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A study of students' perceptions of mathematics learning situations

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ABSTRACT

This study investigated how Korean elementary, middle, and high school students perceive mathematics learning situations to determine whether the mathematics classes provided in schools met the standards of a high-quality educational experience. Using a comprehensive survey that considers both formal and implementation aspects of mathematics classes, responses from 15,418 students were analyzed to gain insights into their views on the classroom environment, instructional methods, and overall learning experience. The results indicate that as students advance in grade level, their perceptions of mathematics learning situations become increasingly negative, and mathematics classes are still perceived as being teacher-centered. Additionally, it was found that mathematical manipulatives and technological tools are not being effectively utilized, and that students' learning experiences are influenced by class size and the availability of mathematics subject-exclusive classrooms. Based on these findings, several recommendations were made to improve the quality of mathematics education and enhance students' perceptions: implementing teaching methods that increase student engagement in learner-centered classes, providing opportunities for active and diverse use of teaching aids and technological tools beyond simple calculations, maintaining appropriate class sizes, and expanding the use of mathematics subject-exclusive classrooms. These considerations are crucial for creating a more engaging and effective mathematics learning environment that aligns with evolving educational standards and meets students' needs. The findings of this study provide actionable insights for educators and policymakers aiming to improve the quality of mathematics education in Korea.

Keywords Students' perceptions, School mathematics classes, Good mathematics classes, Mathematics learning situation, Mathematics education improvement

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Introduction

In an environment where information and scientific developments are progressing at an unprecedented pace, education is also undergoing numerous transformations. To prepare individuals with a competency-based mathematics education so that they can satisfy the demands of today's society, many efforts have been made to revise curricula and amend textbooks to reflect nationwide educational standards. Therefore, it is important to investigate the current state of mathematics classes and determine whether they align with the intended educational policy changes.

There are two perspectives on what constitutes a good class. According to the first, a good class reflects the demands of teachers and students, both of whom are primary participants in class activities. Based on school interviews, Seo (2004) analyzed teachers' and students' perceptions of a beneficial class and classified them into four categories. First, teachers should convey the contents of the subject clearly and effectively. Second, students should reconstruct their knowledge with the help of the class. Third, a good class creates strong relationships by building trust between students and teachers. Finally, the class has achieved a positive result if it is carried out according to the teachers' intentions and students reach class goals.

The second approach to a good class is related to progress in solving the issues at hand, especially per subject, by researching actual conditions in schools. Cho (2001) argued that the crux of the education crisis is the failure or weakening of curriculum and classroom management. Specifically, Cho (2001) emphasized the need to modify class management strategies to focus on actual student achievements, meaning that classroom management should focus on students' participation and accomplishments. In summary, classes can be regarded as beneficial when they enhance students' creativity, capture their attention, enhance their participation, and satisfy them with the contents and methods, evaluation, and class environment (Kim & Byun, 2005).

Both perspectives on beneficial classes hold that it is important to accurately identify the opinions and perspectives of the class takers (i.e., students) as well as those of the class offerors (i.e., teachers) when determining whether a class is beneficial. While teachers may think they are providing a beneficial class, without identifying the students' actual perceptions, it is not possible to confirm whether the class is proceeding as the teacher intends. Although we have made numerous efforts to improve mathematics classroom instruction whenever the curriculum is revised, it is true that we have not paid sufficient attention to analyzing how students actually perceive these mathematics classes (Ko et al., 2017). Previous research has primarily focused on teachers' perceptions and the criteria they believe define a good class (Kang, 2006; Kwon & Pang, 2009), while relatively few studies have examined students' perceptions. Given that students are the ultimate beneficiaries of the lessons, understanding their perspectives is essential for educational improvement. Therefore, this study aims to analyze how students experience and perceive mathematics classes and learning situations and, through this, to seek ways to enhance the quality of mathematics education. The goal is to evaluate whether the mathematics classes provided in schools have a positive impact on students and to suggest necessary improvements.

Theoretical Background

This chapter explores the characteristics of a beneficial or good class and the different perspectives used to analyze mathematics classes or mathematics learning situations.

1. Class Aspects

Conceptually, a class has both external and internal aspects (Kim, 2001). External aspects refer to procedures or phases of the lesson, teaching organization, the use of various materials, and physical objects and their placement. External aspects relate to the exterior or visible aspects of the class rather than the role of a teacher or the importance of educational content. Meanwhile, internal aspects refer to an educator's understanding of class content, modes of content reconstruction, and methods of teaching. Therefore, internal aspects emphasize class contents and the intentions of the educator teaching those contents.

From an external perspective, teaching content is viewed as a mass of knowledge, and high student retention of such knowledge reflects a good class (Kim, 2001). Hence, a class can be taught well using any teaching method, regardless of the content of the lesson. Through the lens of internal aspects, however, an educator must not teach the mass of knowledge itself but rather the process of understanding it. The class content and teaching methods are not separate entities, and teaching methods emerge naturally based on how educators understand the content (Kim, 2001).

The two class aspects, external and internal, serve as mediums for understanding teaching. Limitations exist, however, when explaining the complex phenomena of class and teaching with only one of the two aspects. Some educators emphasize external aspects when defining good classes, believing that they cannot be realized through internal aspects alone and also require practical (external) measures (Kim, 2001). However, considering only external aspects provides a superficial understanding of good class. In order to understand the entirety of a class, it is crucial to consider and reflect on both aspects simultaneously.

2. Analysis of a Good Class

Until the 1990s, in Korea, research on good classes focused on class effectiveness based on students' academic performance, drawing on a high-performing class model (Song & Lee, 2012). Conversely, Zemelman et al. (1998) focused on learners' active construction of knowledge, based on constructivist learning theory (Song & Lee, 2012). They proposed that teachers in good classes should support learner-centered, empirical, reflective, practical, social, collaborative, democratic, cognitive, developmental, and constructivist classes (as cited in Choi, 2002, p. 14).

Porter and Brophy (1987) also focused on student learning when interpreting the meaning of good teaching. They defined good teaching as a "thoughtful practice" based on professional knowledge that is aligned with curriculum goals, instructional strategies, and students' needs (Porter & Brophy, 1987). Accordingly, they presented the following characteristics of a good class: it allows or predicts incorrect student notions, teaches metacognitive strategies, suggests learning goals of varying levels, and provides integrative learning with other academic subjects. Subsequently, Brophy (2000) presented the principles of effective teaching based on classroom studies: A supportive classroom climate; Opportunity to learn; Curricular alignment; Establishing learning orientations; Coherent content; Thoughtful discourse; Practice and application activities; Scaffolding students' task engagement; Strategy teaching; Co-operative learning; Goal-oriented assessment; and Achievement expectations.

Views on good classes have changed, even in Korea. A good class involves active interactions between teachers and students and includes appropriate materials and contents for students to achieve learning goals (Kang & Park, 2005). Further, as social justice issues have risen to the forefront, it has become a factor of good classes to ensure that classes create learning environments where all students have access to quality learning opportunities (Jeon et al., 2023).

Thus, a good class is not only determined by external aspects, such as its structure, procedures, and academic outcomes, but also by internal aspects, such as the contents, the teaching and learning methods, understanding processes, and the interaction and relationship between the teacher and students. Moreover, as the view of a good class has changed from teacher-centered knowledge transfer to student-centered knowledge construction, students' views on the class, including how they perceive, participate in, and construct knowledge from their experiences in the class, are also crucial when determining whether a class is good.

3. A Perspective on Mathematics Class Analysis and Mathematics Learning Situations

To create a framework for analyzing whether a mathematics class is good, it is necessary to investigate the factors that constitute a good mathematics class. The National Council for the Teaching of Mathematics (NCTM) (2000) presented a vision for school mathematics, from which we can derive the following conditions for an ideal mathematics class (p. 3): have ambitious expectations for all students; be well-equipped with necessary facilities; have teachers with abundant mathematical knowledge and resources to support their teaching, who continually develop their expertise; offer a mathematically rich curriculum for understanding important mathematical concepts and procedures; integrate technology as an essential tool for learning mathematics; encourage students to confidently engage in challenging mathematical tasks carefully selected by teachers; promote diverse mathematical perspectives and representations in problem-solving; help students to develop and explore conjectures based on evidence and then use a variety of reasoning and proof strategies to support or refute those conjectures; foster students to be flexible and resourceful problem solvers, working productively and reflectively; enable students to successfully communicate their thoughts and findings both orally and in writing; and support students to pursue active learning mathematics and value mathematics.

