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Leveraging Expert Perspectives to Explore Key Elements in Integrating Sustainability and Statistics Education

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Abstract. The integration of sustainability education across subjects is an effort to instill concern in students for preserving global well-being. However, experts are required to be involved in organizing effective strategies to ensure that the targeted goals are achieved through the integration of sustainability education across subjects. Our research explored expert views on the elements that need to be emphasized in integrating sustainability education and statistics education. This qualitative study used semi-structured interviews to collect data from 13 experts, including lecturers, curriculum developers, and teachers. The continuous comparative analysis of the collected data produced four themes, discovering elements that must be present in integrating sustainability education and statistics education, namely (i) statistics education, (ii) sustainability education, (iii) statistical data, and (iv) learning strategies. The findings of this study significantly contribute to contemporary curriculum development by identifying key components necessary for merging sustainability education with statistics education. Hence, the difficulty of school teachers to integrate sustainability education into statistics education should be recognized, so as to input teachers and curriculum developers in providing relevant learning experiences in the objectives of statistics education and sustainability education.

Keywords: Expert perspective; integration; statistics education; sustainability

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1. Introduction

Moving towards sustainability education through statistical education requires a paradigm shift, recognizing that statistical education is responsible for social, economic, and environmental well-being. As such, a new curriculum in statistical education will undoubtedly require new pedagogies to ensure better use of statistics (Hijazi & Alfaki, 2020), particularly to ensure the preservation of global sustainability. However, the current curriculum teaches each subject separately, which is inadequate to prepare students with the 21st-century skills required to live comfortably in modern society, now and in the future (Al-Mutawar et al., 2022). Therefore, changes should immediately be made by integrating sustainability education across all subjects at the school level (Dominguez-Gonzalez & Delgado-Martin, 2022; Li & Tsai, 2021).

The combination of statistical education and sustainability meets current needs, such as the needs of smart consumers, productive workers, and the formation of a society that is statistically literate and responsible, especially in terms of maintaining global sustainability. Notably, sustainability is the key to promoting faster development, while minimizing and preventing bad environmental outcomes (Lu et al., 2022).

Sustainable Development Goals (SDGs) aim to develop awareness, competence, knowledge, skills, and attitudes toward environmental protection to ensure that every activity related to this operation supports the needs of future generations (Zwolinska et al., 2022). Abidi et al. (2020) argued that education for sustainable Development (ESD) aims to promote and improve the quality of lifelong learning to acquire knowledge and sustainability values. Through the application of sustainability elements during learning, students can increase their awareness, skills, and knowledge about the impact of the activities or management of an organization to increase awareness among communities around the world (Kurucz et al., 2013; Zorio-Grima, 2018). At the same time, statistical education plays a role in shaping the way of thinking of modern society, which can play its respective roles in national development (Lee, 2015). Therefore, integrating statistical education and ESD is necessary to improve students' ability to think statistically and increase their knowledge and awareness of global sustainability. This ensures that a society with a sense of responsibility towards the concept of sustainability in achieving progress can be developed.

However, previous researchers argued that sustainability and statistical education are largely not integrated in the classroom (Li & Tsai, 2021). Furthermore, support from the current curriculum regarding sustainability problems in implementing effective education in secondary schools is still lacking (Domindguez-Gonzalez & Delgado-Martin, 2020). According to Li and Tsai (2021), from a research perspective, almost no research has examined the problems encountered in the statistics learning processes linked to the field of environmental sustainability development over the past two decades. Thus, researchers assume that it is not impossible to integrate education in statistics and global environmental sustainability.

The initiative to broaden the community's understanding of the necessity for integrating sustainability education with statistics education is crucial. The primary objective of this study is to investigate the perspectives of experts regarding the incorporation of sustainability education into statistics courses. To achieve this objective, the central research question guiding this study is:

- What elements are essential for creating a learning session that effectively integrates sustainability education within statistics classes?

