J. Korean Soc. Math. Ed. Ser. D. (2024) 27(1), 49–73
https://doi.org/10.7468/jksmed.2024.27.1.49
ISSN 1226-6191
Online ISSN 2287-9943

RESEARCH ARTICLE

A comparative study of the revised 2022 Korea mathematics curriculum and the international baccalaureate diploma program mathematics: Applications and interpretation standard level - focusing on high school statistics area

Soo Bin Lee[1], Ah Ra Cho[2], Oh Nam Kwon[3]

[1] Graduate student, Mathematics Education, Seoul National University
[2] Teacher, Sinwon High School
[3] Professor, Mathematics Education, Seoul National University

Received: February 5, 2024 / Revised: February 29, 2024 / Accepted: March 4, 2024

Abstract

This study aims to explore the direction of high school statistics education in Korea through a comparative analysis between the revised 2022 Korea mathematics curriculum and the IBDP Mathematics: Application & Interpretation Standard Level (IBDP AI SL) Curriculum and textbooks. The study seeks to investigate the Statistics unit of the two curricula, compare chapter structures and content elements of textbooks, and explore exercises on modeling and utilization of technology tools. The results are as follows: First, the IBDP AI SL statistics covered a broader range of topics. Second, exercises in Korean high school textbooks typically inquire about one or two questions in each topic, whereas the IBDP AI SL textbook's exercises present a real-life scenario on all relevant topics through sub-questions. Third, the Korean textbook guides the utilization of technology tools only in exercises presented after completing the entire chapter or where the calculation is complex. Also, there were only a handful of modeling exercises in the Korean textbook in contrast to most of the lessons and exercises were modeling exercises in the IBDP AI SL textbook. If these findings can be integrated into teaching practices in Korea, it will provide a direction for statistics education in Korean high schools.

Keywords: the revised 2022 Korea mathematics curriculum, IBDP mathematics: application & interpretation standard level curriculum, textbook, technology tools, modeling

• Corresponding Author: Ah Ra Cho, email: ahra604@snu.ac.kr
• Acknowledgments: We express our sincere gratitude to the anonymous reviewers of Series D for their valuable insights and constructive suggestions. Additionally, we extend our appreciation to Vilma M. Mesa (University of Michigan, U.S.) for her thoughtful and perceptive opinions.

I. INTRODUCTION

The revised 2022 Korea mathematics curriculum aims to actively respond to changes in the educational environment by aligning with national and social demands, goal of nurturing proactive talents equipped with inclusiveness and creativity that future society requires (Ministry of Education, 2022). In the overview of the revised 2022 Korea mathematics curriculum, it is emphasized that schools should utilize appropriate assessment methods considering the nature of subjects and characteristics of learners. Specifically, on "substantiating performance assessments and expanding the weight of descriptive and essay-type assessments." (Ministry of Education, 2022) These types of assessments highlight the improvement of the quality of learning through prioritizing problem-solving and critical thinking processes, as well as the expansion of descriptive and essay-type assessments. However, further exploration is required for these types of assessments in the Korean curriculum and textbooks.

With the rapid progress of globalization in recent years, there has been a steady proposal on the integration of the International Baccalaureate (IB) into the mathematics curriculum of Korea. IB is an international curriculum that is currently implemented in many international and public schools worldwide. Although the assessments in IB are primarily composed of written and essay-type evaluations, the thorough assessment methods have earned global recognition for the liability of evaluations for a long time. For effective assessment, each content of the curriculum should be applied to classroom teaching where textbooks play a crucial role in reflecting this systematically. Therefore, exploring textbooks that reflect on the IB curriculum can be meaningful in presenting the direction of mathematics education in South Korea.

For a future-oriented mathematics curriculum, the field of statistics especially requires significant changes from the past curriculum. According to Kim et al. (2020) even in the revised 2015 Korea mathematics curriculum, which emphasizes the 'restructure of statistics content with a focus on real-life applications', the actual implementation of real-life centered statistics education in school settings was not appropriately instructed. In particular, the high school mathematics curriculum in South Korea, which gears toward university entrance exams, often faces challenges in implementing actual lessons according to what is outlined in the curriculum documents. Park et al. (2015) noted that in the revised 2015 Korea mathematics curriculum, there is an emphasis on the experiential aspect of statistical inquiry processes predicting the future through the collection, organization, and analysis of real data, along with the utilization of technology tools. However, historically in South Korea, students have not had a learning environment where they could utilize technology tools, such as graphing calculators or software programs through computers, leading to practical challenges in incorporating the use of such tools in classroom settings. As the development of technology facilitates the creation of increasingly interactive textbook designs, the understanding of how teachers integrate different components incorporated into textbooks is crucial (Mesa, 2021). Nevertheless, as of 2023, various local education offices have planned and implemented the distribution of one-to-one smart learning devices to create an environment where the use of technology tools is feasible, alleviating the burden on teachers and students in practical applications. Mathematical

modeling creates mathematical models using various mathematical representation methods to reflect phenomena related to students' lives. As a teaching and learning strategy, applying mathematical models to real-life situations, societal issues, and natural phenomena can broaden perspectives on the application of mathematics and foster a deeper understanding of practical implications (Ministry of Education, 2022). Therefore, to align with the curriculum's purpose for students to experience statistical inquiry processes and utilize technology tools in the process of learning statistics, a comparative analysis of the textbooks is needed. The result of the analysis may serve as instructional materials that can provide insights into how high school statistics classes need to evolve under the revised 2022 Korea mathematics curriculum.

This study compares content elements of the high school statistics unit in the revised 2022 Korean mathematics curriculum and IB curriculum. In addition to comparing and analyzing the curricula, we conducted a comparison and analysis of textbooks on how the curriculum is reflected and structured according to the relationships in the teaching and learning process. Through this research, we expect to achieve a direction for statistics education in Korea that aligns with the principles of the new curriculum, such as the aspiration for a transformation in statistics education at the school level. The research questions associated with this are as follows:

1. What are the content elements in the revised 2022 Korea mathematics curriculum and the International Baccalaureate Diploma Programme Mathematics: Application & Interpretation Standard Level (hereafter IBDP AI SL) curriculum in the statistics unit?
2. How are the chapter structure and description of chapter contents in the Probability and Statistics textbook for the Korea mathematics curriculum different from the textbook structure in the IBDP curriculum?
3. What are the differences in the modeling and utilization of technology tools in each textbook?

II. BACKGROUND

Literature Review

In recent years, there has been a visible trend towards the adoption of the IB curriculum in public education in South Korea. This has sparked a growing interest not only in the IB curriculum itself but also in comparative studies between the IB curriculum and the Korean curriculum in different subject areas. The field of mathematics education, in particular, has witnessed active research comparing the IB curriculum to the Korean curriculum. Kim et al. (2020) made a comparative analysis of the IB mathematics curriculum with the mathematics curriculum in Korea and the implementation of IB mathematics in local schools in Korea. This research compares an extensive number of contents from elementary to secondary mathematics of the 2015 Korea mathematics curriculum and the IB curriculum. Furthermore, Kim et al. (2020) suggested directions for high school mathematics education based on the content and instructional characteristics of IBDP mathematics, emphasizing the need for more active student-centered classes and

the utilization of technology tools. Yet both of the studies do not provide specific insights for specific grade levels or areas in mathematics.

The research on textbook analysis in comparison of the IB curriculum and Korea mathematics curriculum is as follows. Yang et al. (2015) conducted a comparative study on textbooks for the area of Algebra of the revised 2009 Korea mathematics curriculum and the IBDP HL mathematics curriculum. Lim and Kim (2022) analyzed the content of proofs in the mathematics curriculum and textbooks of South Korea, Japan, and the IB middle school curriculum and provided insights into how proofs in mathematics education should be approached in the revised 2022 Korea mathematics curriculum. Park and Go (2022) focused on the functions, analyzing the mathematical modeling aspects of textbooks in South Korea and the IBDP. However, research on statistics, which assists in responding proactively to the uncertainties of future societies with the use of technology tools, has not yet been conducted.

Statistics Unit in the revised 2022 Korea Mathematics Curriculum

In the Revised 2022 Korea Mathematics Curriculum, students who study ‘Probability and Statistics’ as their elective course require the ability to be rational consumers and producers of information through statistical processes involving data collection, organization, analysis, and inference. This fosters competencies in statistical knowledge, skills, critical thinking, and attitude (Ministry of Education, 2022). From the high school elective course 'Probability and Statistics’, the content structure of the statistics area is as shown in Table 1. The statistics unit covers topics such as probability variables, probability distributions, binomial distributions, normal distributions, and statistical inference.