Several studies have explored the defining characteristics of good mathematics classes and used them to investigate teachers' or students' perceptions of good mathematics classes, often categorizing them into areas such as "teaching and learning methods," "classroom environment and class atmosphere," and "evaluation" (e.g., Jeon, 2011; Kwon & Bang, 2009). In particular, Kwon & Bang's (2009) approach is noteworthy for its emphasis on a social constructivist framework, student-centered learning, and the integration of technology. Their categories also focus on cultivating positive attitudes toward mathematics, ensuring equitable learning opportunities, valuing human relationships, and assessing students' performance and problem-solving abilities in real-life contexts. Meanwhile, the standards for good classes used in Kim's (2010) study concentrated more on the teaching and learning methods. This study delved into aspects such as motivating student learning, effective content delivery, lecture-proceeding techniques, and the instructor's attitude, offering a more focused view on the pedagogical aspects of good classes.

According to previous research, students perceive beneficial classes (or good classes) through both external and internal aspects. In this study, we define external aspects as the formal characteristics of a class, while we define internal aspects as the implementation characteristics. The formal characteristics of a class include observable features such as the classroom environment, class organization and procedures (the instructional model), evaluation methods, and the use of media. On the other hand, implementation aspects concern how the cognitive and affective aspects, as well as the contents of the class, develop. These include the classroom atmosphere, methods of class introduction, and methods of class development.

Based on these concepts, this study operationally defines a 'good mathematics class' as a class that provides a well-structured and student-centered learning environment, actively supporting students' mathematical thinking and understanding through the teacher's deep comprehension of the subject matter and systematic teaching methods. Such a class aims to help students develop a deep understanding of mathematical concepts, enhance their problem-solving skills, and explore various mathematical perspectives. This study uses the 2016 Mathematics Learning Situation Analysis survey (Ko et al., 2017) to examine students' perceptions of their mathematics classes and learning situations, providing a multi-faceted understanding of the elements that constitute an effective and engaging mathematics classroom.

Research Methods and Procedures

This study aims to understand the conditions of mathematics classrooms and the state of mathematics learning from the perspective of students. The 2016 Mathematics Learning Situation Analysis survey (Ko et al., 2017) was tested for reliability and validity through the first preliminary survey (965 students in elementary, middle, and high schools) and the second preliminary survey (354 students in elementary, middle, and high schools). The reliability of the formal and implementation aspects was high (above 0.9 for the entire population). The main survey was conducted online in early December 2016. The subjects of the research were Korean elementary students in grades 4, 5, and 6, middle school students in grades 7, 8, and 9, and high school students in grades 10 and 11. The students from elementary and high schools were convenience sampled, and the middle school students were from the Mathematics Sharing School. Information on the schools and the number of students that participated in the survey is shown in Table 1.

Table 1. Information of survey respondents

Level of schools	Grades	The number of respondents	Percentage (%)
Elementary school	4	164	32.5
	5	204	40.5
	6	136	27.0
	Total	504	100
Middle school	7	5,173	36.2
	8	4,587	32.1
	9	4,547	31.8
	Total	14,307	100
High school	10 (common)	504	83.0
	11 (humanities)	54	8.9
	11 (natural sciences)	49	8.1
	Total	607	100

The 2016 Mathematics Learning Situation Analysis Survey (Ko et al., 2017) was developed and used to investigate the learning situation in mathematics classes from the perspectives of elementary, middle, and high school students. This questionnaire has two focus areas—formal and implementation aspects—and seven sub-factors, for a total of 27 questions. A description of the main areas and their sub-factors is provided in Table 2. Questions 1-23, 25, and 27 employ a four-point Likert scale ("strongly agree," "agree," "disagree," and "strongly disagree"). Questions 24 and 26 require the respondent to choose at most two examples from eight and nine examples, including "other." Questions 25 and 27 consist of four to seven examples related to mathematics content corresponding to each grade level. All the scores used in the analysis were converted scores. For the scales, the maximum score was converted to 100 points and the minimum score to 0 points. For individual items, "strongly agree" was converted to 100 points and "strongly disagree" to 0 points.

A data cleaning process was conducted to refine the survey data by removing incomplete responses or partially answered questionnaires. After this process, frequency analysis was performed on the cleaned data for each item to gather basic information on students' perceptions and current status. Additionally, statistical tests such as F-tests and t-tests were conducted to determine whether there were significant differences in responses based on specific variables. The results of the frequency analyses and statistical tests provided meaningful insights that could inform policy recommendations.

Table 2. Characteristics by sub-factors of aspects in questionnaire (Ko et al., 2017)

Main areas	Sub-factors (question number)	Description
Formal aspects	Classroom environment (1, 2, 3)	- Refers to the exterior appearance of the classroom where students take their math classes - Investigate students' opinions on math subject-exclusive classroom, seating arrangement, moving classes through ability grouping, and other exterior aspects
	Class organization and procedures (4, 5, 6, 25)	- As an external procedure, refers to the apparent methods and order the teachers use to lead a class - Students assess the predictability of class development, direction, and procedures
	Methods of evaluation (7, 8, 9)	- Refers to how well the teacher reached intended teaching goals and evaluation of students to investigate teaching and learning results - Various evaluations of learning from students' perspective - Typically used to evaluate the formative assessment established to verify whether a class has achieved its goals
	Use of media (10, 11, 12, 26)	- Student assessment of the types and frequency of use of teaching aids, technology, and exercise sheets to aid students' understanding of math concepts during class
Implementation aspects	Classroom atmosphere (13, 14, 15, 24)	- Students' thoughts and feelings toward math class and the process of learning math - Verify students' general judgement of math classes
	Methods of class introduction (16, 17, 18)	- Refers to the opening methods of math class in the first five minutes of the class - Students' perception on inducing motivation and interest, verifying advanced learning, introducing learning goals
	Methods of class development (19, 20, 21, 22, 23, 27)	- Refers to students' judgement of how their teachers develop the class in relation to learning topics - Students' evaluation of how they feel about the application of various learning theories and philosophical perspectives in math education

Results

1. Differences in Sub-Factors of the State of Learning in Mathematics Classes by School Level

The results of the one-way ANOVA performed to verify the main areas and sub-factors of the learning situation in mathematics classes and determine if there were any school-level differences are shown in Table 3.

Elementary school results show higher scores in implementation aspects than in formal aspects. Among formal aspects, "classroom environment" scored the highest and "use of media" the lowest. Of the implementation aspects, "methods of class development" scored the most points, while "classroom atmosphere" received the fewest.

The middle school results were similar regarding both formal and implementation aspects. Of the formal aspects, "class organization and procedures" received the most points, while "use of media" received the fewest. Among the implementation aspects, "methods of class introduction" scored the most points, and "classroom atmosphere" obtained the fewest.

For high school, the implementation aspects scored higher than the formal aspects, but the scores were low overall. Regarding formal aspects, "classroom environment" received the most points, while "use of media"

Table 3. The results of F-test on the sub-factors of mathematics learning situation by school level

Areas	Sub-factors	Level of schools	Number of observations	Mean	Standard deviation	F-value	Degree of freedom	p-value	Post-test
Formal aspects	Classroom environment	Elementary	502	75.210	20.986	109.411***	2 15,411	0.000	E>M>H
		Middle	14,307	71.029	20.897				
		High	605	58.953	19.926				
		Total	15,414	70.691	21.009				
	Class organization and procedures	Elementary	496	72.732	17.559	194.350***	2 15,263	0.000	E=M>H
		Middle	14,173	72.176	19.032				
		High	597	56.630	17.204				
		Total	15,266	71.586	19.156				
	Methods of evaluation	Elementary	500	67.933	20.487	77.980***	2 15,334	0.000	M=E>H
		Middle	14,234	69.526	21.530				
		High	603	58.430	20.691				
		Total	15,337	69.038	21.572				
	Use of media	Elementary	502	48.938	20.748	232.697***	2 15,347	0.000	M=E>H
		Middle	14,244	53.057	24.582				
		High	604	31.439	21.393				
		Total	15,350	52.072	24.713				
	Total	Elementary	492	68.181	15.467	213.974***	2 15,133	0.000	E=M>H
		Middle	14,050	68.148	17.752				
		High	594	52.918	15.179				
		Total	15,136	67.551	17.834				
Implementation aspects	Classroom atmosphere	Elementary	503	63.353	20.066	3.921*	2 15,411	0.020	E=M>H
		Middle	14,307	61.035	19.757				
		High	604	60.247	18.398				
		Total	15,414	61.079	19.720				
	Methods of class introduction	Elementary	502	73.152	20.849	66.617***	2 15,412	0.000	E=M>H
		Middle	14,307	71.385	21.587				
		High	606	61.276	20.480				
		Total	15,415	71.045	21.613				
	Methods of class development	Elementary	489	74.082	15.240	76.043***	2 15,259	0.000	E>M>H
		Middle	14,173	70.962	18.692				
		High	600	61.975	17.168				
		Total	15,262	70.709	18.625				
	Total	Elementary	486	71.971	14.697	71.261***	2 15,253	0.000	E>M>H
		Middle	14,173	69.324	16.656				
		High	597	61.517	15.445				
		Total	15,256	69.102	16.628				

*<0.05, ***<0.001.

received the fewest. All implementation sub-factors received nearly equal scores.