2. Literature Review

2.1 The Integration of Statistical Education and Sustainability Education

In statistical education, the ability to think statistically is the main skill that must be mastered by students (Garfield et al., 2015; Meylasari et al., 2021; Zhang & Stephens, 2016). Correspondingly, previous studies suggest that that the ability to think statistically is highly beneficial as it can help solve various problems and is the current need of a developing country (Bailey et al., 2020; Tong, 2019). This indicates the need to integrate sustainability education into statistical education to ensure that the development of a sustainable country can be achieved.

Previous studies report that statistics classes are mostly theoretical and have a procedure (Awuah et al., 2020). The teaching method used by teachers to teach statistics is also outdated and does not interest students in learning (Mazouchova et al., 2021). This is attributable to the fact that most teachers are not trained adequately to prepare students to become citizens with statistical literacy (Batanero et al., 2019). Therefore, a new curriculum in statistical education needs a new pedagogy to ensure the better usage of statistics (Hijazi & Alfaki, 2020). As such, a change in the curriculum of statistical education is necessary to prepare students to better understand and apply statistics (Immekus, 2019; Ridgway, 2016). One of the ways to achieve this is by implementing sustainability elements in learning statistics. For that, a new curriculum in statistical education definitely needs a new pedagogy to ensure better usage of statistics (Batanero et al., 2019; Hijazi & Alfaki, 2020).

Efforts to integrate sustainability education with every subject in school (Dominguez-Gonzalez & Delgado-Martin, 2022; Li & Tsai, 2021) can help students think critically and develop the basic knowledge needed for them to become successful in the future (Al-Mutawah et al., 2022). Furthermore, there is still plenty of space for new innovations in statistical education (Ashley et al., 2019). The integration of statistical education with sustainability education is required to guide students in practicing statistical knowledge to maintain global sustainability. Notably, this method encourages active learning, which catalyzes students to think statistically while solving any problems related to their lives. Hence, the usage of big data can increase the understanding of concepts (Penaloza et al., 2017). It also helps students create short-term and long-term predictions that are strong and believable, without ignoring the global sustainability aspect while solving the problem, even when they are trying to strive for development.

Sustainability education has been criticized for being unable to promote positive behavioral changes in students (Buchann et al., 2019). Gough (2021) argued that

although the goal of sustainability development has been recognized in its significance, it remains isolated in education, leading to failure in applying global sustainability through education. Accordingly, the efforts of most educational institutions worldwide to promote sustainable development as a valuable field that requires attention should be continued (Córdoba-Pachón et al., 2020).

Sustainability in education involves equipping learners with the knowledge, skills, values, and perspectives needed to make informed decisions and take responsible actions that promote environmental integrity, economic viability, and social justice. It emphasizes not only addressing the needs of the present but also ensuring a sustainable future for generations to come. As an essential component of quality education, it fosters a deep understanding of how individual and collective actions can contribute to more sustainable ways of living. Sustainability education needs to be nurtured as early as possible to provide students with more opportunities to build meaningful knowledge. The integration of statistical education and sustainability education can foster collaborative knowledge development to empower students to adopt ESD as a framework for thinking about the world and their actions. Thus, according to the Ministry of Education Malaysia (MoE) statistical education integrated with sustainability education produces students capable of mastering statistical knowledge, skills and values, and equips them with the knowledge, skills and values of sustainability (MoE, 2016).

Education in sustainability is essential to prepare students to face current challenges and issues at local, national, and global levels (MoE, 2018). One of the main objectives of sustainability education is to provide individuals or social groups with the overall opportunity to be actively involved in efforts toward solving the diversity of global sustainability issues (MoE, 2016). In particular, the global sustainability education curriculum includes elements of global sustainability that aim to produce students with the ability to think sustainably and be responsive towards the environment in daily life (MoE, 2017). Thus, the MoE (2016) outlined three key aspects in integrating sustainability education into subjects: (i) sustainable consumers and producers, (ii) global citizenship, and (iii) unity.