The points of contention related to statistical content identified in the Revised 2022 Mathematics Curriculum Development Study (Lee et al., 2022) are as follows. First, there is a debate concerning the section on estimation of population proportions. Experts support the necessity of including the estimation of population proportions in statistical inference to enable students to engage in meaningful statistical inferences through the effective handling of actual statistical data. The estimation of population proportions is closely connected to the development of critical thinking skills, serving as a fundamental aspect of a citizen's democratic literacy and aligning with the spirit of fostering learners' communal values and enhancing competencies in the revised 2022 curriculum. However, the abstract and complex calculations of confidence intervals and learning various distribution formulas can be burdensome for both teachers and students. To alleviate the emphasis on abstract calculations in the assessment criteria, a proposal is made to emphasize intuitive understanding based on the 'utilization of technology tools' and incorporate them into the achievement standards and interpretations.

The second issue pertains to the discussion about the utilization of technology tools in the achievement standards for the 'Statistical Inference' unit. Statistical literacy for accurate predictions in various situations is essential for engaging in modern social life. Therefore, the achievement standards and interpretations in the course of ‘Probability and Statistics’ emphasize understanding the concepts of probability and utilization of technology tools in statistics through experiences such as conducting probability experiments, collecting and representing data, and interpreting data in real contexts

(Ministry of Education, 2022). There is a consensus that the integration of the use of technology tools into the achievement standard for statistical inference is necessary, aligning with the active incorporation of digital literacy emphasized in the revised 2022 Korea curriculum. In particular, it is pointed out that abstract statistical concepts, such as sampling variability, can be presented more concretely through the use of technology tools. In real life, there are few opportunities to directly observe the variability of estimates due to chance by repeatedly taking random samples. However, students can experiment with repeated sampling through simulations or applets, allowing them to directly observe sampling variability. Therefore, instead of focusing on abstract procedural calculation practices, the achievement standards [12ProbStat03-07] in the 'Statistical Inference' unit of 'Probability and Statistics' in the revised 2022 Korea mathematics curriculum explicitly describe the use of technology tools to estimate population means and proportions to interpret the results.

Third, there is a discussion going on around the achievement standards in the statistics unit regarding the technical aspects of 'Statistical Problem Solving.' Statistics education experts have proposed standards such as the 'Statistical Problem-Solving Procedure', 'Organization and Interpretation of Data', 'Estimation of Population Proportions', 'Comparison of Two Groups', and 'Big Data' as learning contents in statistics education (Lee et al., 2022). However, articulating this in the achievement standards for the statistics unit was anticipated to lead to excessive learning burdens and increased class hours. Therefore, for the statistical area of the revised 2022 Korea mathematics curriculum of Probability and Statistics, the content related to statistical problem-solving is intended to be described in the interpretation of the achievement standards.

Table 1. The content structure of the statistics domain in the high school elective subject "Probability and Statistics"

Key Ideas	Estimating the characteristics of the group from a sample is an important tool for understanding societal uncertainty and predicting the future.
Category	Statistics
Knowledge & Understanding	· Probability Distribution · Statistical Inference
Process & Function	· Calculate the mean and standard deviation. · Explain the concepts, principles, and laws of statistics. · Solve problems using appropriate strategies. · Explain the relationships between concepts in statistics. · Apply statistical concepts to real-life situations. · Make judgments (estimations) based on the concepts, principles, and laws of statistics. · Investigate the concepts, principles, and laws of statistics. · Utilize appropriate technology tools. · Collect, organize, and interpret data. Interpret interpreted results
Value & Attitudes	· Awareness of the utility of statistics through connection to real-life situations. · Recognition of the importance of interpreting uncertainty through statistical thinking and inference. · Adopting an attitude of making rational decisions based on statistical evidence.

International Baccalaureate Diploma Program Mathematics

IBDP curriculum is a globally recognized and challenging educational framework. This curriculum is an internationally recognized program that focuses on developing critical thinking, intercultural understanding, and a holistic approach to education.

The IBDP mathematics curriculum offers two levels of study: Standard Level (SL) and Higher Level (HL). These levels are designed to accommodate various levels of mathematical aptitude and cater to students with diverse academic interests. The differences between SL and HL in IBDP Mathematics encompass the depth of content, examination rigor, internal assessment requirements, time commitment, university recognition, career implications, and overall flexibility. At SL, the curriculum provides a broad foundation in fundamental mathematical concepts. Students engage in a comprehensive exploration of topics that form the core of mathematical understanding. Conversely, the HL goes beyond the standard curriculum to provide an in-depth and extended study of mathematical concepts. The HL course in IBDP mathematics includes advanced topics in calculus, algebra, and abstract mathematical structures, demanding a higher level of analytical thinking and mathematical reasoning. The use of technology tools, such as calculators and computer software, is encouraged to enhance problem-solving and visualization skills in both courses.

The IBDP also offers two distinctive SL Mathematics courses, namely Mathematics: Applications and Interpretation (AI SL) and Mathematics: Analysis and Approaches (AA SL). These courses cater to diverse learning styles, aligning with students' academic interests and future aspirations. AI SL takes a pragmatic and applied approach, focusing on the real-world application of mathematical concepts. The curriculum includes topics like statistics, probability, and financial mathematics, providing students with practical skills that have immediate relevance in various professions. In contrast, AA SL is tailored for students with a penchant for theoretical mathematics. It delves into advanced concepts in calculus, algebra, and abstract mathematical structures, providing a rigorous foundation for those aspiring to pursue pure mathematics, physics, engineering, or related disciplines at the university level. This course places a strong emphasis on abstract reasoning and the exploration of complex mathematical ideas, challenging students to think critically and theoretically about mathematical concepts. The choice between AI SL and AA SL for students is a nuanced decision. Students should consider their interests, career aspirations, and the desired balance between applied and theoretical mathematical exploration. This study will focus on the IBDP AI SL course.

The IBDP AI SL course has the most teaching hours in Probability and Statistics, which is 36 hours out of the total 150 hours. Table 2 shows detailed components, concepts, and content-specific conceptual understanding of the IBDP AI SL statistics unit. Within the Statistics unit of the course, students engage deeply with a diverse range of fundamental concepts and topics, constructing a foundation in statistical reasoning. The course provides students with a comprehensive understanding of statistical concepts and their practical applications. In this unit, students acquire the skills needed to effectively analyze and interpret data. The unit extends to cover correlation and regression analysis, empowering students to quantify and interpret relationships between variables. Correlation and regression analysis are not just presented as mathematical procedures but as tools for

uncovering meaningful relationships in data. Through the exploration of bivariate data, students gain valuable skills in visualizing and analyzing complex data sets. Emphasizing a deep and content-specific conceptual understanding, the unit delves into key concepts such as measures of central tendency and dispersion, fostering both the ability to calculate these measures and an understanding of the underlying conceptual rationale. Throughout the statistics unit, students are encouraged to develop a rich conceptual framework, promoting a holistic and applied understanding of statistical principles as they critically analyze and interpret information in various contexts.

Table 2. IBDP AI SL statistics unit suggested concepts and topics with correlating content-specific conceptual understanding

Syllabus Component	Suggested Concepts & Topics	Content-Specific Conceptual Understanding
Topic 4 – Statistics and Probability	Quantity	Organizing, representing, analyzing, and interpreting data, and utilizing different statistical tools facilitate prediction and drawing of conclusions.
	Validity	Different statistical techniques require justification and the identification of their limitations and validity.
	Approximation	Approximation in data can approach the truth but may not always achieve it.
	Modeling	Modeling and finding structure in seemingly random events facilitate prediction.
	Relationships	Different probability distributions provide a representation of the relationship between theory and reality, allowing us to make predictions about what might happen.
	Patterns	Correlation and regression are powerful tools for identifying patterns and equivalence of systems.

IV. METHODS

This study is a comparative analysis of the revised 2022 Korea mathematics curriculum and the IBDP AI SL mathematics curriculum. The aim of the study is to explore the similarities and differences between the two curricula, analyze the depth and method of explaining concepts, and the presentation of exercises, and derive educational implications from these comparisons of the statistics unit. For this study, we selected ‘Document Analysis’ as the analytic framework. Document analysis involves skimming (superficial examination), reading (thorough examination), and interpretation, through content analysis and thematic analysis (Bowen, 2009). We first made a superficial examination of the high school mathematics subject ‘Probability and Statistics’ from revised 2022 Korea mathematics curriculum and the ‘Statistics’ unit from the IBDP AI SL curriculum. ‘Probability and Statistics’ is an elective course in high school where students who seek to develop skills for statistical reasoning take. The IBDP AI SL course is meticulously crafted to offer students a practical and applied approach to mathematics, placing a strong emphasis

on real-world contexts and applications. This emphasis on statistics involves covering practical and technical mathematical content extensively.

