	0.06	0.30	0.90
Strongly agree	0.18	0.50	0.25	0.07	0.32	0.68

P(*Positive*) = P(*strongly agree*) + P(*agree*) and P(*Negative*) = P(*strongly disagree*) + P(dis*agree*)

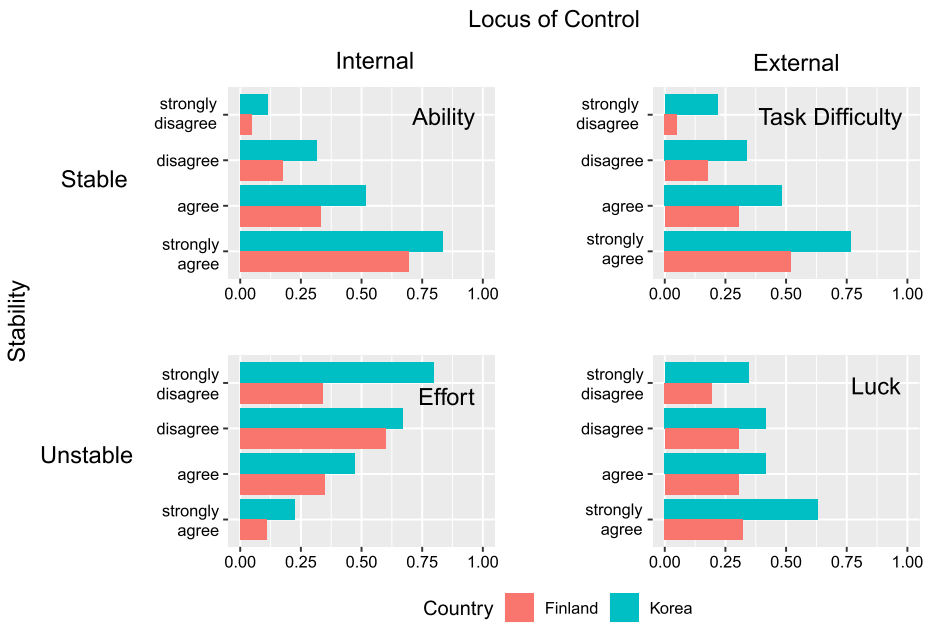

Fig. 3 Probabilities to agree or strongly agree to feeling learned helplessness in Korean and Finnish students

students show more dramatic changes than the Finnish students as their beliefs on locus of control are changed.

However, Korean and Finnish students show different patterns in relationships between effort/luck and learned helplessness. Particularly, Finnish students' beliefs about luck are independent from their feelings of learned helplessness. All responses about luck have a similar probability for learned helplessness from 0.20 to 0.32. However, if Korean students strongly agree that they fail because they are unlucky, they are likely to feel learned helplessness with the chance being 0.63. Moreover, Korean students show monotone increasing probabilities of learned helplessness from strong agreement to strong disagreement that they can succeed with enough effort. As seen in Fig. 3, Finnish students have a considerably different pattern with the attribution of efforts, in which the highest probability is for moderate disagreement.

Learned helplessness and mathematics literacy

Based on the results reported in Table 8, the regression models for the relationship between learned helplessness and mathematics literacy are: $\hat{Y}_F = 455.75 + 26.85D_1 + 68.44D_2 + 117.18D_3$ for Finland ($R^2 = 0.18$) while $\hat{Y}_K = 496.78 + 38.27D_1 + 73.46D_2 + 92.23D_3$ for Korea ($R^2 = 0.08$). All positive coefficients of B_1, B_2, and B_3 indicate that students are likely to have lower scores of mathematical literacy as they strongly agree with feeling learned helplessness.

Table 8 also shows the expected scores of mathematical literacy which might help to provide a broad picture of the effects of learned helplessness on mathematical literacy. In both countries, the expected scores increase as students disagree more. Furthermore, Table 8 shows that the Finnish students with strong agreement to learned helplessness are expected to score 455.75, while the Korean students have the mean score of 496.78. A score increase from strong agreement to moderate agreement is higher in Korea (26.85 for Finland and 38.27 for Korea) while that from strong agreement to strong disagreement is higher in Finland (117.18 for Finland and 92.23 for Korea). Strengthening their

Table 8 Linear regression analysis results and expected scores of each category of learned helpless

	Estimate	Standard error	*t*-value	Expected score by response to learned helplessness	
Finland					
R^2	0.18	0.05	3.65		
Intercept	455.75	15.81	28.84	Strongly disagree	572.93
D_1	26.85	6.12	4.39	Disagree	524.19
D_2	68.44	6.81	10.05	Agree	482.60
D_3	117.18	9.40	12.47	Strongly agree	455.75
Korea					
R^2	0.08	0.01	12.52		
Intercept	496.78	2.73	182.19	Strongly disagree	589.01
D_1	38.27	2.56	14.94	Disagree	570.24
D_2	73.46	2.23	32.98	Agree	525.05
D_3	92.23	5.07	18.18	Strongly agree	496.78

disagreement to learned helplessness is expected to improve students' scores considerably more in Finland (48.74 for Finland and 18.77 for Korea).