Current research proves that numerous benefits can be obtained by integrating sustainability education into subjects (Al-Mutawah et al., 2022; Boiyo, 2014; Vincent & Mulkey, 2015). Moving toward global environmental sustainability education through statistical education requires a paradigm shift that statistical education is responsible for social, economic, and environmental well-being. Hence, integrating sustainability education across all subjects in school (Dominguez-Gonzalez & Delgado-Martin, 2022; Li & Tsai, 2021) can help students think critically and develop foundational knowledge needed to gain success in the future (Al-Mutawah et al., 2022). There is no exception for statistical education when there is still plenty of room for innovation in this field (Ashley et al., 2019). In conclusion, the integration of statistical education and sustainability education should be developed as it has substantial benefits in the educational world and is suitable for modern societies' needs. One of the benefits is that it can prepare

students with a lifetime supply of education, causing it to be highly required in the educational world (Maisyafriana et al., 2019). Moreover, understanding the integrated curriculum approach can help support the implementation of meaningful learning that integrates statistical education and sustainability education. Through this curriculum learning, students are hoped to gain comprehensive knowledge. This implies that it is not only limited to one subject but involves various important units or disciplines in sustainable development. Therefore, some strategies need to be made towards a different initiative aiming to improve integrated statistical education curriculum and sustainability education among the current generation.

3. Research Methodology

3.1 Research Approach and Design

This study employed a qualitative approach to investigate experts' views on the elements that must be present to integrate sustainability education in statistics classes. The research design was a single case study that involves an in-depth understanding of a case or natural world phenomenon, limited to a person, to provide an analysis of the context that illuminates the theoretical issues. This particular design was highly suitable as it facilitates the acquisition represented by experts in statistics education and sustainability education.

3.2 Participants and Sampling Technique

The present study employed purposive sampling, a non-probability technique also known as judgmental, selective, or subjective sampling. This method involves the deliberate selection of participants based on the researchers' informed judgment, ensuring that those chosen possess specific characteristics or experiences relevant to the research objectives (Wannenburg & Curlewis, 2023). In addition, this methodology facilitates the acquisition of a comprehensive understanding of the case being investigated by the researchers. Following this sampling technique, a total of 13 expert panels were selected and expressed their agreement to be involved in this study. Table 1 summarizes the details of the expert panel based on job title and field of expertise.

Table 1. Participants' demographic characteristics

Pseudonym	Year of experience	Current Status	Field on expertise
Expert 1	25	Lecturer (Prof. Dr.)	Statistics/ Mathematics Education
Expert 2	25	Lecturer (Prof. Dr.)	Statistics/ Mathematics Education
Expert 3	24	Lecturer (Dr.)	Statistics/ Mathematics Education
Expert 4	20	Lecturer (Dr.)	Statistics/ Mathematics Education
Expert 5	16	Lecturer (Dr.)	Statistics/ Mathematics Education
Expert 6	19	Lecturer (Dr.)	Sustainability Education/ Statistics
Expert 7	18	Lecturer (Dr.)	Sustainability Education/ Statistics
Expert 8	27	Curriculum Development Officer	Sustainability Education
Expert 9	25	Curriculum Development Officer	Sustainability Education
Expert 10	17	Curriculum Development Officer	Statistics/ Mathematics Education
Expert 11	21	Excellent Mathematics Teacher	Statistics/ Mathematics Education
Expert 12	13	Excellent Mathematics Teacher	Statistics/ Mathematics Education
Expert 13	15	Excellent Mathematics Teacher	Statistics/ Mathematics Education

Experience in the field of mathematics education, statistics education, or sustainability education is one of the selection criteria for the expert panels. Accordingly, six expert panel members selected have experience in their respective fields related to this study for more than ten years, and seven experts have more than 20 years of experience. In general, the experience of the expert panel greatly influences the search of the study since the high knowledge and skills possessed by the expert panel will affect the expert panel's ability to provide an opinion on a matter.