The results show that all students in elementary, middle, and high school were generally satisfied with the formal aspects but not with the "use of media" and less satisfied with the "classroom atmosphere" in terms of implementation aspects. Additionally, elementary schools outperformed middle and high schools in terms of formal and implementation aspects. High school students, especially, reported significantly lower scores for every aspect. Figure 1 summarizes the sub-factor scores. Students seem to perceive the sub-factors similarly except for "use of media" under formal aspects. Even middle school, which had the highest scores for media usage, had comparatively lower scores than the other sub-factors. Therefore, we conclude that despite the emphasis on the use of computers and calculators since the seventh revised mathematics curriculum (beginning in 2000), current data suggests that the implementation of these tools is still not as widespread or effective as intended.

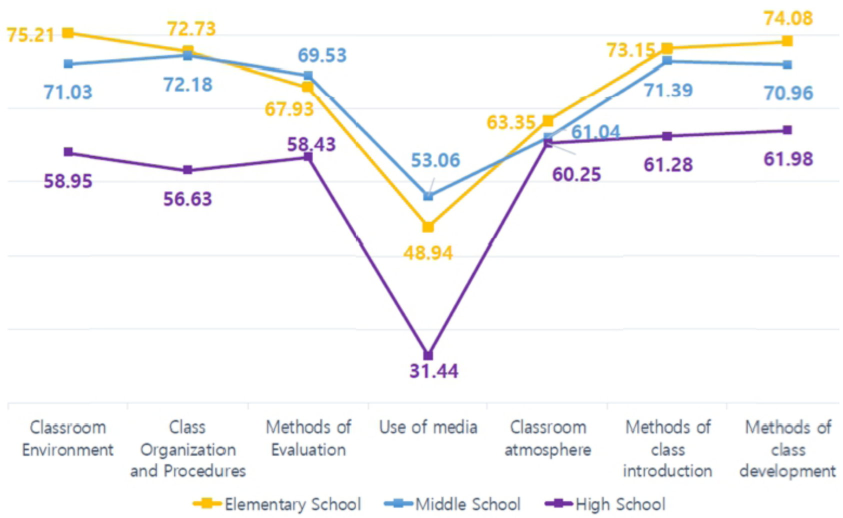

Figure 1. The average of converted scores of sub-factors by school level.

2. Characteristics in Sub-Factors of the State of Learning in Mathematics Classes by Classroom Condition

The differences among sub-factors of mathematics class learning situations were studied in terms of the number of students per classroom and the existence of mathematics subject-exclusive classrooms by school level. Teaching conditions were categorized by whether the class had fewer than 20 or more than 30 students and the existence of mathematics subject-exclusive classrooms. In Korea, while it varies from school to school, students take all of their classes in the same classroom in most schools, except for special classes in the music room or lab. Therefore, it is necessary to investigate whether the existence of mathematics subject-exclusive classrooms makes a difference in students' perceptions of mathematics classes and learning situations.

(1) Elementary School

The results of the sub-factor analysis of the number of students per classroom in elementary school are shown in Table 4. The groups with fewer than 20 students scored higher than the groups with 30 or more students overall. Large differences were apparent in the formal aspects "classroom environment" and "class organization and procedures" and the implementation aspects "classroom atmosphere" and "methods of class introduction." For the "use of media" sub-factor in the formal aspects, however, groups with fewer than 20 students scored lower than groups with 30 or more students, which is unusual. Meanwhile, the existence (or absence) of mathematics subject-exclusive classrooms does not make a difference in elementary school students' perceptions of their mathematics classes (Table 5).

Table 4. Mean and standard deviation of sub-factors by the number of students per classroom in elementary school

Areas	Sub-factors	Number of students per classroom	Number of observations	Mean	Standard deviation	Mean	Standard deviation
Formal aspects	Classroom environment	Fewer than 20	112	81.548	19.478	80.153	19.684
		More than 30	19	71.930	19.376		
	Class organization and procedures	Fewer than 20	112	76.786	16.608	75.382	16.750
		More than 30	19	67.105	15.522		
	Methods of evaluation	Fewer than 20	112	70.734	19.560	69.635	19.433
		More than 30	19	63.158	17.783		
	Use of media	Fewer than 20	112	48.512	20.450	49.194	20.766
		More than 30	19	53.216	22.704		
	Total	Fewer than 20	112	71.569	13.296	70.588	13.513
		More than 30	19	64.809	13.686		
Implementation aspects	Classroom atmosphere	Fewer than 20	112	66.964	20.201	64.970	21.193
		More than 30	19	53.216	23.593		
	Methods of class introduction	Fewer than 20	112	77.480	19.643	75.148	20.153
		More than 30	19	61.404	17.904		
	Methods of class development	Fewer than 20	111	77.044	15.878	76.296	15.445
		More than 30	19	71.930	12.053		
	Total	Fewer than 20	111	75.115	14.522	73.795	14.594
		More than 30	19	66.082	12.805		

Table 5. Mean and standard deviation of sub-factors by existence of mathematics subject-exclusive classroom in elementary school

Areas	Sub-factors	Classroom type	Number of observations	Mean	Standard deviation	Mean	Standard deviation
Formal aspects	Classroom environment	Subject-exclusive	63	74.780	21.605	75.227	21.003
		Traditional	438	75.292	20.940		
	Class organization and procedures	Subject-exclusive	61	71.448	17.177	72.736	17.577
		Traditional	434	72.917	17.644		
	Methods of evaluation	Subject-exclusive	62	70.430	20.610	67.980	20.481
		Traditional	437	67.633	20.462		
	Use of media	Subject-exclusive	63	53.439	18.275	48.924	20.767
		Traditional	438	48.275	21.040		
	Total	Subject-exclusive	61	68.563	14.712	68.192	15.481
		Traditional	430	68.140	15.603		
Implementation aspects	Classroom atmosphere	Subject-exclusive	63	63.139	20.137	63.347	20.086
		Traditional	439	63.376	20.101		
	Methods of class introduction	Subject-exclusive	63	75.132	17.929	73.165	20.868
		Traditional	438	72.882	21.260		
	Methods of class development	Subject-exclusive	63	73.251	14.040	74.097	15.252
		Traditional	425	74.222	15.435		
	Total	Subject-exclusive	63	71.605	12.948	71.982	14.710
		Traditional	422	72.038	14.968		

(2) Middle School

Table 6 presents the sub-factor results organized by the classroom size in middle school. The scores of students in the smaller classroom were relatively higher than those in the larger classroom. The gap between the scores was not as wide as in elementary school, but clear evidence indicates that students from the smaller classrooms were assigned more points. Additionally, the gap was more evident in the responses regarding formal aspects compared to implementation aspects.

Table 6. Mean and standard deviation of sub-factors by the number of students per classroom in middle school

Areas	Sub-factors	Number of students per classroom	Number of observations	Mean	Standard deviation	Mean	Standard deviation
Formal aspects	Classroom environment	Fewer than 20	2,630	72.429	21.475	70.609	21.482
		More than 30	3,847	69.364	21.400		
	Class organization and procedures	Fewer than 20	2,604	73.064	19.237	71.948	19.356
		More than 30	3,818	71.187	19.402		
	Methods of evaluation	Fewer than 20	2,620	70.433	22.200	69.128	22.072
		More than 30	3,827	68.234	21.943		
	Use of media	Fewer than 20	2,621	54.636	25.267	52.656	25.046
		More than 30	3,829	51.301	24.805		
	Total	Fewer than 20	2,586	69.305	18.306	67.813	18.140
		More than 30	3,784	66.793	17.957		
Implementation aspects	Classroom atmosphere	Fewer than 20	2,630	61.369	20.322	60.800	20.035
		More than 30	3,847	60.411	19.830		
	Methods of class introduction	Fewer than 20	2,630	72.231	21.838	71.218	21.980
		More than 30	3,847	70.525	22.053		
	Methods of class development	Fewer than 20	2,604	70.814	18.397	71.073	18.688
		More than 30	3,818	71.249	18.884		
	Total	Fewer than 20	2,604	69.449	16.448	69.325	16.759
		More than 30	3,818	69.240	16.970		

The outcomes related to mathematics subject-exclusive classrooms are shown in Table 7. The group that used the designated classroom for mathematics assigned comparatively higher scores to both formal and implementation aspects than the group taught in traditional classrooms. Particularly, there were large differences between the “classroom environment” and “use of media” scores (both formal aspects).

(3) High School

The sub-factors analysis of the classroom size in high school is shown in Table 8. Regarding formal aspects, students in the smaller classroom scored higher than those in the larger classroom. For “use of media” in the formal aspects, there were large differences in scores between the smaller classroom and the larger classroom. However, the opposite trend was seen in implementation aspects except for “methods of class development.” That is, the larger classroom students scored higher than the smaller classroom students.