The Korean and Finnish models are approximately parallel from strong agreement to moderate disagreement to learned helplessness because the gaps range from 41.03 to 46.05. However, the gap between Finnish and Korean students having strong disagreement is noticeably dropped to 16.08. This means the Finnish students have a big jump in their average scores from moderate to strong disagreement compared to their peers in Korea.

Discussion and conclusion

As seen in the literature review, Weiner's (1979) attribution theory has contributed to understanding conditions in which students' maladaptive behaviors could occur. Based on this theory, researchers have scrutinized the way in which students attribute their failure to perceived causes. Weiner's model originally suggested four main attributions: academic ability, effort spent in preparation, difficulty of tasks, and luck in solving tasks. Most prior research argued that students are likely to feel learned helplessness if perceived causes are out of their control. Accompanying the prior research, I examine who is likely to feel learned helplessness in Korea and Finland by attribution. In addition, I describe the relationships between learned helplessness and mathematics literacy in each country.

Answering the first research question, I conclude that attribution theory could be generally useful in predicting students' learned helplessness when students consider ability and task difficulties as the cause of their failure. This is because the patterns in students' probabilities for learned helplessness are similar between Korea and Finland. Students who attribute their failure to a lack of ability are most likely to feel learned helplessness in both countries. For both attributes, the monotonic patterns indicate that students could be less likely to feel learned helpless as we help them to disagree that task difficulty and academic ability cause their failure. It should be noted that more evidence is necessary to generalize this finding to other educational systems. However, at least in Korea and Finland, we might be able to predict students' learned helplessness with attribution theory regardless of educational systems.

At the same time, the differences between the two countries indicate that there are certainly limitations of attribution theory to fully explain students' learned helplessness. The binational comparison produces two interesting findings that attribution theory cannot account for: (1) Korean students report higher probabilities of feeling learned helplessness than their peers in Finland in all observed cases; And (2) stability of the attributions is involved in the differences. To be specific, if attributions are stable, the patterns in the probabilities for learned helplessness are somewhat parallel between the two counties. Otherwise, nationality mediates the relationships between an attribution and learned helplessness. The most different pattern is uncovered in the case of *effort,* which is one of the unstable attributions. Even for the attribution of luck which is independent from learned helplessness of Finnish students, Korean students who strongly agree that they fail because of misfortune are likely to feel learned helplessness. This indicates alternative explanations for these cases by considering social and cultural factors of learned helplessness.

The differences are also found in the relationships between mathematics literacy and learned helplessness. If students disagree that they feel learned helplessness, students have higher scores in mathematics literacy. For the Korean students, the magnitude of students' disagreement to feeling learned helplessness, moderate or strong, is not very important to explaining their achievement in mathematical literacy. In other words, the improvement of Korean students as their disagreements become stronger is relatively small. However, scores of Finnish students significantly increase (by 48.74 for Finland and 18.77 for Korea) as students more strongly agree with learned helplessness. When students agree to feeling learned helplessness regardless of strength of their beliefs, their expected scores are parallel between Korea and Finland.

The attribution theory could contribute to better understanding of learned helplessness in students in Korea and Finland. At the same time, the findings reinforce that learned helplessness is a complex problem in which multiple factors at different levels are involved. Students are unlikely to feel learned helplessness when they believe that they fail due to misfortune or they can succeed with enough effort. Furthermore, recent movement to make the Korean national curriculum easier might contribute to reducing the chance of students' learned helplessness. However, because missing is empirical evidence to connect *mathematics abandoners* and feeling of learned helplessness, I cannot argue that all Korean students could have benefits from easier tasks to resolve feeling of learned helplessness. I recognize that this is an important limitation of this study. However, we need to help mathematics abandoners and the findings in this article partially contribute to this. Also, mathematics educators should be concerned about other educational and social factors impacting on learned helplessness because attribution theory cannot explain learned helplessness completely.