3.3 Data Collection Instruments

This study used semi-structured interviews and document analysis. The semi-structured interview questions contained open-ended questions to identify the necessary elements to integrate sustainability education and statistics education in school. An interview protocol was prepared to enhance the study's reliability and provide guidance to the researcher during the interview sessions. The interview protocol underwent a review and validation process by three experts before being used in the study. The interviews were then transcribed immediately, and the study participants reviewed and validated them before the data were analyzed to improve the validity of the study data. At the same time, Cohen's kappa analysis was conducted to determine the degree of coding done by the researcher in comparison with the coding performed by field experts to illustrate the extent to which the selected themes were accurate and aligned with the research questions (Ghazali & Sufean, 2016). Accordingly, the Cohen's kappa index value for this study was 0.96, indicating that the items categorized thematically were accurate and could be utilized to answer the research questions. Meanwhile, document analysis was performed on the curriculum documents of statistical education, science education, and sustainability education found in the education system in Malaysia. Analyzing curriculum documents facilitates the integration of relevant concepts of sustainability and statistics education, ensuring that the curriculum remains up-to-date and aligned with current educational needs.

3.4 Ethical Issues

In order to ensure the achievement of research objectives, it was crucial to adhere to various ethical norms. Therefore, the researcher requested consent from the participants before conducting the interview. The participants were also required to provide informed consent prior to participating in the study, as interviews were deemed necessary for data collection purposes. Furthermore, the participants were provided with information about the nature of their involvement, the study's objectives, the expectations of their commitment, assurances of the confidentiality of their identity, the importance of their contribution to the existing body of knowledge, and their qualifications. The sampling of this study also considered the researcher's collaboration with the study participants. This was emphasized to ensure that the study can be conducted with minimal disruption. The willingness of the study participants to get involved in the study was also considered to ensure that the researcher could explore the experts' views in depth and that the experts were willing to offer their respective views. The experts also had the right to withdraw from participating in the study and the right to demand that their identity be kept confidential by the researcher.

3.5 Trustworthiness

After the interview was transcribed, the researcher asked the study participants to review the interview data to ensure that the interview data coincided with what was stated by the study participants during the interview. Next, verification of the accuracy of the interview transcripts was provided. The researcher also discussed the analysis process and findings with peers and experts to get feedback and insights on the correct interpretation. Discussions with peers and experts were required to obtain their feedback and views to ensure the accuracy and appropriateness of the emerging themes formed by the researcher based on the interview data.

3.6 Data Analysis

The collected data for this exploratory case study were purely qualitative and originated from the interview transcripts. A constant comparison analysis explored data gathered to answer the proposed research questions. Consequently, iterative and inductive data reduction techniques were employed to compare varying data pieces against each other to determine whether the data are conceptually the same or different. The present study utilized the analysis technique outlined by Memon et al. (2017), which has four distinct phases. Prior to commencing the analysis, the interview data underwent transcription which produced interview transcripts prepared for analysis. The initial phase involved the development of inductive category coding, wherein the researchers generated provisional categories by employing criteria, such as visual and tactile similarities and forming an initial list of codes. Subsequent to this procedure, refining categories was undertaken by establishing rules of inclusion, which led to generating a list of categories based on the propositional statement. The third phase involved the examination of relationships between categories, wherein the researchers amalgamated several categories into a limited number of overarching ones. This process resulted in the formation of two final sets of categories, namely stand-alone propositions and outcome propositions. In the last stage, Stage 4, data integration was performed by searching for significance within the data and generating a synthesis. The process of coding and theming was facilitated with the utilization of NVivo 20 software.

4. Results and Discussions

The investigation of expert perspectives identified key elements required to create effective learning sessions that integrate sustainability education and statistical education within statistics classes. The experts' views were categorized into four themes derived from the analysis of the interview data, namely (i) statistics education, (ii) sustainability education, (iii) statistics data, and (iv) learning strategies. The following section discusses the findings and discussions based on each of the themes formed. Figure 1 summarizes the theme determination for creating a learning session that effectively integrates sustainability education within statistics classes.