Document analysis combines an interactive process of content analysis and thematic analysis (Bowen, 2009). Content analysis is the process of organizing information into categories related to the central questions of the research and thematic analysis is a form of pattern recognition within the data, with emerging themes becoming the categories for analysis (Bowen, 2009). To thoroughly examine and interpret the statistics unit covered in each curriculum, the following procedures were adopted. First, the achievement standards for 'Probability and Statistics' in the revised 2022 Korea mathematics curriculum were organized into a table. Achievement standards represent the abilities that students should possess after the lesson, indicating the knowledge and skills they need to acquire and providing guidance to teachers in shaping the direction of the lessons (Lee et al., 2014). The standards of IBDP AI SL, including 'Content' and 'Guidance, clarification, and syllabus link,' were deemed equivalent to the achievement standards of the revised 2022 Korea mathematics curriculum as it combines the content elements of the curriculum with guidance on the teacher's instructional direction. In subsequent descriptions of the IBDP AI SL curriculum, a unified approach that is similar to South Korea's achievement standards was adopted; however, the description of the achievement standards related to the mathematical content elements presented in the curriculum differed between the two curricula. Afterward, we compared the formal structure and contents of the statistics unit in the textbooks of each curriculum. Finally, in the teaching and learning methods stated in the revised 2022 Korea mathematics curriculum of 'Probability and Statistics' emphasis is placed on 'enhancing information processing skills, utilizing teaching aids and technology tools to visualize abstract mathematical content, facilitating intuitive understanding of mathematical concepts, principles, and logical reasoning' and 'Mathematical modeling; creating mathematical models using various mathematical representations connected to phenomena in students' lives and teaching and learning strategies focus on applying mathematical models back to real-life situations, societal contexts, or natural phenomena, which aims to broaden students' perspective on the practical applications of mathematics' (Ministry of Education, 2022) as the aspects of importance in mathematical modeling and use of technology tools. A comparative analysis was made based on the extent of mathematical modeling and the utilization of technology tools in the revised 2022 Korea mathematics and IBDP AI SL curricula and textbooks.

For the documents, we selected the Korean high school 'Probability and Statistics' textbook authored by Ko et al. (2019) and IBDP AI SL textbook from Pearson (Garry et al., 2019), which both are textbooks that are widely used in the field. One to note is that South Korea has recently revised its curriculum in 2022, so textbooks corresponding to the new curriculum have not yet been released. However, the only difference in the content elements between the revised 2022 Korea mathematics curriculum and the 2015 Korean mathematics curriculum is that 'statistical inference' contains additional content on the estimation of population proportions. Moreover, statistical inference is not included in the IBDP AI SL curriculum. Therefore, we determined that selecting textbooks based on the 2015 Korea mathematics curriculum for analysis would likely yield similar results,

considering no significant differences in the outcomes.

V. RESULT

Comparing Content Elements in the Curriculum

Table 3 presents the achievement standards for the statistics unit of 'Probability and Statistics' in the revised 2022 Korea mathematics curriculum. Table 4, identified as ‘content guidance’ for the statistics unit of IBDP AI SL, is compared with the achievement standards of the revised 2022 Korea mathematics curriculum. The results are as follows. The statistics unit in IBDP AI SL covers content elements related to population, sample, and sampling in [SL 4.1]. In the revised 2022 Korea mathematics curriculum, this corresponds to the content elements covered in [12ProbStat03-05]. However, [SL 4.1] also includes learning of data sources' reliability, convenience, and bias in sampling, sampling techniques and their impact, and interpreting anomalies, which are not covered in the revised 2022 Korea mathematics curriculum. Subsequently, [SL 4.2] ~ [SL 4.4] in IBDP AI SL covers content elements such as measures of central tendency, relative frequencies, calculation of mean and standard deviation, dispersion, box plots, and scatter plots. These topics are already covered in the middle school mathematics curriculum in Korea. In addition, IBDP AI SL introduces additional content not covered in Korea, such as cumulative frequencies, quartiles, range, modal class, quartiles for discrete data, Pearson's product-moment correlation coefficient, and regression equations. The achievement standards [12ProbStat03-01] ~ [12ProbStat03-04] in the Korean curriculum align with the content elements in [SL 4.7] ~ [SL 4.9] in IBDP AI SL, particularly in the part dealing with probability variables and distributions, expectations of discrete random variables, and the meanings and properties of the binomial distribution and normal distribution. However, the IBDP AI SL includes content on inverse normal calculations, which is not covered in the revised 2022 Korea mathematics curriculum.

Table 3. Achievement standards of statistics unit for the revised 2022 Korean mathematics

[12ProbStat03-01] Can explain the meaning of a random variable and probability distribution.
[12ProbStat03-02] Can calculate the expected value (mean) and standard deviation of a discrete random variable.
[12ProbStat03-03] Understands the meaning and properties of the binomial distribution and can calculate its mean and standard deviation.
[12ProbStat03-04] Understands the meaning and properties of the normal distribution and can explain its relationship with the binomial distribution.
[12ProbStat03-05] Knows the meanings of population and sample and can explain methods of sample extraction.
[12ProbStat03-06] Understands and can explain the relationship between sample mean and population mean, as well as sample proportion and population proportion.
[12ProbStat03-07] Can estimate population mean and population proportion using technology tools and interpret the results.

Table 4. Standard level mathematics applications and interpretation for the IB diploma statistics content guidance

[SL 4.1]
1. Concepts of population, sample, random sample, discrete and continuous data.
2. Reliability of data sources and bias in sampling
3. Interpretation of outliers
4. Sampling techniques and their effectiveness

[SL 4.2]
1. Presentation of data (discrete and continuous): frequency distributions (tables).
2. Histograms. Cumulative frequency; cumulative frequency graphs; use to find median, quartiles, percentiles, range, and interquartile range (IQR).
3. Production and understanding of box and whisker diagrams.

[SL 4.3]
1. Measures of central tendency (mean, median, and mode). Estimation of mean from grouped data.
2. Modal class
3. Measures of dispersion (interquartile range, standard deviation, and variance).
4. Effect of constant changes on the original data.
5. Quartiles of discrete data.

[SL 4.4]
1. Linear correlation of bivariate data. Pearson's product-moment correlation coefficient, r.
2. Scatter diagrams; lines of best fit, by eye, passing through the mean point.
3. Equation of the regression line of y on x. Use of the equation of the regression line for prediction purposes. Interpret the meaning of the parameters, a and b, in a linear regression $y = ax + b$.

[SL 4.7]
1. Concept of discrete random variables and their probability distributions. Expected value (mean), E(X) for discrete data. Applications.

[SL 4.8]
1. Binomial distribution. Mean and variance of the binomial distribution.

[SL 4.9]
1. The normal distribution and curve. Properties of the normal distribution. Diagrammatic representation.
2. Normal probability calculations.
3. Inverse normal calculations

[SL 4.10]
1. Spearman's rank correlation coefficient, rs
2. Awareness of the appropriateness and limitations of Pearson's product moment correlation coefficient and Spearman's rank correlation coefficient, and the effect of outliers on each.

[SL 4.11]
1. Formulation of null and alternative hypotheses, H0 and H1. Significance levels. p - values.
2. Expected and observed frequencies. The $\chi 2$ test for independence: contingency tables, degrees of freedom, critical value. The $\chi 2$ goodness of fit test.

In the later part of the statistics unit in the revised 2022 Korea mathematics curriculum, the achievement standards [12ProbStat03-06] ~ [12ProbStat03-07] cover content elements related to sample mean and population mean, sample proportion and population proportion, and estimation and interpretation of population mean and proportion. However, IBDP AI SL does not cover these topics, as they are addressed in IBDP AI HL course. Notably, there is a significant difference in content when it comes to statistical and bivariate analyses, where IBDP AI SL covers elements such as Spearman's rank correlation coefficient, formulation of null and alternative hypotheses, p-values, and the $\chi 2$ test for independence in [SL 4.10] ~ [SL 4.11]. The content covered in the statistics unit of IBDP AI SL is more extensive than that of the revised 2022 Korea mathematics curriculum, encompassing various sampling techniques and their impacts, convenience in sampling, reliability of data sources, interpretation of outliers, inverse normal calculations, Pearson's correlation coefficient, Spearman's rank correlation coefficient, and advanced topics such as testing. These topics are not addressed in the revised 2022 Korea mathematics curriculum.

Comparison of the Chapter Structures and Contents in the Statistics Unit

The comparison of the chapter structures between the Korean high school textbook (Ko et al., 2019) and the IBDP AI SL textbook (Garry et al., 2019) yields the following results. First, the order of the chapters in the two textbooks shows a major difference. The Korean textbook (Ko et al., 2019) covers probability distributions, binomial distributions, and normal distributions. The chapter on statistical inference progresses with topics on populations, samples, and the estimation of population means. In contrast, IBDP AI SL (Garry et al., 2019) starts with data and variables, including populations and samples, providing an overall explanation of statistics. It then covers probability distributions, binomial distributions, and normal distributions and thereafter, addresses statistical testing and bivariate analysis, which are topics not covered in the Korean high school textbook (Ko et al., 2019).