Table 9 presents the survey results regarding mathematics subject-exclusive classrooms. Students taught in a designated mathematics classroom assigned relatively higher scores to both formal and implementation aspects. Regarding formal aspects, “use of media” showed large differences. For implementation aspects, a clear gap existed related to the “methods of class introduction.”

Table 7. Mean and standard deviation of sub-factors by existence of mathematics subject-exclusive classroom in middle school

Areas	Sub-factors	Classroom type	Number of observations	Mean	Standard deviation	Mean	Standard deviation
Formal aspects	Classroom environment	Subject-exclusive	4,670	74.361	21.096	71.029	20.897
		Traditional	9,637	69.414	20.608		
	Class organization and procedures	Subject-exclusive	4,622	74.221	19.195	72.176	19.032
		Traditional	9,551	71.186	18.875		
	Methods of evaluation	Subject-exclusive	4,646	71.316	21.871	69.526	21.530
		Traditional	9,588	68.659	21.310		
	Use of media	Subject-exclusive	4,653	57.189	24.801	53.057	24.582
		Traditional	9,591	51.052	24.223		
	Total	Subject-exclusive	4,587	70.735	18.116	68.148	17.752
		Traditional	9,463	66.894	17.436		
Implementation aspects	Classroom atmosphere	Subject-exclusive	4,670	62.072	20.629	61.035	19.757
		Traditional	9,637	60.532	19.302		
	Methods of class introduction	Subject-exclusive	4,670	73.388	21.641	71.385	21.587
		Traditional	9,637	70.414	21.495		
	Methods of class development	Subject-exclusive	4,622	72.221	18.767	70.962	18.692
		Traditional	9,551	70.353	18.627		
	Total	Subject-exclusive	4,622	70.674	16.831	69.324	16.656
		Traditional	9,551	68.670	16.532		

Table 8. Mean and standard deviation of sub-factors by the number of students per classroom in high school

Areas	Sub-factors	Number of students per classroom	Number of observations	Mean	Standard deviation	Mean	Standard deviation
Formal aspects	Classroom environment	Fewer than 20	29	56.705	21.891	53.843	19.345
		More than 30	263	53.528	19.063		
	Class organization and procedures	Fewer than 20	29	58.046	20.319	54.413	15.821
		More than 30	259	54.006	15.231		
	Methods of evaluation	Fewer than 20	29	58.621	22.982	53.761	18.700
		More than 30	262	53.223	18.137		
	Use of media	Fewer than 20	29	40.230	25.095	28.957	20.325
		More than 30	263	27.714	19.388		
	Total	Fewer than 20	29	54.767	19.530	49.580	13.767
		More than 30	258	48.997	12.883		
Implementation aspects	Classroom atmosphere	Fewer than 20	29	56.705	17.655	59.832	18.717
		More than 30	262	60.178	18.831		
	Methods of class introduction	Fewer than 20	30	57.778	24.828	60.068	19.922
		More than 30	263	60.330	19.324		
	Methods of class development	Fewer than 20	30	56.364	19.159	61.801	15.840
		More than 30	259	62.431	15.329		
	Total	Fewer than 20	29	56.525	15.502	61.031	14.576
		More than 30	257	61.540	14.411		

3. Analysis of Mean Differences Between Groups Based on Classroom Conditions

To examine the mean differences between groups according to the number of students per classroom and the existence of mathematics subject-exclusive classrooms, F-tests and t-tests were conducted.

Table 9. Mean and standard deviation of sub-factors by existence of mathematics subject-exclusive classroom in high school

Areas	Sub-factors	Classroom type	Number of observations	Mean	Standard deviation	Mean	Standard deviation
Formal aspects	Classroom environment	Subject-exclusive	20	64.444	21.509	58.996	19.915
		Traditional	584	58.809	19.851		
	Class organization and procedures	Subject-exclusive	20	62.083	17.569	56.669	17.191
		Traditional	576	56.481	17.163		
	Methods of evaluation	Subject-exclusive	20	58.889	14.465	58.472	20.683
		Traditional	582	58.457	20.873		
	Use of media	Subject-exclusive	20	41.111	22.542	31.435	21.411
		Traditional	583	31.103	21.314		
	Total	Subject-exclusive	20	58.235	14.716	52.951	15.170
		Traditional	573	52.767	15.165		
Implementation aspects	Classroom atmosphere	Subject-exclusive	20	61.667	22.361	60.254	18.413
		Traditional	583	60.206	18.283		
	Methods of class introduction	Subject-exclusive	20	68.889	19.279	61.322	20.465
		Traditional	585	61.064	20.471		
	Methods of class development	Subject-exclusive	20	63.485	19.000	62.018	17.151
		Traditional	579	61.967	17.099		
	Total	Subject-exclusive	20	64.118	16.760	61.554	15.431
		Traditional	576	61.465	15.391		

(1) Mean Differences between Groups Based on the Number of Students per Classroom

Class size was categorized in increments of 10 students to allow for more precise group distinctions: 10 or fewer, 11-20, 21-30, 31-40, and more than 41 students. The results of the analysis of the mean differences between groups in the formal aspects of the mathematics learning situations based on class size are presented in Table 10, while the results for the implementation aspects are shown in Table 11.

First, looking at the analysis results from the formal aspects (Table 10), significant mean differences were found between groups for all sub-factors. In all formal aspects, except for the “ued of media” sub-factor, smaller class groups with 20 or fewer students showed more positive responses to mathematics classes compared to larger class groups with 31 or more students. In the “use of media” sub-factor, smaller classes also showed more positive responses, except for the group with more than 41 students. The significantly higher average score in the group with more than 41 students is likely due to the small sample size of only 11 cases.

Next, regarding the analysis of the implementation aspects, significant mean differences were found between groups for all sub-factors (Table 11). Overall, smaller classes with 20 or fewer students showed more positive responses in the implementation aspects of mathematics classes compared to larger classes with 31 or more students.

(2) Mean Differences between Groups Based on the Existence of Mathematics Subject-Exclusive Classrooms

The previous analysis of sub-factors based on the existence of mathematics subject-exclusive classrooms showed minimal differences at the elementary school level compared to middle and high school levels. To explore this further, the mean differences between groups based on the existence of mathematics subject-exclusive classrooms were analyzed separately for each school level.

Table 10. The overall result of the F-test on the mean differences of sub-factors within the formal aspects based on the number of students per classroom

Areas	Sub-factors	Number of students per classroom	Number of observations	Mean	Standard deviation	F-value	Degree of freedom	p-value
Formal aspects	Classroom environment	10 or fewer	977	71.125	23.128	22.009***	4 15,407	0.000
		11-20	1,794	73.455	20.572			
		21-30	8,512	71.187	20.441			
		31-40	4,118	68.383	21.552			
		41 or more	11	62.626	35.581			
		Total	15,412	70.692	21.007			
	Class organization and procedures	10 or fewer	966	72.464	20.228	11.309***	4 15,259	0.000
		11-20	1,779	73.379	18.646			
		21-30	8,423	71.841	18.867			
		31-40	4,085	70.095	19.569			
		41 or more	11	65.152	29.420			
		Total	15,264	71.588	19.155			
	Methods of evaluation	10 or fewer	973	69.727	22.965	10.734***	4 15,330	0.000
		11-20	1,788	70.644	21.666			
		21-30	8,466	69.486	21.114			
		31-40	4,097	67.261	21.986			
		41 or more	11	64.646	30.558			
		Total	15,335	69.038	21.570			
	Use of media	10 or fewer	975	54.405	25.196	16.769***	4 15,343	-0.000
		11-20	1,787	54.144	25.133			
		21-30	8,475	52.468	24.269			
		31-40	4,100	49.743	25.119			
		41 or more	11	71.717	29.550			
		Total	15,348	52.072	24.714			
	Total	10 or fewer	961	68.587	19.265	19.154***	4 15,129	0.000
		11-20	1,766	69.601	17.594			
		21-30	8,346	67.924	17.457			
		31-40	4,050	65.652	18.151			
		41 or more	11	65.775	28.889			
		Total	15,134	67.552	17.833			

***<0.001.

① Elementary School

The results of the analysis of mean differences between groups based on whether the mathematics classroom was the mathematics subject-exclusive classroom or a general classroom are presented in Table 12. Both the formal and implementation aspects, including all sub-factors, showed no significant differences between the two groups. This suggests that there is almost no difference between learning in the mathematics subject-exclusive classroom and a general classroom at the elementary school level.

