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(Attached Form 6)

学位論文の要旨（論文の内容の要旨）
Summary of the Dissertation (Summary of Dissertation Contents)

論　文　題　目
Dissertation title:

The Development of a Theoretical Framework and Tools to Measure Social and Emotional Skills in Mathematics in the Mongolian Lower Secondary Education

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In the 21st century, technological advancement, together with the rapidly changing job market and the social and economic climate, requires individuals to learn varying skills to live in an unpredictable world (OECD, 2015; WEF, 2016). Consequently, many organizations and scholars have initiated skills under the term ‘social and emotional skills’ to enable students to face modern challenges. These encapsulate a balanced set of skills, including cognitive (creativity and critical thinking), interpersonal (collaboration and cooperation), and intrapersonal skills (managing emotions, goal-orientation, perseverance). Therefore, many countries have incorporated social and emotional skills into their national education policies and curricula to help future citizens thrive in an advanced society (OECD, 2015; Ontario, 2016).

With the rapid technological advancement, there is a need for change in all aspects of society, including culture and education, and mathematics is no exception. Previously, individuals were required to learn to perform basic arithmetic calculations. With the advent of technology, the need to learn numeric skills has diminished due to the availability of advanced tools that can be used to perform these calculations. Most smartphone users rarely use basic arithmetic calculations due to technological advancement (Global Mobile Phone Report, 2016). A labor market study revealed that employers in the technology sector look for individuals with sound mathematical knowledge of coding and algorithms and outstanding communication and cooperation skills. Hence, employee interpersonal and intrapersonal skills are equally important, along with their mathematical proficiency. Consequently, it is crucial to rethink mathematical competencies that initially were limited to basic arithmetic operations of addition, subtraction, multiplication, and division of whole numbers, fractions, and decimals (OECD, 2017). Subsequently, the challenges of the 21st century cannot be addressed through the disciplinary knowledge of only mathematics.

Although some of the social and emotional skills are related to the affective domain in mathematics education, the affective domain concept does not go beyond emotions and motivation. Emotions include enjoyment, anxiety, boredom, and motivation, including individual and situational interest. Due to the limitations involved, the affective domain cannot fully address the challenges of the 21st century. Being an extension of the affective domain, social and emotional skills encapsulate a more comprehensive range of social skills such as communication and cooperation and cognitive skills such as creativity and critical thinking.

Although several countries and organizations have proposed different frameworks to include social and emotional skills in mathematics, most frameworks are based on survey findings from investigations of the most in-demand skills for the 21st-century context. Moreover, the frameworks have some inconsistencies in categorizing the skills into certain conceptual domains. For example, some frameworks identify perseverance (Hasratuddin, 2011; MOE, Singapore, 2012) as an emotion, while others classify it as motivation (Social and Emotional Learning program [SEAL], 2007; Ontario Mathematics Curriculum, 2020). Additionally, some frameworks cover only social skills and emotional management (Collaborative for Academic, Social, and Emotional Learning [CASEL], 2017; SEAL, 2007), while other frameworks include cognitive skills, such as creativity and critical thinking (CCR, 2015; Ontario Mathematics Curriculum, 2020).

Nevertheless, the identification of social and emotional skills in mathematics requires more discussion from a theoretical perspective. Moreover, studies conducted in Asia and Africa have demonstrated that most countries do not have the tools to assess social and emotional skills directly (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2015). Similar to the challenges related to assessing social and emotional skills in a global context, there has been a lack of assessment of pedagogical practice to measure social and emotional skills at the school and system levels in Mongolia. However, the national curriculum includes these skills as assessment objectives. Educators and researchers have been attempting to measure social and emotional skills using self-ratings and questionnaires in current assessment practice. At the same time, these instruments are subject to different types of biases, including socially desirable responses and cultural biases, which can affect the reliability and validity of the instruments. Therefore, further research is required to develop reliable and valid ways to measure these skills. Based on the discussion thus far, the present study aims to answer the following three research questions:

RQ1: What framework can be used to capture social and emotional skills in mathematics?

RQ2: What valid tools can measure social and emotional skills in mathematics reliably?

RQ3: What is the status of social and emotional skills among Mongolian students?