The Korean high school textbook authored by Ko et al. (2019) exhibits a pedagogical approach to evoke interest and curiosity among learners. In the introduction of each chapter, practical scenarios associated with the core content are provided to facilitate critical thinking and elevate engagement. Content elements are systematically developed to enable students to independently derive mathematical concepts, principles, and laws. Next, the presented contents are summarized in a chart. The exercises showcase representative problems related to the learning content along with exemplary solutions, while the exercises provide problems that encourage a correct understanding of the content elements. Additionally, various mathematical tasks, such as explaining concepts, identifying errors, and problem-solving, are provided to allow students to confidently engage in mathematics learning. At the end of each subsection, the structure of the questions is designed to enable students to independently summarize the learning content by providing three levels of problems to facilitate tiered learning. Throughout the book, mathematics competency plus and the utilization of technology tools pages are strategically placed to reinforce the learning content. Thus, the Korean high school textbook (Ko et al.,

2019) is focused on sparking students' interest in mathematics, and it places significant emphasis on utilizing various materials and activities to effectively convey learning in alignment with the objectives outlined in the curriculum.

The IBDP AI SL textbook (Garry et al., 2019) begins each major section by explaining the objectives of the unit and its connection to the previous sections. In each subsection, real-life scenarios are used to derive mathematical concepts, principles, and laws. The mathematical concepts are then organized and described followed by exercises and solutions based on the content elements presented. In contrast to the Korean high school textbook (Ko et al., 2019), the IBDP AI SL textbook (Garry et al., 2019) introduces exercises based on real-life scenarios after the completion of each topic, rather than providing a section evaluation of the end of the subsection.

Furthermore, in the Korean high school textbook (Ko et al., 2019), exercises typically focus on one or two questions for each topic. In contrast, the IBDP AI SL textbook presents multiple sub-questions for each topic, which requires students to utilize all previous concepts learned to solve the problems. Modeling exercises are often included, which may ask for explanations and justification of the students' responses. After the completion of each chapter, the comprehensive chapter exercises include various real-life context problems, assisting in enhancing problem-solving skills. In the Korean high school textbook (Ko et al., 2019), various activities and pictures are presented to help students understand the value of mathematics and foster a positive attitude toward mathematics. In contrast, the IBDP AI SL textbook (Garry et al., 2019) places more emphasis on introducing mathematical knowledge and presenting various exercises related to it, with minimal use of visual illustrations such as pictures, drawings, and reading materials.

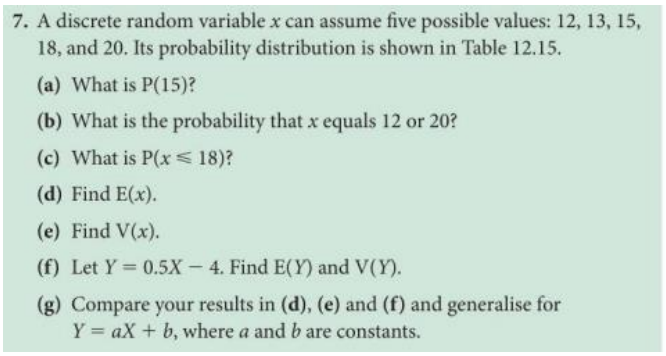
The chapters within the statistics unit in the Korean high school textbook (Ko et al., 2019) and IBDP AI SL textbook (Garry et al., 2019) are listed in Table 5. Only the common content elements between the two curricula are compared for the chapter-by-chapter content comparison. In Table 5, common content elements of the two textbooks have been listed along with the learning objectives. The common content elements are probability variables and distributions, mean and standard deviation of discrete probability variables, binomial distribution, normal distribution, and population and sample.

Probability Distribution and Random Variables, Mean and Standard Deviation of Discrete Random Variables

The content covered in probability distributions, discrete random variables, continuous random variables, and the mean and standard deviation of discrete random variables is similar in both textbooks. However, in the Korean high school textbook (Ko et al, 2019), the content regarding the mean and standard deviation of aX+b is presented and organized in the textbook's main lessons, whereas in IBDP AI SL textbook (Garry et al., 2019) students are guided to generalize by solving exercises on E(X) and V(X) first and continue to find E(Y) and V(Y) when Y=0.5X-4 in the sub-question, which can be seen in Figure 1. This reflects a difference in approach, encouraging students to be able to generalize the formula themselves.

Table 5. The chapters within the statistics unit in Korean high school textbook(Ko et al., 2019) and IBDP AI SL textbook (Garry et al., 2019)

Korean high school textbook (Ko et al., 2019)			IB AI SL textbook (Garry et al., 2019)	
III. Statistics	1. Probability Distribution	1. Random Variables and Probability Distributions • Understand the meanings of random variables and probability distributions.	7. Descriptive statistics	7.1 Data and variables • concepts of population, sampling, random sampling, outliers(introduction), discrete and continuous data • sampling techniques and their effectiveness and bias in sampling
				7.2 Displaying distributions using graphs
		2. Mean and Standard Deviation of Discrete Random Variables • Be able to calculate the expected value (mean) and standard deviation of discrete random variables.		7.3 Measures of central tendency and spread
		3. Binomial Distribution • Understand the meaning of the binomial distribution and can calculate its mean and standard deviation.	12. Probability distributions	12.1 random variables • discrete random variables and their probability distributions • expected value and their probability distributions
				12.2 The binomial distribution • the binomial; distribution, including its mean and variance
		4. Normal Distribution • Understand the meaning of the normal distribution and comprehend its properties.		12.3 Continuous distributions - the normal distribution • the normal distribution : properties, normal probability calculations, and inverse normal calculations • standardizing normal variables(z-value) • inverse normal calculations where mean and standard deviation are unknown
	2. Statistical Inference	1. Population and Sample •Understand the meanings of population and sample and comprehend the principles of sample extraction.	13. Statistical analysis	13.1 Hypothesis testing in statistics
				13.2 Goodness-of-fit(GOF) test and test for independence
		2. Estimation of Population Mean	14. Bivariate analysis	14.1 Scatter diagrams
				14.2 Measures of correlation
				14.3 Linear regression



7. A discrete random variable x can assume five possible values: 12, 13, 15, 18, and 20. Its probability distribution is shown in Table 12.15.

(a) What is P(15)?

(b) What is the probability that x equals 12 or 20?

(c) What is $P(x \leqslant 18)$?

(d) Find $E(x)$.

(e) Find $V(x)$.

(f) Let $Y = 0.5X - 4$. Find $E(Y)$ and $V(Y)$.

(g) Compare your results in **(d)**, **(e)** and **(f)** and generalise for $Y = aX + b$, where a and b are constants.

x	P(x)
12	0.14
13	0.11
15	
18	0.26
20	0.23

Table 12.15 Data for question 7

Figure 1. IBDP AI SL (Garry et al., 2019) probability distribution sample exercise

Binomial Distribution

The contents related to binomial distribution were similar in both textbooks, but the Korean high school textbook (Ko et al., 2019) additionally covered the Law of Large Numbers. Although the Law of Large Numbers is not explicitly mentioned in the curriculum achievement standards, it is emphasized in the textbook for the practical application of statistics in real-life scenarios. The Law of Large Numbers is a mathematical theorem that states as the number of trials increases, mathematical probability can substitute statistical probability.

Normal Distribution

In the section on normal distribution, differences were observed. In the IBDP AI SL textbook (Garry et al., 2019), an important property of the normal distribution, the 'Empirical Rule' is discussed, which is not covered in the Korean high school textbook (Ko et al., 2019). The Korean high school textbook (Ko et al., 2019) places significant emphasis on 'the standard normal distribution and the standardization of normal distribution,' which is crucial for problem-solving, whereas the IBDP AI SL textbook (Garry et al., 2019) only explains z-values concerning GDC results. Additionally, the Korean high school textbook (Ko et al., 2019) provides a standard normal distribution table in the appendix, enabling problem-solving without the use of technology tools. The significant difference between the two textbooks is evident in the fact that only the standard normal distribution table is briefly provided in exercises, without the need for utilizing technology tools.

In the IBDP AI SL textbook (Garry et al., 2019), the lessons and exercises address the concept and calculation of 'The inverse normal distribution' using graphing calculators. However, in the Korean high school textbook (Ko et al., 2019), the concept of the inverse normal distribution in situations where the mean and standard deviation are unknown is not covered. Also, in the IBDP AI SL textbook (Garry et al., 2019), the relationship between the binomial distribution and the normal distribution is not addressed. However, in the Korean high school textbook (Ko et al., 2019), there is a discussion on the relationship in the main lesson. This concept is connected to the Law of Large Numbers presented in the earlier section on the binomial distribution, highlighting the significance placed in the Korean high school textbook (Ko et al., 2019) on how mathematical probability can substitute statistical probability.