② Middle School

The results of the analysis of mean differences between groups based on the existence of mathematics

Table 11. The overall result of the F-test on the mean differences of sub-factors within the implementation aspects based on the number of students per classroom

Areas	Sub-factors	Number of students per classroom	Number of observations	Mean	Standard deviation	F-value	Degree of freedom	p-value
Implementation aspects	Classroom atmosphere	10 or fewer	977	59.581	19.323	7.289***	4 15,407	0.000
		11-20	1,794	62.616	20.771			
		21-30	8,513	61.274	19.482			
		31-40	4,117	60.403	19.791			
		41 or more	11	45.455	11.605			
		Total	15,412	61.079	19.721			
	Methods of class introduction	10 or fewer	978	71.404	22.676	6.941***	4 15,408	0.000
		11-20	1,794	72.767	21.389			
		21-30	8,512	71.229	21.303			
		31-40	4,118	69.861	21.968			
		41 or more	11	59.596	35.926			
		Total	15,413	71.045	21.611			
	Methods of class development	10 or fewer	967	69.454	19.149	2.566*	4 15,255	0.036
		11-20	1,778	71.699	17.949			
		21-30	8,419	70.652	18.621			
		31-40	4,085	70.708	18.764			
		41 or more	11	65.794	22.682			
		Total	15,260	70.710	18.623			
	Total	10 or fewer	966	68.070	16.518	4.457**	4 15,249	0.001
		11-20	1,778	70.342	16.366			
		21-30	8,416	69.135	16.543			
		31-40	4,083	68.762	16.900			
		41 or more	11	61.250	18.101			
		Total	15,254	69.103	16.626			

*<0.05, **<0.01, ***<0.001.

subject-exclusive classrooms in the middle school level are presented in Table 13. Significant differences were found in both the formal and implementation aspects, including all sub-factors, with students in the mathematics subject-exclusive classrooms showing higher averages. This indicates that students who received instruction in the mathematics subject-exclusive classrooms had significantly better perceptions of mathematics classes compared to those in general classrooms at the middle school level.

③ High School

At the high school level, the results of the analysis of mean differences between groups based on whether the mathematics classroom was the mathematics subject-exclusive classroom or a general classroom are presented in Table 14. The analysis revealed that significant differences were found only in the "use of media" sub-factor within the formal aspects. This indicates that while no significant differences were observed in other formal sub-factors or in the implementation aspects based on the existence of mathematics subject-exclusive classrooms, students in the mathematics subject-exclusive classrooms had more positive perceptions of mathematics classes in terms of media usage compared to those in general classrooms.

Table 12. The result of the t–test on the mean differences of sub–factors based on the existence of mathematics subject–exclusive classrooms at the elementary school level

Areas	Sub–factors	Classroom type	Number of observations	Mean	Standard deviation	t–value	Degree of freedom	p–value
Formal aspects	Classroom environment	Subject–exclusive	63	74.780	21.605	−0.181	499.000	0.857
		Traditional	438	75.292	20.940			
	Class organization and procedures	Subject–exclusive	61	71.448	17.177	−0.611	493.000	0.542
		Traditional	434	72.917	17.644			
	Methods of evaluation	Subject–exclusive	62	70.430	20.610	1.006	497.000	0.315
		Traditional	437	67.633	20.462			
	Use of media	Subject–exclusive	63	53.439	18.275	1.850	499.000	0.065
		Traditional	438	48.275	21.040			
	Total	Subject–exclusive	61	68.563	14.712	0.200	489.000	0.842
		Traditional	430	68.140	15.603			
Implementation aspects	Classroom atmosphere	Subject–exclusive	63	63.139	20.137	−0.088	500.000	0.930
		Traditional	439	63.376	20.101			
	Methods of class introduction	Subject–exclusive	63	75.132	17.929	0.800	499.000	0.424
		Traditional	438	72.882	21.260			
	Methods of class development	Subject–exclusive	63	73.251	14.040	−0.471	486.000	0.638
		Traditional	425	74.222	15.435			
	Total	Subject–exclusive	63	71.605	12.948	−0.218	483.000	0.828
		Traditional	422	72.038	14.968			

Table 13. The result of the t–test on the mean differences of sub–factors based on the existence of mathematics subject–exclusive classrooms at the middle school level

Areas	Sub–factors	Classroom type	Number of observations	Mean	Standard deviation	t–value	Degree of freedom	p–value
Formal aspects	Classroom environment	Subject–exclusive	4,670	74.361	21.096	13.252***	9,048.223	0.000
		Traditional	9,637	69.414	20.608			
	Class organization and procedures	Subject–exclusive	4,622	74.221	19.195	8.872***	9,003.166	0.000
		Traditional	9,551	71.186	18.875			
	Methods of evaluation	Subject–exclusive	4,646	71.316	21.871	6.853***	8,981.011	0.000
		Traditional	9,588	68.659	21.310			
	Use of media	Subject–exclusive	4,653	57.189	24.801	14.069***	14,242.000	0.000
		Traditional	9,591	51.052	24.223			
	Total	Subject–exclusive	4,587	70.735	18.116	11.931***	8,771.939	0.000
		Traditional	9,463	66.894	17.436			
Implementation aspects	Classroom atmosphere	Subject–exclusive	4,670	62.072	20.629	4.276***	8,711.131	0.000
		Traditional	9,637	60.532	19.302			
	Methods of class introduction	Subject–exclusive	4,670	73.388	21.641	7.725***	9,183.481	0.000
		Traditional	9,637	70.414	21.495			
	Methods of class development	Subject–exclusive	4,622	72.221	18.767	5.569***	9,078.722	0.000
		Traditional	9,551	70.353	18.627			
	Total	Subject–exclusive	4,622	70.674	16.831	6.686***	8,994.359	0.000
		Traditional	9,551	68.670	16.532			

Table 14. The result of the t-test on the mean differences of sub-factors based on the existence of mathematics subject-exclusive classrooms at the high school level

Areas	Sub-factors	Classroom type	Number of observations	Mean	Standard deviation	t-value	Degree of freedom	p-value
Formal aspects	Classroom environment	Subject-exclusive	20	64.444	21.509	1.245	602.000	0.214
		Traditional	584	58.809	19.851			
	Class organization and procedures	Subject-exclusive	20	62.083	17.569	1.434	594.000	0.152
		Traditional	576	56.481	17.163			
	Methods of evaluation	Subject-exclusive	20	58.889	14.465	0.092	600.000	0.927
		Traditional	582	58.457	20.873			
	Use of media	Subject-exclusive	20	41.111	22.542	2.061*	601.000	0.040
		Traditional	583	31.103	21.314			
	Total	Subject-exclusive	20	58.235	14.716	1.587	591.000	0.113
		Traditional	573	52.767	15.165			
Implementation aspects	Classroom atmosphere	Subject-exclusive	20	61.667	22.361	0.349	601.000	0.727
		Traditional	583	60.206	18.283			
	Methods of class introduction	Subject-exclusive	20	68.889	19.279	1.684	603.000	0.093
		Traditional	585	61.064	20.471			
	Methods of class development	Subject-exclusive	20	63.485	19.000	0.389	597.000	0.697
		Traditional	579	61.967	17.099			
	Total	Subject-exclusive	20	64.118	16.760	0.755	594.000	0.450
		Traditional	576	61.465	15.391			

*<0.05.

4. Students' Fundamental Perceptions of Mathematics Class by School Level

This section discusses students' fundamental perceptions of mathematics classes and their current states, focusing on survey questions and sub-factors that showed differences in response rates by school level or that could have policy implications.

First, the study results revealed students' perceptions of the use of teaching aids in mathematics classrooms. As part of the "use of media" sub-factor, Figure 2 presents the analysis results of a single question, specifically focusing on students' responses regarding the utilization of mathematical manipulatives.

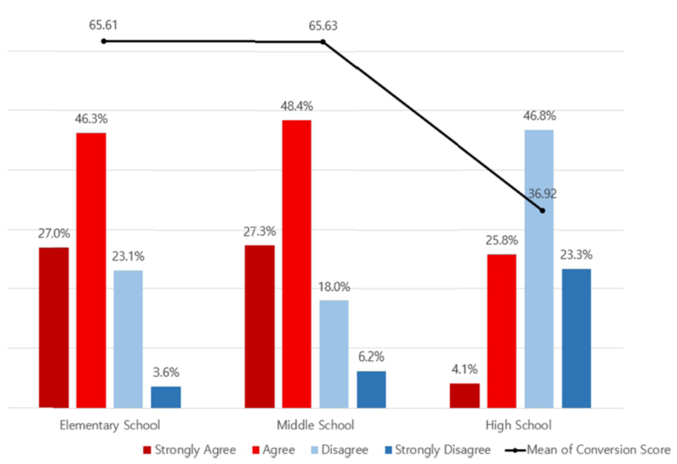

Figure 2. The students' perceptions of the use of mathematical manipulatives in mathematics class.