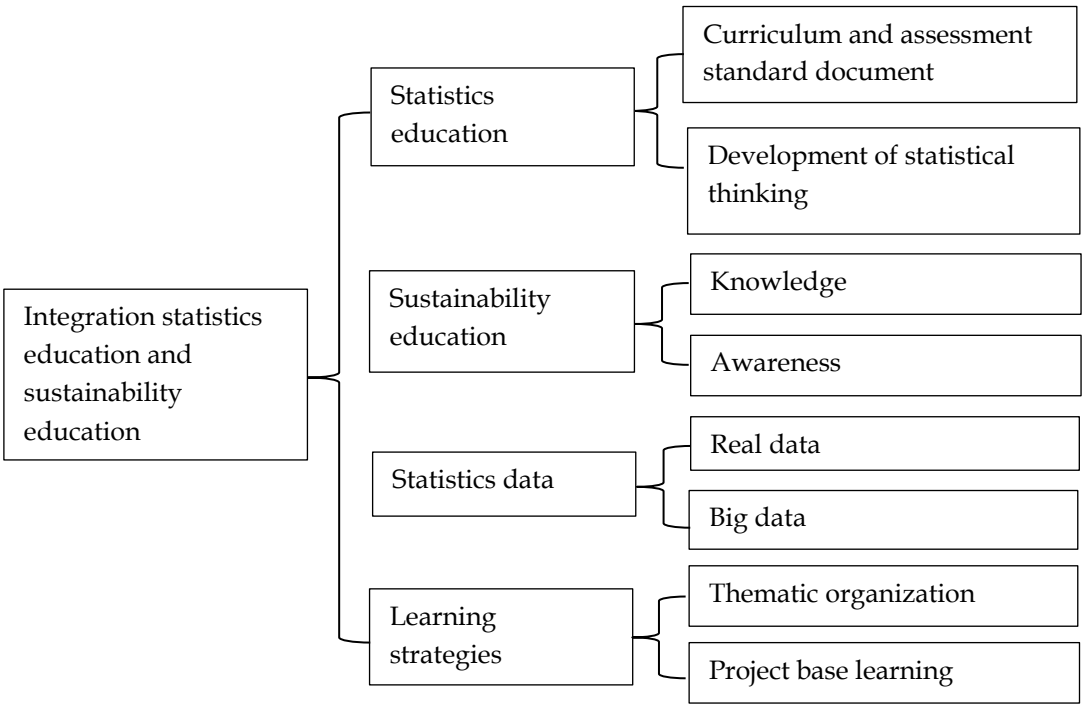

Figure 1: Summary of the theme determination obtained based on interviews with experts related to the integrates sustainability education within statistics classes

Theme 1: Statistics Education

The majority of experts (12/13) expected that the content of teaching and learning should be based on the curriculum and assessment standard document (CASD), although involving sustainability education in statistics classes. According to Expert 5, the combination of statistics education with elements of global sustainability is undoubtedly helpful in today's world of education. However, statistics classes still need to be guided by CASD, which is published by the curriculum development department of the MoE in Malaysia. This guide is intended to ensure that the application of sustainability elements in statistics classes does not hinder the learning outcomes of statistics education. According to Experts 3 and Expert 8, CASD was developed by experts in the field of education. Indeed, CASD is organized according to the needs of the current generation, and it is necessary to ensure that students can compete at the global level.

Expert 1 voiced the opposite opinion that integrating statistics education and sustainability education does not need to be limited to the content of CASD. Expert 1 believed it would be a good thing if the researcher were able to include new things that are not in CASD in the developed teaching and learning process to stimulate students to use their wisdom to develop new ideas. This is attributable to the fact that students possess various levels of thinking that we cannot confirm. However, according to him, in order to include new things that are not in the existing CASD, researchers should be meticulous in examining the ability of teachers to make assessments on students later.

Although the integration of sustainability education is done in statistics classes, the main objective of statistics education still needs to be ensured to be achieved. In agreement with an international agreement, the experts believed that the objective required in statistical education is the development of statistical thinking, that needs to be maintained as the main learning outcome in statistical education, integrated with sustainability education. Therefore, according to experts, the development of statistical thinking involves four processes, which are explaining data, representing data, organizing and reducing data, as well as analyzing and interpreting data, must be ensured to be achieved.