A limitation of this research is that detailed pictures of the findings about the relationships between learned helplessness and attribution theory are beyond the scope of this research. We cannot answer the important question, why Korean and Finnish students show different relationships between learned helplessness and attribution theory. Therefore, this limitation provides various avenues for further research. This study can be replicated with other countries in the PISA to acquire more information at a societal level. It is also possible that the finding cannot be generalized to other mathematics achievement scores because of the uniqueness of mathematical literacy. Thus, researchers could use other databases. Furthermore, more quantitative and qualitative research on the same topic would be beneficial. This research applied a single-level original regression model, which could be over-simplified considering a stratified sampling design of the PISA 2012. Multilevel statistical analysis including contextual variables could contribute to better understanding about mathematics abandoners. Qualitative research on the same topic could provide details that this research cannot observe. Lastly, it could be necessary to review prior studies on how to changes students' beliefs on the attributions and apply them to resolving students' learned helplessness.

Authors' contributions
This research was developed by a single author. The author read and approved the final manuscript.

Competing interests
The author has no competing interests.

Availability of data and materials
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References

Abramson, L. Y., Seligman, M. E. P., & Teasdale, J. D. (1978). Learned helplessness in humans: Critique and reformulation. *Journal of Abnormal Psychology, 87*(1), 49–74.

Alloy, L. B., Peterson, C., Abramson, L. Y., & Seligman, M. E. P. (1984). Attributional style and the generality of learned helplessness. *Journal of Personality and Social Psychology, 46*(3), 681–687.

Andrews, P., Ryve, A., Hemmi, K., & Sayers, J. (2014). PISA, TIMSS and Finnish mathematics teaching: An enigma in search of an explanation. *Educational Studies in Mathematics, 87*(1), 7–26. https://doi.org/10.1007/s10649-014-9545-3.

Caro, D. & Biecek, P. (2018). *intsvy: International assessment data manager*. R package version 2.3. https://github.com/eldafani/intsvy

Chaney, B., Jocelyn, L., Levine, D., Mule, T., Rizzo, L., Roey, S., et al. (2001). *User's guide for the Third International Mathematics and Science Study (TIMSS) (NCES 2001-065)*. Washington, DC: U.S. Department of Education. National Center for Education Statistics.

Clarke, D. (2003). International comparative research in mathematical education. In A. J. Bishop, M. A. Clements, C. Keitel, J. Kilpatrick, & F. K. S. Leung (Eds.), *Second international handbook of mathematids education* (pp. 143–184). Dordrecht, Netherlands: Kluwer Academic Publishers.

Di Martino, P., & Zan, R. (2011). Attitude toward mathematics: A bridge between beliefs and emotions. *ZDM Mathematics Education, 43,* 471–482. https://doi.org/10.1007/s11858-011-0309-6.

Diener, C. I., & Dweck, C. S. (1978). An analysis of learned helplessness: Continuous changes in performance, strategy, and achievement cognitions following failure. *Journal of Personality and Social Psychology, 36*(5), 451–462. https://doi.org/10.1037/0022-3514.36.5.451.

Hammouri, H. (2004). Attitudinal and motivational variables related to mathematics achievement in Jordan: findings from the Third International Mathematics and Science Study (TIMSS). *Educational Research, 46*(3), 241–257. https://doi.org/10.1080/0013188042000277313.

Hannula, M. S. (2002). Attitude towards mathematics: Emotions, expectations and values. *Educational Studies in Mathematics, 49*(1), 25–46.

Hau, K.-T., & Salili, F. (1993). Measurement of achievement attribution: A review of instigation methods, question contents, and measurement formats. *Educational Psychology Review, 5*(4), 377–422.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21*(1), 33–46.

Hiroto, D. S., & Seligman, M. E. P. (1975). Generality of learned helplessness in man. *Journal of Personality and Social Psychology, 31*(2), 311–327.

Holloway, S. D. (1988). Concepts of ability and effort in Japan and the United States. *Review of Educational Research, 58*(3), 327–345.

Jung, S. H. (2015, April 31). Students will learn less in Korean, English, and mathematics since 2018. *Kukminilbo*. [In Korean] Retrieved from http://news.kmib.co.kr/article/view.asp?arcid=0009806633&code=61121111&cp=nv.

Keitel, C., & Kilpatrick, J. (1999). The rationality of irrationality of international comparative studies. In G. Kkaiser, E. Luna, & I. Huntley (Eds.), *International comparison in mathematics education* (pp. 241–256). London, UK: Palmer Press.