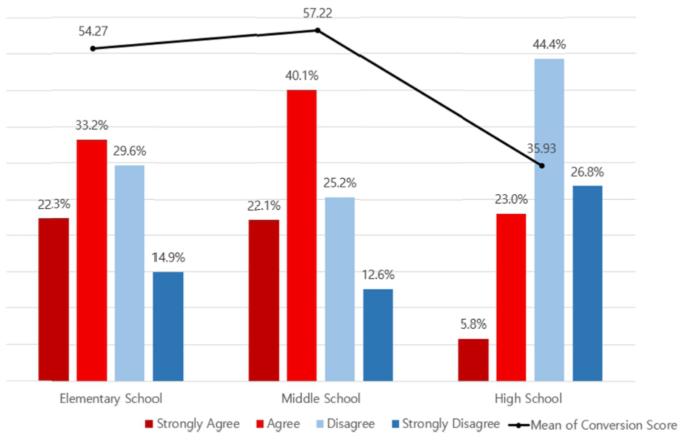

Figure 3. The students' perceptions of the use of mathematics computer programs in mathematics class.

Based on the scores, it is hard to say that teaching aids are being actively utilized at all school levels. In addition, for the question about the use of computer programs in mathematics class, the average scores were 54.2 points for elementary school, 57.2 points for middle school, and 35.9 points for high school (Figure 3). Thus, the students' responses showed that technological tools like computer programs are not used frequently in mathematics classes.

Second, students perceived their friends' indifference to mathematics class. As part of the "classroom atmosphere" sub-factor, the students were asked about their indifference toward or passive participation in mathematics class. The number of students who demonstrated indifference toward or passive participation in mathematics class was smallest in elementary school (over 30%), and the rates increased in both middle and high school (over 40%) (Figure 4).

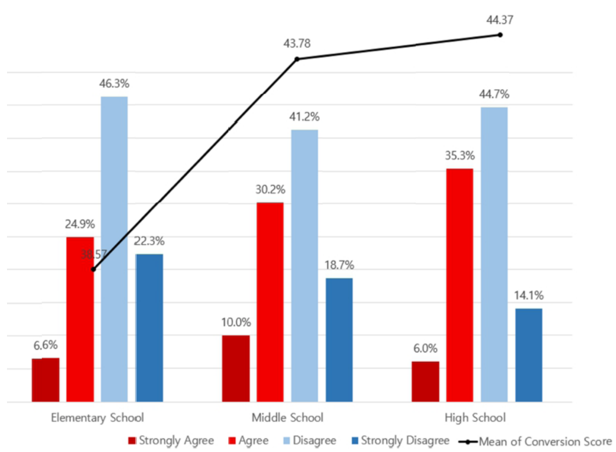

Figure 4. The students' perceptions of their peers' disinterest or passive participation in mathematics class.

Last, the study results indicated that students need more sufficient teachers' responses to student questions in mathematics classrooms. Regarding methods of class development, students were asked if teachers had not provided noticeably different responses when asked an initial question and a subsequent follow-up question regarding a specific mathematics topic or concept (Figure 5). The scores were 45, 49, and 45 points for elementary, middle, and high school, respectively. While many responses from the three school levels (61.5%, 51.1%, and 61.5%) indicated that a difference exists between teachers' first and second explanations (strongly disagree and disagree), there were also a number of responses (38.5%, 48.8%, and 38.4%) indicating that no difference exists (strongly agree and agree). These responses suggest that little difference exists between the quality of the first explanation of mathematical concepts or ideas and subsequent explanations. Thus, mathematics teachers need to be better prepared to respond to students' questions using better language and techniques to explain mathematical concepts or ideas.

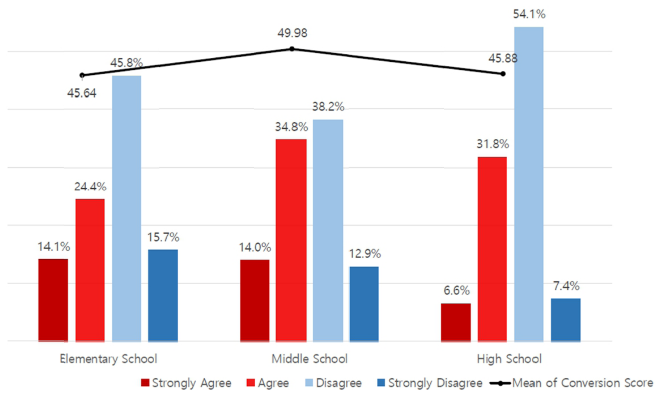

Figure 5. The students' perceptions of whether the teachers' responses to student questions in mathematics class are the same.

5. Current States of Mathematics Classes as Perceived by Students

Questions 24 through 27 differ in nature from prior questions on the questionnaire. Question 24 requires respondents to select two from a list of choices that best describe "my current mathematics class." Question 25 gives one specific mathematical topic with five different teaching methodologies and asks students which method they will most likely be taught in class. Question 26 asks students to pick two situations in which mathematics teaching aids or computers are most often used. Question 27 presents specific mathematical tasks and asks students to choose one that they can solve confidently. Students' perceptions were analyzed for each question.

(1) Students' Perceptions of the Description that Best Fits Their Current Mathematics Classes

To analyze the classroom atmosphere, students were asked to choose multiple phrases that best described their mathematics classes (Figure 6). Elementary students most often selected "highly active" and also picked "without discrimination" frequently. Middle school students chose "without discrimination" most frequently, along with "helping classmates in need." High school students also selected "without discrimination" most frequently, followed by "helping classmates in need."

Meanwhile, the least popular answer chosen by students at all levels was "rowdy and hard to concentrate," followed by "learner-centered." Hence, we can conclude that students do not believe that their current mathematics classes are centered around learners.

(2) Students' Perceptions of Learning Methods in Current Mathematics Classes

This section examines the class organization and procedures sub-factors. Students were presented with a mathematics topic and five different learning methods. Then, for each of the five methods, they were asked to indicate how likely they were to learn a given mathematics topic using that method. The five different

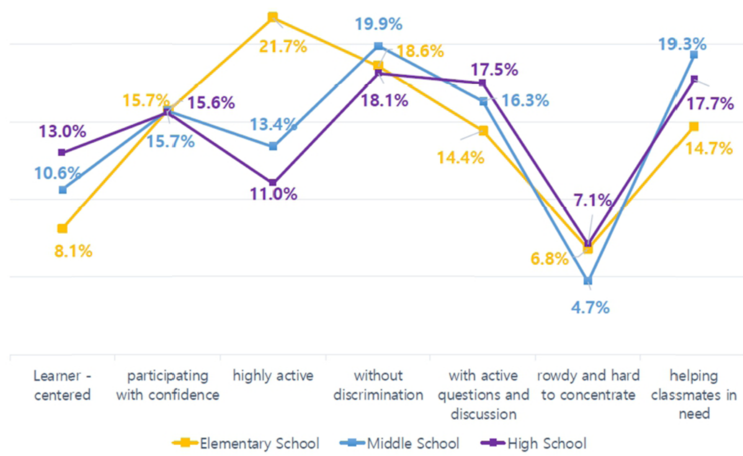

Figure 6. The students' perceptions of the best description of their current mathematics class.

Table 15. The students' perceptions of learning methods in mathematics class

School level	Learning methods	Are you likely to learn a given mathematics topic using each of these methods?					
		Mean (standard deviation)	Frequency (%)				
			Strongly agree	Agree	Disagree	Strongly disagree	Total
Elementary school	Explanation-oriented learning	78.926 (22.707)	232 (46.1%)	235 (46.7%)	25 (5.0%)	11 (2.2%)	503 (100.0%)
	Discovery learning	71.892 (25.511)	175 (34.7%)	251 (49.8%)	60 (11.9%)	18 (3.6%)	504 (100.0%)
	Project-based learning	69.643 (25.440)	151 (30.0%)	267 (53.0%)	66 (13.1%)	20 (4.0%)	504 (100.0%)
	Discussion-based learning	66.137 (27.987)	143 (28.4%)	239 (47.5%)	91 (18.1%)	30 (6.0%)	503 (100.0%)
	Learning with teaching aids	68.995 (27.266)	164 (32.7%)	230 (45.9%)	85 (17.0%)	22 (4.4%)	501 (100.0%)
Middle school	Explanation-oriented learning	77.808 (21.463)	5,874 (41.4%)	7,386 (52.1%)	689 (4.9%)	224 (1.6%)	14,173 (100.0%)
	Discovery learning	72.742 (24.006)	4,849 (34.2%)	7,411 (52.3%)	1,560 (11.0%)	353 (2.5%)	14,173 (100.0%)
	Project-based learning	70.846 (25.300)	4,601 (32.5%)	7,229 (51.0%)	1,862 (13.1%)	481 (3.4%)	14,173 (100.0%)
	Discussion-based learning	71.048 (25.405)	4,660 (32.9%)	7,226 (51.0%)	1,777 (12.5%)	510 (3.6%)	14,173 (100.0%)
	Learning with teaching aids	71.544 (25.538)	4,773 (33.7%)	7,276 (51.3%)	1,549 (10.9%)	575 (4.1%)	14,173 (100.0%)
High school	Explanation-oriented learning	69.747 (23.111)	158 (26.1%)	364 (60.1%)	66 (10.9%)	18 (3.0%)	606 (100.0%)
	Discovery learning	54.766 (27.088)	78 (12.9%)	285 (47.1%)	190 (31.4%)	52 (8.6%)	605 (100.0%)
	Project-based learning	49.587 (27.966)	64 (10.6%)	240 (39.7%)	228 (37.7%)	73 (12.1%)	605 (100.0%)
	Discussion-based learning	52.263 (29.310)	77 (12.7%)	271 (44.9%)	174 (28.8%)	82 (13.6%)	604 (100.0%)
	Learning with teaching aids	48.062 (29.989)	61 (10.1%)	252 (41.9%)	181 (30.1%)	108 (17.9%)	602 (100.0%)

types of learning methods include explanation-oriented learning, discovery learning, project-based learning, discussion-based learning, and learning with teaching aids such as mathematical manipulatives or computer programs. The students' responses are shown in Table 15.