From the experts' view of students in Malaysia, it was discovered that students need extensive exposure to statistics education to ensure that they are able to think statistically. They highlighted that, when examining statistical data, students tend to think more casually and are unable to see beyond making an analysis. The view by Expert 2 described this problem:

> "*We are able to apply statistical thinking when dealing with data to students. We need to train our students; he will think quickly and accurately. Although we may see statistical thinking only related to data, but if we train them to think in such a way about things that have nothing to do with statistics, nothing to do with sustainability, or nothing to do with data*." (Expert 2)

To develop a way of thinking statistically among students, all experts suggested that all statistical thinking processes be implemented. Generally, statistical thinking involved four different processes, which are (i) explaining data, (ii) organizing data (arranging and reducing data), (iii) representing data, and (iv) analyzing and interpreting data (Ardiansyah et al., 2021; Jones et al., 2000; Masjudin et al., 2020; Mooney, 2002; Qomariyah et al., 2019; Snee, 1990). In particular, emphasizing the development of statistical thinking as the main objective of statistical education has long been suggested by some statistical education specialists.

However, in the Malaysia statistics education curriculum, the separation of the statistical thinking process occurs according to the student's grade. For example, the statistical education curriculum for Form Four focuses more on interpreting and analyzing data. Students must go through each process and continue to the next process in order to enrich their statistical thinking. Notably, by including all statistical thinking processes, the development of students' thoughts in solving problems is improved. Thus, each process plays a vital role in building thoughts that are interconnected with each other.

Expert 7 stated that students must be exposed to all statistical thought processes. This is due to the fact that students do not have the skills or way of thinking statistically except when provided with examples of statistical applications in their surroundings. According to him, students have an idea about statistics; however, the use of more complex statistical thinking without teacher guidance is minimal. Hence, creating a variety of statistical thinking tasks using non-routines involving sustainability problems allows students to explore the problem

themselves, identify, think independently, draw conclusions, and then take further action.

To encourage students to think statistically, the expert panel suggested that integrating statistical education and sustainability education should involve various forms of statistical graphic display. Among the recommended statistical graphic displays are bar graphs, dot plots, data tables, stem-leaf plots, and box plots, to name a few. Notably, the variety of statistical graphic displays will attract interest and make students able to think more statistically.

Theme 2: Sustainability Education

Based on the views of all experts, a themed learning approach is appropriate for integrating statistics education and sustainability education. In fact, all experts suggested that the theme of environmental sustainability should be applied. In addition to the theme of environmental sustainability, two experts suggested the theme of financial and consumer sustainability. All the suggested themes matter thoroughly to students' lives and are expected to open student's minds to the application of statistics in their lives.

In integrating sustainability education in certain subjects, the two main goals of sustainability education need to be taken seriously, namely (i) to increase students' knowledge and (ii) to increase students' awareness. According to experts 2, 4, and 7, with the current global environmental situation becoming increasingly alarming, students need to be equipped with knowledge and awareness of various issues related to global sustainability. Therefore, the planning of learning activities should include elements of environmental knowledge such as waste management, saving electricity, and climate change.

Expert 4 stated that knowledge and awareness of global environmental sustainability can be fostered by guiding students to the skills of thinking sustainably and the skills to act towards the environment sustainably. Therefore, teaching that integrates sustainability education and statistics education needs to try to apply these things in every planned learning activity. Expert 3 also suggested that in addition to assigning statistical tasks, tasks should also involve matters related to sustainability that refer more to knowledge. This also includes actions that need to be taken, precautionary measures in preserving global sustainability, the application of elements of sustainability, and noble values. Therefore, it is hoped that awareness can be developed and become a consistent practice in students with clear knowledge about the global sustainability of the environment.

The importance of global sustainability education is emphasized as an effective way of raising awareness among the current generation to be more sensitive to global sustainability issues (Boiyo, 2014). This is to widen the minds of students towards environmental problems in the world and being responsible for creating sustainable development, not only for Malaysia, but also for global well-being. Expert 5 stated that linking this environmental issue between Malaysia and foreign countries is necessary.