Kleinbaum, D. G., Kupper, L. L., Azhar, N., & Rosenberg, E. S. (2014). *Applied regression analysis and other multivariable methods* (5th ed.). Boston, MA: Cengage Learning.

Kupiainen, S., Hautamäki, J., & Karjalainen, T. (2009). *The Finnish education system and PISA*. Finland: Ministry of Eduaction Publications.

Lesh, R., & Fennewald, T. (2013). Intruction to Part I modeling: What it is? Why do it? In R. Lesh, P. L. Galbraith, C. R. Haines, & A. Hurford (Eds.), *Modeling students' mathematical modeling competencies: ICTMA 13* (pp. 5–10). New York, NY: Springer.

Leung, F. K. S. (2001). In search of an East Asian identity in mathematics education. *Educational Studies in Mathematics, 47,* 35–51.

Long, J. S. (1997). *Regression models for categorical and limited dependent variables*. Thousand Oaks, CA: SAGE.

Maier, S. F., & Seligman, M. E. P. (2016). Learned helplessness at fifty: Insights from neuroscience. *Psychological Review, 123*(4), 349–367. https://doi.org/10.1037/rev0000033.

Marsh, H. W. (1990). A multidimensional, hierarchical model of self-concept: Theoretical and empirical justification. *Educational Psychology Review, 2*(2), 77–172.

Marsh, H. W., Cairns, L., Relich, J., Barnes, J., & Debus, R. L. (1984). The relationship between dimensions of self-attribution and dimensions of self-concept. *Journal of Educational Psychology, 76*(1), 3–32.

McNabb, T. (2003). Motivational issues: Potential to performance. In N. Colangelo & G. Davis (Eds.), *Handbook of gifted education* (3rd ed., pp. 417–423). Boston, MA: Allyn & Bacon.

Menard, S. (2000). Coefficients of determination for multiple logistic regression analysis. *The American Statistician, 24*(1), 17–24.
Mullis, I. V. S., Martin, M. O., Foy, P., & Arora, A. (2012). *TIMSS 2011 international results in mathematics*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College and International Association for the Evaluation of Educational Achievement (IEA).
Na, G.-S., Park, K.-M., & Park, Y.-E. (2016). Examining SENKs' and teachers' recognition about mathematics teaching and learning. *Journal of Educational Research in Mathematics, 26*(1), 63–77.
Newman, R. S. (1980). Ileviating learned helplessness in a wilderness setting: An application of attribution theory to Outward Bound. In L. J. Fyans (Ed.), *Achievement motivation: Recent trends in theory and research* (pp. 312–345). New York, NY: Plenum Press.
OECD. (2009). *PISA 2009 assessment framework—Key competencies in reading, mathematics and science*. Paris, France: OECD Publishing.
OECD. (2013). *PISA 2012 assessment and analytical framework: Mathematics, reading, science, problem solving and financial literacy*. Paris, France: OECD Publishing.
OECD. (2014). *PISA 2012 technical report*. Paris, France: OECD Publishing.
Ripley, B., Venables, B., Bates, D. M., Hornik, K., Gebhardt, A., & Firth, D. (2018). *MASS: Support functions and datasets for Venables and Ripley's MASS*. R package version 7.3-51. http://www.stats.ox.ac.uk/pub/MASS4/
Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. *Psychological Monographs: General and Applied, 80*(1), 1–28. https://doi.org/10.1037/h0092976.
Seaberg, R. L. (2015). Mathematics lessons from Finland and Sweden. *Mathematics Teacher, 108*(8), 593–598.
Simson, P. E., & Weiss, J. M. (1989). Altered activity of the locus coeruleus in an animal model of depression. *Neuropsychopharmacology, 1*(4), 287–295.
Tuss, P., Zimmer, J., & Ho, H.-Z. (1995). Causal attributions of underachieving fourth-grade students in China, Japan, and the United States. *Journal of Cross-Cultural Psychology, 26*(4), 408–425.
von Davier, M., Gonzalez, E., & Mislevy, R. J. (2009). What are plausible values and why are they useful? *IERI Monograph Series. Issues and Methodologies in Large-Scale Assessments, 2,* 9–36.
Weiner, B. (1979). A theory of motivation for some classroom experiences. *Journal of Educational Psychology, 71*(1), 3–25. https://doi.org/10.1037/0022-0663.71.1.3.
Weiner, B. (1986). *Attributional theory of motivation and emotion*. New York, NY: Springer.