To answer these research questions, first, a systematic literature review was conducted as a tool to 1) identify social and emotional skills related to mathematics in this study, 2) outline conceptual links between the selected skills and existing theories and concepts, and 3) construct the theoretical framework for this study. As an output of the systematic literature review, a theoretically predicted framework was constructed consisting of six components: 'Mathematical creativity', 'Mathematical perseverance', 'Cooperative learning in mathematics', 'Mathematical enjoyment', 'Mathematical self-efficacy' and 'Mathematical anxiety'.

Second, questionnaires followed by anchoring vignettes (AVs) and problem-posing were introduced as a methodological solution against the issues related to measuring social and emotional skills in this study. AVs are short descriptions of hypothetical individuals that illustrate different levels of skills or traits (King et al., 2004). Problem-posing in mathematics is when students use their mathematical knowledge to generate relevant problems from the given information (Sriraman and Lee, 2011). The questionnaires and problem-posing tasks were adapted from previous works, while the author developed AVs based on the questionnaires. In total, the present study employed three instruments consisting of 34 items, including 1) 15 questionnaires, 2) 15 AVs, and 3) four problem-posing tasks.

Third, the tools were administered to Mongolian ninth-grade students to examine their social and emotional mathematics skills and validate the theoretical framework and tools. In total, 308 ninth-grade students comprising 151 males (49 per cent) and 157 females (51 per cent) from eight public schools in urban, suburban, and rural areas were sampled using the convenience sampling method. The students' ages ranged from 13 to 16, with a mean age of 14.0 (Standard Deviation [SD] = 0.51).

For the first research question, a reflective measurement model was derived from the indicator items using the Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) approaches to validate the theoretically predicted framework. According to the factor structures provided by an EFA, the items were classified into six independent factors without any cross-loading, consistent with the structure of the theoretically predicted framework. Next, a CFA was performed to validate the EFA outcome. Various model fit statistics were used for the CFA to assess whether the theoretical model fits the selected data. According to the CFA, all fit indices were within acceptable values, implying that the theoretically predicted model was a good fit for the selected data (Normed Chi-Square [$\chi 2/df$)] = 1.32; Normed Fit Index [NFI] = 0.92; Comparative Fit Index [CFI = 0.98]; Tucker Lewis Index [TLI] = 0.97; Parsimony Normed Fit Index [PNFI] = 0.64; Root Mean Square Error of Approximation [RMSEA] = 0.03). Based on the EFA and CFA results, a theoretically predicted framework on social and emotional skills in mathematics was empirically confirmed for the first time in this study.

For the second research question, to test the reliability and validity of the tools, reliability and validity analyses were conducted in multiple ways including convergent, discriminant, nomological, and criterion validity. First, a reliability analysis was conducted in two stages using McDonald's ω coefficient and composite reliability (CR). The analysis results indicated that McDonald's ω and the CR value of the tools fulfilled the suggested criteria (> 0.7) in the literature, demonstrating that the items used in this study were internally consistent and reliable. The psychometric results demonstrated that problem-posing tasks and self-rating items adjusted by AVs are valid and reliable tools for measuring social and emotional skills in mathematics among ninth-grade students in Mongolia.

Students' performance on the vignette-corrected new scale and problem-posing tasks were analysed to answer the third research question. According to the findings, Mongolian ninth-grade students tend to be less creative and more anxious about mathematics; however, they demonstrate moderate performance on cooperative learning in mathematics, mathematical perseverance, mathematics enjoyment, and mathematical self-efficacy.

It is hoped that the theoretical framework in this study can provide researchers with a way to conduct empirical studies related to the social and emotional aspects of mathematics. However, the theoretical framework can be extended by adding more social and emotional skills and validated in future studies by applying EFA and CFA approaches in two different sample sizes. Future studies should employ the parametric solution of the AV approach (e.g., compound hierarchical ordered probit model) to handle some of the disadvantages of the non-parametric approach (i.e., ties and order violations). Future studies could also investigate learning activities and other classroom practices to offer insights into curriculum implementation to develop mathematical creativity in Mongolian students.

備考　論文の要旨はＡ４判用紙を使用し，4, 000字以内とする。ただし，英文の場合は1, 500語以内とする。

Remark: The summary of the dissertation should be written on A4-size pages and should not exceed 4,000 Japanese characters. When written in English, it should not exceed 1,500 words.