> *"When we focus on global sustainability, we have to link our country with foreign countries. We want to preserve students' thinking, in the future, what will happen to our country and the world."* (Expert 5)

Based on the three key aspects of global sustainability education outlined by the MoE (2016), namely sustainable consumption and production, global citizenship, and unity, Expert 10 suggested selecting elements of sustainable consumption and production that are considered more suitable for the subject of Mathematics. Under this element of sustainable consumption and production, Expert 10 suggested four appropriate things to be included in the statistics classes, namely waste, food, climate, and energy. According to Expert 10, knowledge related to environmental sustainability, including waste management, food, climate, and energy, is closely connected to students' lives. In fact, it is a critical issue that requires urgent attention from the current generation to ensure they are able to preserve the world and keep it safe for future inhabitants.

Theme 3: Statistics Data

An analysis of textbooks in the field of statistical learning used in Malaysia showed that the data used are limited and small in size (less than 100). Most of the data used were also fictitious data. This does not lead students to real situations where statistical applications are used in life. All experts believed that real data are critical in statistics class to ensure that students can picture the use of statistical concepts in the reality of life. Hence, real data are used to create statistical learning situations closer to students' lives and relevant to global environmental sustainability issues. The goal is for students to be exposed and be able to apply data more meaningfully by thinking statistically.

The use of real data has become a principle accepted by most statisticians and has been proven to increase student motivation by seeing statistics in real applications (Beth, 2017). To develop statistical thinking, students need to gain experience by going through all statistical thinking processes using real scenarios (Cummiskey et al., 2020). According to experts, using realistic data makes statistics classes more interesting since students can go through class sessions with a sense of curiosity. In addition, it is attributable to the fact that the problems presented in class open students' minds about the application of statistics in their lives.

Expert 11 believed that the involvement of all statistical thinking processes in solving a sustainability problem based on relevant real data will build complete statistical skills from the initial stage to being able to conclude an event. The experience of using real data and going through all statistical thinking processes is essential so students make conclusions and decisions when solving a problem. In addition, learning based on real data also exposes students to how a statistical concept can be applied in real life (Latham & Carr, 2012).

As Weber (2017) views it, statistical thinking leads to deeper knowledge and is required to reason through statistical reasoning, which is a subset of statistical thinking. It is clear here that statistical learning developed based on data in real situations can mutually strengthen statistical thinking and life skills (Woltman,

2017). Supporting this finding, Callejo-Canal et al. (2020) also proved that the use of real-life phenomena develops statistical thinking and further leads to a solid understanding of statistical concepts. Thus, strengthening the concept of statistics allows students to make decisions in problem-solving (Ardiansyah et al., 2021) and can even help students take appropriate actions with a sense of responsibility through critical thinking.

One of the ways to implement the integration of statistics education with sustainability education is through activities that reflect real-world problems and contextualize student learning (Coutts et al., 2022). Real-world problems related to sustainability refer to current things happening in students' lives, including global warming due to sudden temperature changes, environmental pollution and the use of renewable energy. Therefore, experts suggested using real data related to the situation in statistics classes. Usually, statistics education only focuses on teaching the skills of organizing data, statistical calculations, and probability distribution theory through fictitious examples instead of involving statistics in the real world (Kang & Kim, 2022). As such, engaging statistics with the real world allows students to meaningfully view statistics and global environmental sustainability education in a more enriched way.

A study by Callejo-Canal et al. (2020), which was conducted based on real-life phenomena, discovered that applying statistical thinking led to a solid understanding of statistical concepts. Based on this solid understanding of statistical concepts, students can make decisions and take appropriate actions with a sense of responsibility through critical thinking. This is in view of statistical thinking, which leads to the in-depth knowledge required to reason in statistical reasoning (Weber, 2017), a subset of statistical thinking to be used in solving problems, referring to a person's cognitive abilities in thinking systematically and abstractly.