Across elementary, middle, and high school levels, a consistent trend emerges in students' learning experiences in mathematics classes. Students at all levels reported that explanation-oriented learning is the most prevalent teaching method. Conversely, each school level indicated a lack of engagement with other learning methods. Elementary students reported the least exposure to discussion-based learning, middle school students to project-based learning, and high school students to learning with teaching aids. These findings suggest that while explanation-oriented teaching is dominant, other interactive and resource-based learning methods are significantly underutilized in mathematics classes across all school levels.

(3) Students' Perceptions of the Use of Manipulatives or Computers in Mathematics Classrooms

This section discusses the use of media. Students were asked to choose the situation(s) in which mathematical manipulatives or computer programs were used (up to two answers were permitted). The results are shown in Figure 7. Students across elementary, middle, and high school levels predominantly selected "when calculation is complex" as their top choice, with a notably higher percentage compared to other options. Meanwhile, students of all grades least frequently chose "when providing students with self-study time." Thus, students are seldom permitted to use computers or manipulate independently in mathematics class.

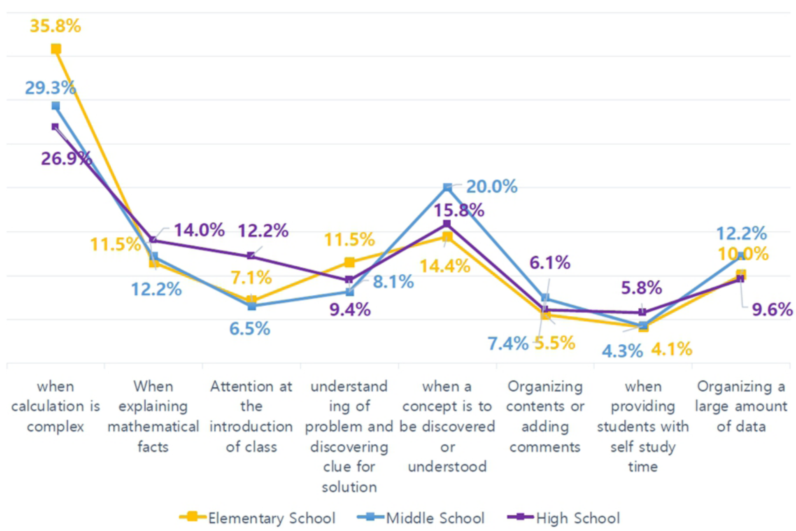

Figure 7. The students' perceptions of the use of manipulatives or computers in their current mathematics class.

(4) Students' Perception of Their Own Understanding or Problem-Solving Related to the Topics Taught in Mathematics Class

This section describes students' perceptions of the methods of class development. Students were presented with four to seven different types of mathematics problems and asked to choose one they felt they could understand or solve confidently, seeking to identify what types of mathematics problems were emphasized in school mathematics classes.

Elementary school students were presented with four different types of problems: calculating, reasoning in geometry, describing a calculating process, and measurement-related problems (Figure 8). "Calculation" problems scored the highest, while "reasoning in geometry" problems scored the lowest.

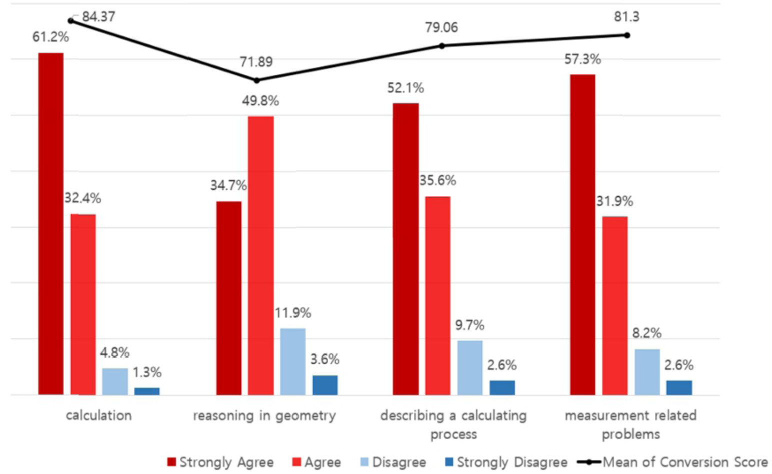

Figure 8. Types of mathematics problems elementary school students can confidently solve.

Middle school students were presented with seven different types of problems or mathematical topics: solving equations, reasoning in algebra, explaining geometry formulas, describing a calculating process or explaining algebra formulas, reasoning in geometry, problems connecting different mathematical concepts, and measurement-related problems (Figure 9). The students excelled in "reasoning in algebra" problems and "solving equations" problems but struggled with problems "connecting different mathematical concepts" and "explaining geometry formulas."

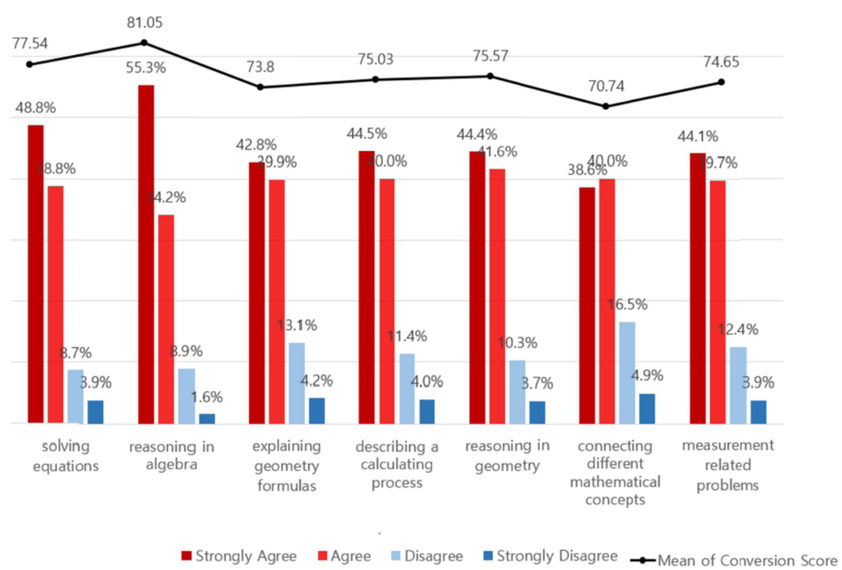

Figure 9. Types of mathematics problems middle school students can confidently solve.

Finally, six topics were presented to high school students: solving equation problems, reasoning in algebra, explaining geometry formulas, describing a calculating process, proving geometry problems, and problems connecting different mathematical concepts (Figure 10). "Solving equations" problems received the highest score, while the lowest scoring topics were "proving geometry problems" and "explaining geometry formulas."

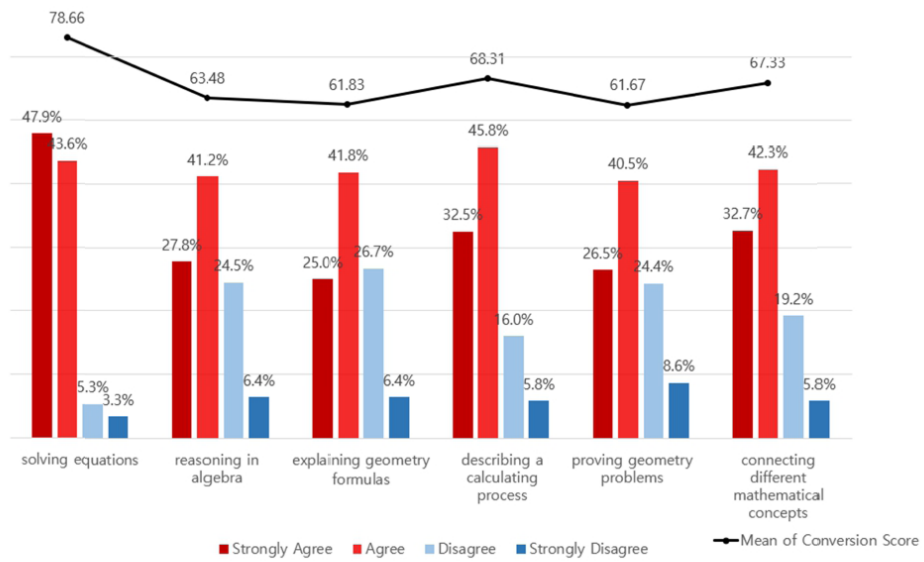

Figure 10. Types of mathematics problems high school students can confidently solve.