Population and Sample

In the Korean high school textbook (Ko et al., 2019), the concepts of population and sample, as well as sampling methods, are introduced in the final section. In contrast, the IBDP AI SL textbook (Garry et al., 2019) covers statistical concepts in the first unit of section 7, addressing population, sampling, and sampling techniques. In the Korean high school textbook (Ko et al., 2019), definitions and explanations are provided for population, complete investigation, sample, and sample survey, along with concepts such as random sampling, replacement sampling, and non-replacement sampling. The associated exercises are presented in a relatively straightforward manner. On the other hand, the IBDP AI SL textbook (Garry et al., 2019) defines individuals, variables, populations, samples, parameters, and statistics. It provides a more detailed explanation of the sampling process, which can be seen in Figure 2, and introduces various types of sampling falling under random and non-random categories. The IBDP AI SL textbook (Garry et al., 2019) aims to enhance the understanding of variables in real-life situations, identify appropriate sampling methods, and guide the interpretation of statistics in various real-life scenarios.

The two textbooks exhibited differences in the topics of population, sample, and sampling methods. According to Figure 3, the Korean high school textbook (Ko et al., 2019) prompted students to calculate the number of possible outcomes based on the learning content, depending on the sampling method. In contrast, the IBDP AI SL textbook (Garry et al., 2019) presented problems that require making decisions about which sampling plan is more appropriate in given situations, encouraging students to contemplate the practical use of statistics in real-life scenarios.

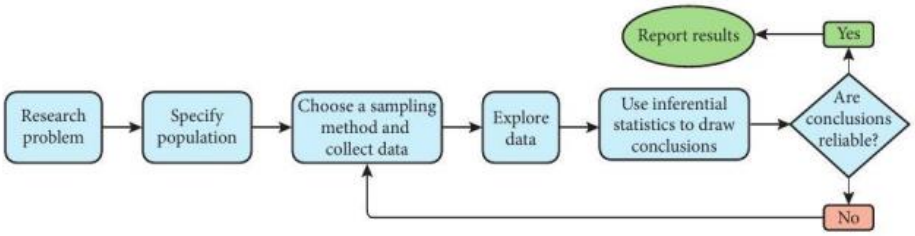
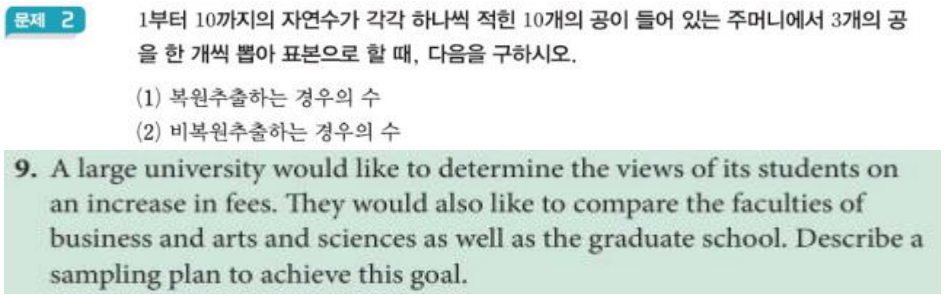


Figure 2. Sampling process in IBDP AI SL textbook (Garry et al., 2019)


문제 2

1부터 10까지의 자연수가 각각 하나씩 적힌 10개의 공이 들어 있는 주머니에서 3개의 공을 한 개씩 뽑아 표본으로 할 때, 다음을 구하시오.

(1) 복원추출하는 경우의 수

(2) 비복원추출하는 경우의 수

9. A large university would like to determine the views of its students on an increase in fees. They would also like to compare the faculties of business and arts and sciences as well as the graduate school. Describe a sampling plan to achieve this goal.

Figure 3. Problems presented in the population and sample of the Korea high school textbook (Ko et al., 2019) and practice exercises provided in the IBDP AI SL (Garry et al., 2019) section 7.1 on data and variables

In the Korean high school textbook (Ko et al., 2019), definitions of population mean, population variance, population standard deviation, sample mean, sample variance, and sample standard deviation are provided. The properties of the mean, variance, and standard deviation of the sample mean are derived by the definition of each topic. However, in the IBAI SL textbook (Garry et al., 2019), there is no coverage of the mean, variance, and standard deviation of the sample mean. The Korean high school textbook (Ko et al., 2019) represents the sample mean as $\bar{x}$, while the IB AI SL textbook (Garry et al., 2019) and GDC use the notation $\bar{x}$ to denote the arithmetic mean or average of a set of n measurements, showing a difference in symbol notation. Additionally, the symbol for the population mean is represented as 'm' in the Korean high school textbook (Ko et al., 2019), whereas in the IBAI SL textbook (Garry et al., 2019), it is represented as 'μ'. The IBDP AI SL textbook (Garry et al., 2019) also covers content elements such as median, mode, range, quartiles, box plot, and outlier, which are not covered in the revised 2022 Korean mathematics curriculum for high school 'Probability and Statistics' but are addressed in the middle school curriculum.

Comparison of the Utilization of Technology Tools and Modeling Exercises

Comparison through Curriculum Guide

The use of technology tools plays a pivotal role in enhancing the learning experience and preparing students for real-world applications of mathematical concepts in Statistics. Table 6 compares the utilization of technology tools in the two curricula. In the IBDP AI AL course, technology tools are seamlessly integrated to facilitate a deeper understanding of mathematical principles and their practical implications. Students are encouraged to utilize graphing calculators, mathematical software, and other technology tools to perform complex calculations, visualize mathematical relationships, and analyze data efficiently. This is also well stated in the revised 2022 Korean Mathematics Curriculum. The teaching and learning direction of the 'Probability and Statistics' course asks to select suitable technology tools to enhance effective teaching and learning, fostering the development of students' digital skills.

The Statistics unit of IBDP AI SL course, in particular, benefits significantly from the integration of technology tools. Students can employ statistical software to process and analyze large data sets, allowing for a more comprehensive exploration of statistical concepts. The use of graphing calculators helps visualize data distributions, probability graphs, and regression analyses, providing a dynamic and interactive learning experience. Additionally, technology tools enable students to conduct simulations and experiments, allowing them to observe and understand the practical implications of statistical concepts in various scenarios. It is also stated in the assessment that technology tools are required for students to solve problems during the exams.

Table 6. Comparison of the utilization of technology tools and modeling in the revised 2022 Korea mathematics curriculum and IBDP AI SL

	Korea	IBDP AI SL
Teaching & Learning Direction	1. 'Probability and Statistics' content requires the selection of appropriate teaching aids or technology tools to facilitate efficient teaching and learning, promoting the cultivation of students' digital literacy.	1. Statistics is concerned with the collection, analysis, and interpretation of quantitative data. 2. Statistical representations and measures allow us to represent data in many different forms to aid interpretation.
Teaching & Learning Method	1. Fostering an attitude of exploring and collecting data in real-life and mathematical problem situations, processing it mathematically, and making informed decisions. 2. Utilizing teaching aids or technology tools to visualize abstract mathematical content, aiding in the intuitive understanding of mathematical concepts, principles, and laws, as well as fostering logical reasoning. 3. Encourage students to actively explore using teaching aids or technology tools. 4. In instructional situations where the goal is not to foster computational skills, technology tools are provided for complex calculations. 5. Mathematical modeling is an instructional approach that involves creating mathematical models using various mathematical representations, connecting phenomena related to students' lives allowing for the application of mathematical models to real-life, societal, and natural phenomena, fostering a broad perspective on the practical applications of mathematics in students' lives.	1. The use of technology such as simulations, spreadsheets, statistics software, and statistics apps can greatly enhance this topic. 2. It is expected that most of the calculations required will be carried out using technology, but explanations of calculations by hand may enhance understanding. 3. The emphasis is on choosing the most appropriate technique and understanding and interpreting the results obtained in context.
Assessment Method	1. When assessing the achievement standards, the effective use of teaching aids or technology tools can be utilized to conduct evaluations to determine the attainment of learning objectives. 2. When utilizing teaching aids or technology tools for assessment, the evaluation focuses on the exploration process of mathematical content rather than the functionality and operation of the teaching aids or technology tools.	1. In examinations students should be familiar with how to use the statistics functionality of allowed technology.

"Statistics is concerned with the collection, analysis, and interpretation of quantitative data. Statistical representations and measures allow us to represent data in many different forms to aid interpretation." (IBO, p. 50)

In the revised 2022 Korea Mathematics curriculum, students are directed to investigate and collect data in various real-world and mathematical situations. This process entails mathematically analyzing the gathered data and subsequently making informed decisions. The incorporation of teaching aids or technology tools is pivotal in this educational process, serving as instruments to visually depict complex mathematical concepts. These tools contribute to a natural comprehension of mathematical principles and laws, nurturing logical reasoning abilities. Actively encouraging students to interact with these aids promotes a hands-on exploration of mathematical concepts. In situations where the primary objective isn't centered on refining computational skills, technology tools are introduced to facilitate intricate calculations. The adoption of mathematical modeling as an instructional approach involves students creating models using diverse mathematical representations. This method establishes connections between phenomena relevant to students' lives, facilitating the practical application of these models to real-life, societal, and natural occurrences, which instills a comprehensive understanding of the practical applications of mathematics.

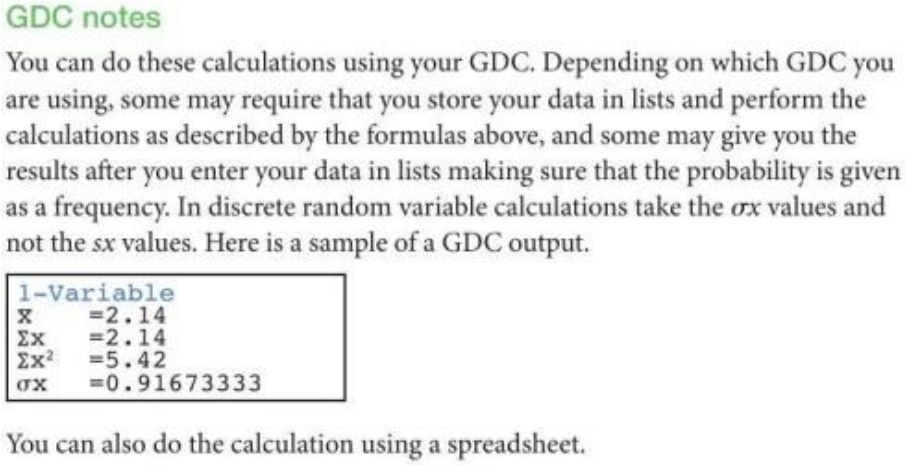
In both curriculums the use of technology tools in Statistics facilitates the exploration of mathematical models, helping students simulate and analyze real-world situations. Spreadsheet software, mathematical apps, and interactive online platforms offer avenues for collaborative learning and problem-solving. The application of technology aligns with the course's emphasis on practical, real-world applications, preparing students for the demands of an increasingly data-driven and technologically advanced society.

Comparison through Textbooks

Technology Tools.

GDC Notes. The Statistics unit benefits significantly from the judicious use of technology tools. Both the IBDP AI SL course and the revised 2022 Korean Mathematics curriculum emphasize on how the integration of technology enhances the learning experience and allows students to explore mathematical concepts in a dynamic and applied manner. Students can efficiently calculate measures of central tendency and dispersion, such as mean, median, standard deviation, and interquartile range while graphing calculators enable them to visualize the impact of data variations on statistical measures dynamically.

From lessons and sample exercises from the textbook for IBDP AI SL course, graphing calculators and statistical software are employed to delve into the realm of descriptive statistics. As seen in Figure 4, from lessons, ‘GDC notes’ are given to students for their understanding and use of technology tools step by step whereas in the Korean high school textbook (Ko et al., 2019), students are asked to engage in this process by hand. Furthermore, for the Korean high school textbook, there are no exercises on using graphing calculators or software for calculations or conceptual understanding of topics in this unit. Most of the understanding of concepts is done through abstract proof and complex calculations without the use of technology tools.


GDC notes

You can do these calculations using your GDC. Depending on which GDC you are using, some may require that you store your data in lists and perform the calculations as described by the formulas above, and some may give you the results after you enter your data in lists making sure that the probability is given as a frequency. In discrete random variable calculations take the σx values and not the sx values. Here is a sample of a GDC output.

```
1-Variable
x̄    =2.14
Σx   =2.14
Σx²  =5.42
σx   =0.91673333
```

You can also do the calculation using a spreadsheet.

Figure 4. 'GDC notes' and use of technology tools in IBDP AI SL textbook (Garry et al., 2019)

Lesson. The integration of technology in the IBDP AI SL course enriches the educational experience by providing students with tools to explore, analyze, and apply mathematical concepts in real-world contexts. This approach aligns with the course's overarching goal of preparing students for the challenges of an increasingly complex and technology-driven world. This interactive exploration fosters a deeper conceptual understanding of statistical concepts. The use of technology tools enables students to enhance their understanding in diverse ways, such as understanding abstract concepts and equations and applying them to real-life scenario exercises. Whereas the revised 2022 Korea Mathematics offers a diverse range of use in technology tools in the curriculum throughout the course but is not seen in textbook lessons or sample exercises except for only a handful of exercises provided at the end of the entire chapter. As seen the Figure 5, the exercises that enable the use of technology tools are specifically labeled as 'Exercise using Technology tools' and ask for students to use a specific software program to analyze and visualize the abstract equation instead of applying technology tools to modeling or real-life related problems. Unlike the use of diverse technology tools such as graphing calculators and different statistical software shown in IBDP AI SL course where mathematical modeling and use of technology tools are integrated into every lesson and exercise provided, the revised 2022 Korea Mathematics does not use diverse technology tools nor provide diverse types of sample exercises for students to engage in the use of the technology tools.

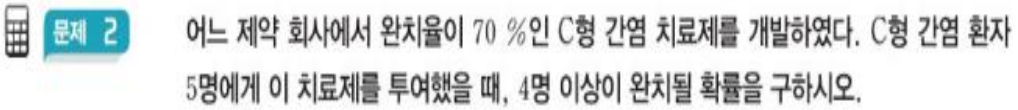

문제 2 어느 제약 회사에서 완치율이 70 %인 C형 간염 치료제를 개발하였다. C형 간염 환자 5명에게 이 치료제를 투여했을 때, 4명 이상이 완치될 확률을 구하시오.

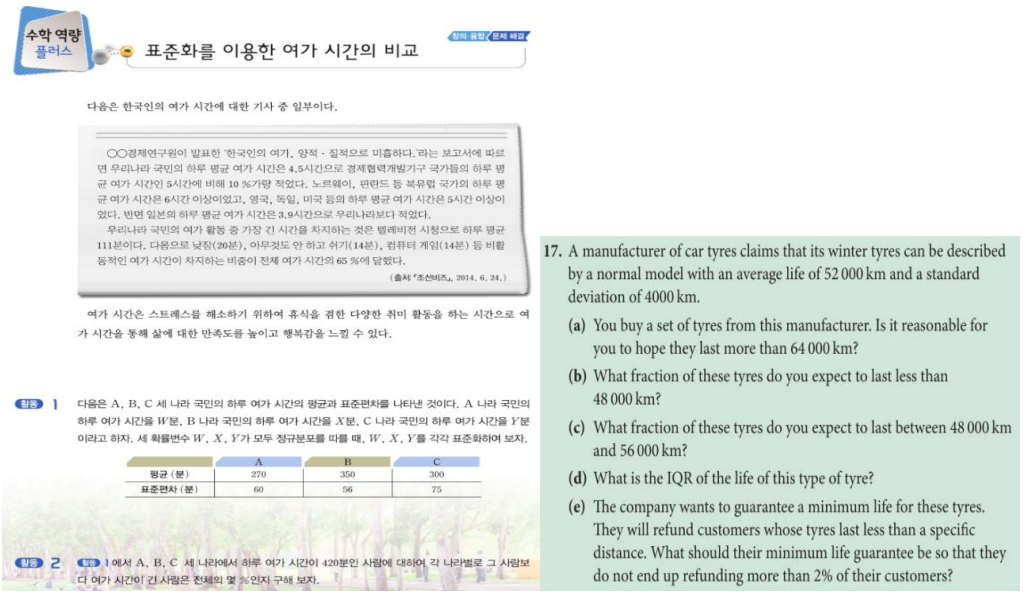
Figure 5. Utilization of graphing calculators in exercises in Korea high school textbook (Ko et al., 2019)

Exercises. Within the IBDP AI SL textbook (Garry et al., 2019), the use of graphing calculators is commonly accepted, and even in exercises where explicit guidance on calculator usage is not provided, students frequently utilize calculators. This approach emphasizes strengthening computational skills through the use of technology tools and promoting learning in practical problem-solving scenarios. Yet, in the Korean high school textbook (Ko et al, 2019), exercises where calculator usage is recommended are often explicitly indicated. Especially in situations requiring complex calculations or specific types of exercises, the use of technology tools may be suggested. Such recommendations aim to cultivate a certain level of computational proficiency in students and enhance their mathematical reasoning skills. Therefore, within the IBDP AI SL textbook (Garry et al., 2019), calculator usage is considered routine, and students often use calculators even in the absence of explicit guidance in exercises. In contrast, the Korean high school textbook (Ko et al, 2019), particularly in cases involving intricate calculations, may recommend calculator usage, as evidenced by explicit indications in certain instances using the calculation sign on the left of the exercises, which can be seen in Figure 5.