This trend indicates a consistent strength in computational and algebraic skills and weakness in geometric reasoning and proving across grades, while highlighting a need for enhanced focus on the connections of various mathematical concepts, especially at the middle school level.

Conclusion and Implications

In this study, a survey was conducted to examine students' perceptions of mathematics classes and classrooms. Each time the Korean mathematics curriculum has undergone revisions, efforts have been made to improve mathematics lessons and classrooms. However, few studies have examined how students actually perceive mathematics classes. Thus, this study analyzed the perceptions of students participating in mathematics classes in elementary, middle, and high schools, drawing the following implications.

First, the results showed a certain grade-level trend. As grades increased, scores tended to decrease across both formal and implementation aspects and across all sub-factors. Compared to elementary and middle school, high school showed significantly lower scores. Although no significant differences emerged between the elementary and middle school scores, the scores in the elementary school were higher. This suggests a need for targeted improvements in middle and high school mathematics classes, considering both formal and implementation aspects.

Second, regarding formal aspects, the sub-factor "use of media" indicates a gap between curriculum emphasis and classroom implementation. Although middle school had the highest scores among the three school levels, its score for "use of media" was far lower than other sub-factor scores. We believe that such a low score accurately reflects the current state of media usage in Korea's mathematics education. This finding is consistent with the recent study by Choi et al. (2021), which also highlighted that despite the advantages of using technological tools in mathematics classes being known for over 20 years, these tools are still not widely used. Even though media has been emphasized in every revision of the mathematics curriculum, our results show that it is still not adequately implemented in actual classrooms. Therefore, along with ensuring access to and facilities for using technological tools in school mathematics, there is a need for professional development to train teachers on how to use these tools effectively during mathematics class.

However, while the use of digital technology is increasingly considered essential for effective mathematics learning, it is equally important to address the potential problems and considerations associated with this technology. In the study conducted by Kim et al. (2024), many elementary school teachers expressed concerns about the negative impacts of digital technology, such as digital overload, excessive dependency, and a lack of digital ethics awareness. Therefore, systematic support is needed, including training programs on how to address various issues related to digital and technological use, digital ethics education, and strategies to prevent digital addiction or other negative effects on students. By providing such support, we can maximize the positive effects of digital technology while minimizing its negative impacts.

Third, based on the learning method results, most mathematics classes are still explanation-oriented (teacher-centered) rather than project-based or discussion-based (learner-centered). This approach to teaching and learning can affect students' perceptions of the class and can be related to the fact that a high percentage of students remain indifferent or passive in mathematics classes. Following the seventh educational curriculum implementation, Korean education pursues learner-centered classes. However, according to the responses, the majority of elementary, middle, and high school students do not believe that their mathematics classes are learner-centered. Thus, changes in mathematics curriculum and policy, as well as teachers' efforts, are needed to convert classes from teacher-centered to learner-centered, prioritizing student participation. That is, revision of the curriculum and educational environmental and professional teacher supports are needed to allow for more activity-based, discussion-based, or student-customized instruction that considers students' individual levels and aptitudes.

Fourth, efforts to improve teachers' explanations and responses to student questions are required. The study results indicated that teachers' explanations and responses to students' questions are insufficient from the students' perspective. For students who do not understand their teacher's initial explanation, a second supplementary explanation that is qualitatively different from the first should be provided. Yet, the current mathematics classes in Korea fall short of this goal. Professional development support should be provided for teachers to help them respond to students' questions and provide effective explanations.

Fifth, the study revealed a limited application of manipulatives and computers in mathematics classes, primarily confined to executing complex calculations, with little independent study time. A possible contributing factor to this underutilization could be the narrow scope in which teachers employ these tools, often limited to specific functions or methods. Therefore, when providing mathematics teachers with technical training and materials, they should be encouraged to use manipulatives or computer programs for a variety of purposes and in a variety of ways in their mathematics classes.

Sixth, all students in elementary, middle, and high school are most confident solving computational problems and using algebraic skills (e.g., equations) but struggle with explaining, reasoning, and proving in geometry. Accordingly, mathematics classes need to shift from calculation-oriented lessons to those that encourage explanation, reasoning, and proving based on what they have learned.

Seventh, the results showed that smaller class sizes are related to more positive students' perceptions of mathematics classes in both formal and implementation aspects. This tendency was more apparent in lower grades. Thus, policy-based adjustments are needed to manage the number of students per class. The declining birth rate in Korea has resulted in a substantial decrease in the number of students. Consequently, the government is progressively reducing the number of teachers. However, this is not an adequate solution, as our research shows that smaller class sizes are associated with more positive perceptions of mathematics classes. Therefore, policy support is required to maintain class sizes below 20 students.

Finally, a comparative analysis was conducted on mathematics classes taken in mathematics subject-exclusive classrooms and regular classrooms. Elementary school students perceived little difference between the two classrooms, but middle and high school students reported higher overall satisfaction with subject-exclusive classrooms. This difference may stem from the distinct teacher assignment systems in elementary and secondary schools. In elementary schools, homeroom teachers are responsible for teaching all subjects in a single classroom. This allows them to freely use teaching aids and mathematics-related materials within their designated classroom, reducing the perceived need for mathematics subject-exclusive classrooms. On the other hand, in secondary schools, mathematics teachers often move between different classes, which may limit their ability to freely arrange and utilize teaching aids and materials. Consequently, mathematics subject-exclusive classrooms are likely to have a more positive impact on middle and high school mathematics classes. In addition to financial support to expand mathematics subject-exclusive classrooms, continuous support is needed to improve mathematics classes in subject-exclusive classrooms by providing diverse programs or teaching and learning materials.

In this study, we examined the perceptions of Korean elementary, middle, and high school students regarding mathematics classes in schools. While many studies have analyzed school mathematics classes from a policy or teacher perspective, we believe that this study is meaningful because it examines how students currently perceive school mathematics classes in light of a sizable survey. We hope that the results will lead to the establishment of realistic mathematics education policies and changes in mathematics classes, considering the perspectives of Korean students.

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Conflict of Interest

The authors declare that they have no competing interests.

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수학 학습 상황에 대한 학생들의 인식에 관한 연구

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초 록

본 연구는 현재 학교에서 제공하는 수학 수업이 수준 높은 교육 경험의 기준을 충족하는지 알아보기 위해, 한국의 초, 중, 고등학교 학생들이 수학 학습 상황을 어떻게 인식하는지 조사하였다. 수학 수업의 형식적 측면과 수행적 측면을 모두 고려한 포괄적인 설문 조사를 활용하여 15,418명의 학생의 응답을 분석함으로써, 수학 교실 환경, 교육 방법 및 전반적인 학습 경험에 대한 그들의 견해에 대한 통찰력을 얻었다. 조사 결과, 학년이 높아질수록 수학 수업 상황에 대한 부정적인 인식이 강해졌으며, 수학 수업은 여전히 교사 중심으로 인식되고 있었다. 또한 수학 교구나 공학도구를 효과적으로 활용하지 못하고 있으며, 학급 규모와 수학 교과 전담 교실의 유무에 따라 학생들의 수학 학습 경험이 영향을 미치는 것으로 나타났다. 따라서 연구 결과를 바탕으로, 수학 수업의 질을 향상시키고 학생들의 인식을 개선하기 위한 제언은 다음과 같다. 효과적인 수학 교육을 위해서는 학습자 중심 수업을 위해 학생들의 참여를 증진시킬 수 있는 교수학습 방법을 적용하거나, 교구나 공학도구 같은 교수학습 도구를 주체적으로 적극 활용할 수 있는 기회가 필요하다. 특히 공학도구를 단순 계산을 넘어 다양한 목적과 방식으로 활용할 수 있는 기회를 제공할 필요가 있다. 또한, 적절한 학급 규모를 유지하고 수학 교과 전담 교실의 확대를 추진해야 한다. 이러한 고려사항은 발전하는 교육 표준에 부합하고 학생들의 요구를 충족하는 보다 매력적이고 효과적인 수학 학습 환경을 조성하는 데 중요하다. 본 연구결과는 한국 수학 교육의 질 향상을 목표로 하는 교육자와 정책 입안자에게 실행 가능한 통찰력을 제공할 수 있다.

주요어 학생들의 인식, 학교 수학 수업, 좋은 수학 수업, 수학 학습 상황, 수학교육 개선