Modeling. The Statistics unit within both IBDP AI SL course and the revised 2022 Korea Mathematics place a significant emphasis on the essential skill of mathematical modeling. This involves the creation of mathematical representations that effectively articulate real-world situations, enabling students to bridge abstract mathematical concepts with practical applications and thereby fostering a profound comprehension of statistical principles. According to the curriculum guide, students are directed to actively explore diverse scenarios, employing statistical techniques to model and analyze real-life data throughout the unit. They are encouraged to utilize a variety of mathematical representations, including graphs, equations, and statistical models, to describe and interpret data meaningfully.

Mathematical modeling serves as a dynamic and integral component, bridging theoretical statistical concepts with their practical applications, empowering students to recognize the adaptability of statistics in addressing real-life challenges, and cultivating the skills essential for thoughtful and informed decision-making in various contexts. The crucial difference between the two textbooks is the technology tools that are used to visualize and calculate data from the given or collected sample, which can be seen from the examples in Figure 6. IBDP AI SL textbook (Garry et al., 2019) integrates practical applications where students create mathematical models to address specific problems, such as predicting trends, making informed decisions based on data analysis, or grappling with the uncertainty inherent in statistical predictions. Most exercises in IBDP AI SL textbook (Garry et al., 2019) had some modeling aspects with the option of the use of technology tools such as graphing calculators or statistical software are also given to students as an option for calculation. In the Korean high school textbook (Ko et al, 2019), students are asked to do complex calculations such as standardizing variables following normal distribution by hand. In addition, only a handful of exercises were given to students throughout the entire chapter of the textbook (Ko et al, 2019). The exercise example above in Figure 6 incorporates real-life scenarios, but the mathematical concepts that are

integrated are not any different from the abstract and complex calculations students are asked to do in the main lessons and exercises.


수학 역량 플러스

표준화를 이용한 여가 시간의 비교

다음은 한국인의 여가 시간에 대한 기사 중 일부이다.

○○경제연구원이 발표한 '한국인의 여가, 양적 · 질적으로 미흡하다.'라는 보고서에 따르면 우리나라 국민의 하루 평균 여가 시간은 4.5시간으로 경제협력개발기구 국가들의 하루 평균 여가 시간인 5시간에 비해 10 %가량 적었다. 노르웨이, 핀란드 등 북유럽 국가의 하루 평균 여가 시간은 6시간 이상이었고, 영국, 독일, 미국 등의 하루 평균 여가 시간은 5시간 이상이었다. 반면 일본의 하루 평균 여가 시간은 3.9시간으로 우리나라보다 적었다.

우리나라 국민의 여가 활동 중 가장 긴 시간을 차지하는 것은 텔레비전 시청으로 하루 평균 111분이다. 다음으로 낮잠(20분), 아무것도 안 하고 쉬기(14분), 컴퓨터 게임(14분) 등 비활동적인 여가 시간이 차지하는 비중이 전체 여가 시간의 65 %에 달했다.

(출처 『조선비즈』, 2014. 6. 24.)

여가 시간은 스트레스를 해소하기 위하여 휴식을 겸한 다양한 취미 활동을 하는 시간으로 여가 시간을 통해 삶에 대한 만족도를 높이고 행복감을 느낄 수 있다.

활동 1 다음은 A, B, C 세 나라 국민의 하루 여가 시간의 평균과 표준편차를 나타낸 것이다. A 나라 국민의 하루 여가 시간을 W분, B 나라 국민의 하루 여가 시간을 X분, C 나라 국민의 하루 여가 시간을 Y분이라고 하자. 세 확률변수 W, X, Y가 모두 정규분포를 따를 때, W, X, Y를 각각 표준화하여 보자.

	A	B	C
평균 (분)	270	350	300
표준편차 (분)	60	56	75

활동 2 활동 1에서 A, B, C 세 나라에서 하루 여가 시간이 420분인 사람에 대하여 각 나라별로 그 사람보다 여가 시간이 긴 사람은 전체의 몇 %인지 구해 보자.

17. A manufacturer of car tyres claims that its winter tyres can be described by a normal model with an average life of 52 000 km and a standard deviation of 4000 km.

(a) You buy a set of tyres from this manufacturer. Is it reasonable for you to hope they last more than 64 000 km?

(b) What fraction of these tyres do you expect to last less than 48 000 km?

(c) What fraction of these tyres do you expect to last between 48 000 km and 56 000 km?

(d) What is the IQR of the life of this type of tyre?

(e) The company wants to guarantee a minimum life for these tyres. They will refund customers whose tyres last less than a specific distance. What should their minimum life guarantee be so that they do not end up refunding more than 2% of their customers?

Figure 6. Modeling exercises in Korea high school textbook (Ko et al., 2019) and IBDP AI SL textbook (Garry et al, 2019)

VI. DISCUSSION AND CONCLUSION

This study aimed to explore the direction of high school statistics education in Korea through a comparative analysis conducted between the revised 2022 Korean mathematics curriculum and the IBDP AI SL Curriculum and textbooks. The results are as follows.

First, when comparing the revised 2022 Korea mathematics curriculum with the IBDP AI SL curriculum, it was observed that IBDP AI SL curriculum covered a broader range of topics. The curriculum not only includes contents learned in elementary and middle school in Korea This study aimed to explore the direction of high school statistics education in Korea through a comparative analysis conducted between the revised 2022 Korean mathematics curriculum and the IBDP AI SL Curriculum and textbooks. The results are as follows.

First, when comparing the revised 2022 Korea mathematics curriculum with the IBDP AI SL curriculum, it was observed that IBDP AI SL curriculum covered a broader range of topics. The curriculum not only includes contents learned in elementary and middle school in Korea but also advanced topics that are not covered in the revised 2022 Korea mathematics curriculum, such as various sampling techniques and their effects, biases in sampling, reliability of data sources, interpretation of outliers, inverse normal

calculations, Pearson's correlation coefficient, Spearman's rank correlation coefficient, and hypothesis testing. The revised 2022 Korean mathematics curriculum covers a substantial amount of content, particularly in statistical inference, addressing the estimation of population mean and proportion, while the IBDP AI SL curriculum focuses on hypothesis testing. This discrepancy suggests that each curriculum places different emphases on the topic of statistical inference. The revised 2022 Korea mathematics curriculum covers less content, along with the fact that students need to perform complex calculations through almost no use of technology tools during class time by hand. This implies that, unlike the IBDP AI SL curriculum, the Korean curriculum requires students to engage in manual calculations when solving exercises, which reduces the learning experience such as interpreting and applying statistical data to real-life situations and making decisions based on them directly.

Second, the Korean high school textbook (Ko et al, 2019) incorporates diverse learning materials to foster a positive attitude toward mathematics in students. They also present various activities aimed at enhancing students' communication skills, creativity, and other cognitive abilities. However, in actual school settings, due to the prevalent focus on entrance exam-oriented education, not all materials in textbooks are effectively utilized. This limitation prevents students from fully experiencing the intended learning outcomes as outlined in the textbooks. In contrast, the IBDP AI SL textbook is structured with a focus on adhering to learning objectives, comprising main lessons, exercises, and sub-section exercises. However, exercises in Korean high school textbooks typically inquire about one or two questions in each topic, whereas the IBDP AI SL textbook's exercises present a real-life scenario on all relevant topics through sub-questions. This approach encourages students to recall previously learned content and organize them systematically. Occasionally, exercises also involve decision-making, prompting students to contemplate the practical use of statistics in real-life scenarios. This provides meaningful insights into the expanded emphasis on descriptive and essay-type assessments in the revised 2022 Korean mathematics curriculum. Furthermore, the sub-questions of exercises in the IBDP AI SL textbook are not overly challenging, allowing students to approach problem-solving with increased confidence and repeated practice. It is expected that Korean statistics education may reflect on the repetition of sub-questions covering fundamental concepts that will allow assistance in students gaining the minimum proficiency levels that are required to achieve. Additionally, the Korean textbook emphasizes the practicality of statistics by highlighting topics in statistical probability, such as the law of large numbers and the relationship between the binomial distribution and normal distribution. The textbook also emphasizes the importance of standardizing normal distributions for calculating standard normal distributions. However, in the IBDP AI SL textbook, despite sharing similar learning objectives with the revised 2022 Korea mathematics curriculum, these topics are not covered. The IBDP AI SL textbook addresses the calculation of the inverse normal distribution in situations where the mean and standard deviation are not given, a topic that is not covered in the Korean high school textbook. This discrepancy appears to be influenced by the extent of utilizing technology tools in textbooks. In Korean high school textbooks, the focus seems to be on presenting the topic where students can

experience the utility of statistics in real-life situations without explicit emphasis on the use of technology tools unless specified.

Third, the most significant difference in the comparative analysis of textbooks lies in the utilization of technology tools and mathematical modeling. In the IBDP AI SL textbook, approaches on how students can utilize technology tools in problem-solving are outlined when 'GDC notes' are provided. However, unlike the emphasis on the use of technology tools in the revised 2022 Korea mathematics curriculum, the textbook guides the utilization of technology tools only in exercises presented at the end of the chapter or where the calculation is complex, often accompanied by a calculator symbol indicating the recommended use of a calculator. For the practical use of technology tools to be realized in actual school settings, guidance on the use of technology tools should be explicitly included in the textbook. Furthermore, IBDP AI SL specifies 'Technology required' in its assessment methods. However, in Korea, the use of technology tools is not permitted in the College Scholastic Ability Test (CSAT), creating a reluctance to incorporate technology tools in classroom instruction and internal assessments. Nevertheless, considering that the revised 2022 Korea mathematics curriculum, especially in the statistics unit, emphasizes moving beyond procedural calculations toward conceptual understanding and practical application in real-life scenarios, it would be beneficial if specific guidance is provided in more detailed and diverse ways to use technology tools for understanding concepts. Particularly, with the widespread distribution of one-to-one smart learning devices in Korea, providing specific guidelines for the use of technology tools in the high school statistics unit could significantly support meaningful teaching and learning in statistics. Also, mathematical modeling in statistics not only enhances quantitative skills but also cultivates critical thinking as they evaluate the significance of statistical models across various contexts. Both the curriculum of IBDP AI SL and the revised 2022 Korea Mathematics Curriculum incorporated and emphasized the importance of mathematical modeling, but in textbooks were presented in extreme differences. IBDP AI SL textbook challenges students to apply statistical concepts and methods to solve real-life related exercises, ultimately fostering a holistic and applied understanding of statistical modeling. However, Korean high school textbooks provide students with only a handful of real-life context modeling exercises while asking for complex calculations by hand and abstract proof of statistical concepts.

This study differs from previous research presented in the literature review, which concentrated on studies suggesting the direction of high school mathematics education through a comparative analysis of the revised 2015 Korea mathematics curriculum and the IB curriculum and comparing Korean and IB textbooks in areas of Algebra, Proofs, and Functions through mathematical modeling. The revised 2022 Korean mathematics curriculum is competency-based, but the revised 2015 Korean mathematics curriculum is competency-oriented. The difference between the two curricula in terms of goal, purpose, and descriptions of learning contents may be found. Thus, this study has limitations as it compares textbooks based on the 2015 revised Korea curriculum since the textbooks reflecting the revised 2022 Korea mathematics curriculum were still in development at the time of the research. Additionally, the analysis did not cover all textbooks that were

published based on the Korean and IBDP AI SL curricula. However, through a comparative analysis of the revised 2022 Korea mathematics curriculum and the international IBDP AI SL curriculum and textbooks, this paper aims to propose a direction for statistics education in the revised 2022 Korea mathematics curriculum.

The expansion of descriptive and essay-type exercises can enhance students' mathematical competencies and the provision of specific guidelines to use technology tools can ensure the achievement of students' conceptual understanding and minimum proficiency levels. To enhance the direction of statistics education in South Korea, it is crucial to conduct research that compares and analyzes textbooks aligned with the revised 2022 Korea Mathematics curriculum. Additionally, beyond the insights gained from examining IB curriculum textbooks, a more definitive path for Korean statistics education can be established by undertaking comparative analysis of educational curricula and textbooks from other countries. Presently, although South Korea promotes the utilization of technology tools into the curriculum and classrooms, effective implementation in school environments remains limited. Investigating the comparative advantages of enhancing the use of technology tools versus the necessity of manual computations, as evident in the Korean context, can offer valuable insights into the appropriate integration of technology tools in Korean statistics education. The research poses a direction for the potential to refine the Korean statistics education curriculum by addressing uncertainties surrounding the utilization of technology tools.

REFERENCES

Bargagliotti, A., Franklin, C., Arnold, P., Gould, R., Johnson, S., Perez, L., & Spangler, D. A. (2020). *Pre-K-12 guidelines for assessment and instruction in statistics education II: A framework for statistics and data science education.* American Statistical Association. https://www.amstat.org/asa/files/pdfs/GAISE/GAISEIIPreK-12_Full.pdf

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal, 9*(2), 27-40. https://doi.org/10.3316/QRJ0902027

Garry, T., Ibrahim, W., Kevin, F., & Bryan, L. (2019) *Standard level mathematics applications and interpretation for the IB diploma*. Pearson Education Limited.

International Baccalaureate Organization (2019). *Diploma programme mathematics: applications and interpretation guide first examinations 2021*. IBO.

Ko, E. S., Lee, J. H., Cha, S. G., Cho, S. C., Lee, S. W., & Kim, Y. H. (2019). *High school <Probability and Statistics>*. Sinsago.

Kim, D. W., Hong, J. G., Kim, S. H., Shin, B. M., Kim, Y., Park, J. H., Tak, B. J., Hwang, J. H., Wang, H. W., & Song, C. G. (2020). *An analysis of the current state of the revised 2015 mathematics curriculum and its implementation in Schools.* Research Report BD21010009. Korea Foundation for the Advancement of Science & Creativity.

Kim. D. J., Park, T. Y., Song, S. J., Lim, C. Y., Yoo, Y. J., Yeo, I. G., & Han, S. Y. (2019). *Elementary and secondary school statistics curriculum improvement research report*. Research Report 2019-01. The Korean Statistical Society.

Kim, K. H. (2018). A study on the implication of IBDP student assessment for high school

academic achievement test in Korea. *Journal of Education & Culture, 24*(2), 79-99. http://doi.org/10.24159/joec.2018.24.2.79

Kim, S. H., Lee, E. J., & Kim, S. M. (2020). *A comparative analysis of international curriculum and Korean mathematics curriculum.* KOFAC Research Report C1015119-01-01.

Kim, S. H., Kim S. M., Lee, E. J. (2020). Exploring the direction of high school mathematics education based on IB curriculum. *Journal of Educational Research in Mathematics, 30*(2), 329-351. http://doi.org/10.29275/jerm.2020.05.30.2.329

Lee, K. H., Kim, S. H., Kim, Y. M., Kang, E. J., Kim, N. G., Choi, I. Y., Joo, S. Y., Cho, S. M., Lim, M. I., Kim, E. H., Na, G. S., Byun, H. H., Jung, J. K., Choi, J. S., Kim, D. J., Yang, J. E., Tak, B. J., Lee, S. H., Jeon, J. S., Rim, H. M., ... Kim, Y. J. (2022). *A study on the development of the revised 2022 mathematics curriculum.* Ministry of Education.

Lee, K. W., Jung, Y. G., Seo, Y. J., Jung, C. W. Choi, J. S., Park, M. H., Lee, B. W., Jin, E. N., Lee, K. E., Park, S. Y., Joo, H. M., Baek, N. J., On, J. D., Lee, G. H., & Kim, S. H. (2014). *A study on the guidelines for subject curriculum development*. Report of Korea Institute for Curriculum and Education CRC 2014-7.

Mesa, V., Ma, Y., Quiroz, C., Gerami, S., Liakos, Y., Judson, T., & Chamberlain, L. (2021). University instructors' use of questioning devices in mathematics textbooks: An instrumental approach. *ZDM–Mathematics Education, 53*(6), 1299-1311.

Ministry of Education (2015). *Mathematics curriculum*. Ministry of education notice 2015-74[supplement 8].

Ministry of Education (2022). *High school curriculum*. Ministry of education notice 2022-33[supplement 4].

Ministry of Education (2022). *Mathematics curriculum*. Ministry of education notice 2022-33[supplement 8].

Park, K. M., Lee, H. C., Park, S. H., Kang, E. J., Kim, S. H., Rim, H. M., Jang, H. W., Kang, T. S., Kwon, J. R., Kim, M. J., Pang, J. S., Lee, H. Y., Lee, M. G., Kim, H. K., Yoon, S. H., Lee, K. E., Lee, G. S., Cho, H. J., Kwon., O. N., ... Hwang, S. M. (2015). *A policy study on the development of the 2015 revised mathematics curriculum draft*. Research Report BD15110001. Korea Foundation for the Advancement of Science & Creativity.

Park, W. H., & Koh, S. S. (2022). A comparative study on international baccalaureate diploma programme (IBDP) textbooks and Korean textbooks by the 2015 revised curriculum - Focus on function from a mathematical modeling perspective -. *Journal of the Korean School Mathematics Society, 25*(2), 125-148. http://doi.org/10.30807/ksms.2022.25.2.002

Rim, H. M., & Kim. B. M. (2022). Analysis of proof content in Korea, Japan, and IB middle school mathematics curriculum and textbooks. *The Journal of Curriculum and Evaluation, 25*(2), 89-117.

Yang, H. J., Choa, J. S., & Choe, S. H. (2015). A comparative study of mathematics textbook between 2009 revised curriculum and IB diploma program - The case of high school algebra -. *Communications of Mathematical Education, 29*(3), 391-421. https://doi.org/10.7468/jksmee.2015.29.3.391