The use of big data in statistical education at the school level has received various views from experts. A large number of experts (11 experts) thought that applying big data is suitable to be developed for the use of upper secondary students, starting with Form Four students. This selection was made based on the preparation of Form Four (Grade 10) students, who are considered to be stronger in statistical knowledge. This is in reference to the statistics education curriculum in Malaysia that they have gone through from primary school to junior secondary level. According to Expert 5, the use of big data is still new in statistics education at the school level. Therefore, an introduction to big data needs to be provided in a module specifically for teachers.

According to Expert 12, the use of big data in statistics education is an interesting idea that allows students to see statistics on global issues. Experts also thought that the use of real big data in statistics education can open students' minds to think more creatively and critically. This is crucial to help students clearly see the use of statistics in their lives. The following Expert 7 statement reflected the views of all experts.

> *"I think this is a good thing. Reveal the real situation, even if it uses big data, but it is good. Because it can open students' eyes, be creative, critical, be able to see what reality is, real life."* (Expert 7)

The use of big data offers students the opportunity to observe the state of the world realistically. This raises awareness through the comparison of the health of the world in the past and the present. By appreciating universal values, students are expected to be able to solve problems and make wise decisions through learning experiences related to global sustainability (MoE, 2016). This matter is in line with MoE's intention, which is 21st-century skills aiming to produce students with characteristics capable of being competitive at the global level (Ghazali & Sufean, 2016) and without disrupting global sustainability. Therefore, it is appropriate that statistical education and global environmental sustainability are considered together in forming student knowledge by being absorbed through the content of the statistical education curriculum. This is to gain significant new importance, especially in relation to the urgent need to address various global environmental sustainability issues.

There is a need to expose the current generation to big data through statistical education (Bailey et al., 2020) to open their minds to the world's challenges of the big data era. However, the change from the use of small-sized fictitious data to big data will indeed be a challenge for educators. Moreover, the use of this real big data can revolutionize the use of richer data sets for analysis (Johnson, 2019). The application of statistical thinking using big data in the statistics curriculum is an innovation. The presence of big data can represent a change in our paradigm of how to utilize and analyze information creatively for the public interest since it can encourage students to continue accessing relevant information and then analyze the data and finally make connections among big data (Gonzalez et al., 2019). According to Penaloza et al. (2017), big data can improve the understanding of concepts and can also produce strong and reliable short-term and long-term forecasts.

Theme 4: Teaching and Learning Strategies

In integrating statistics education and sustainability education, all experts are of the opinion that most teachers face constraints in implementing it due to a lack of knowledge and guidance related to this matter. This finding is similar to that of Chylenska et al. (2022), which suggested that although the curriculum content for each subject has been improved towards increasing pro-environmental attitudes, pro-environmental values still cannot increase among students due to the weakness of teachers in bringing this element into the classroom.

In fact, according to Moreno-Pino et al. (2022), most teaching staff do not feel capable of including sustainability education in the syllabus for the subjects they teach. Therefore, experts suggested that teachers be provided with professional training and sufficient guidance to apply sustainability education in the statistics class. This is in view of the fact that it is impossible to expect mathematics teachers to take action to address the perspective of sustainability education in their

teaching unless the professional development of mathematics teachers pays more attention to sustainability education (Li & Tsai, 2021).

Elements of global environmental sustainability have been expressed in most subjects. However, the curriculum content of each subject does not clearly state how it should be linked to learning objectives in other knowledge domains (Nordén & Avery, 2020). Syafei et al. (2020) proposed three different methods to implement the integration curriculum, namely (i) thematic organization, (ii) student projects, and (iii) student activity units. This view is aligned with the analysis of expert interviews. According to experts, statistics classes integrated with sustainability education should be designed to produce active, creative learning and create cooperation among students. In line with that, all experts (13/13) believed that active learning should be practiced in the classroom by focusing on students. Moreover, all experts recommended using project-based learning as an appropriate learning strategy. Notably, project-based learning aims to encourage collaboration between students to enable the development of student thinking through the sharing of ideas. The use of project-based learning strategies also provides space for students to be active during the teaching and learning process. According to Expert 1,

> *"We need to make statistics classes not oriented towards mathematics. If statistics is taught towards mathematics, we will emphasize the calculation and use of formulas without emphasizing the statistical elements that are important for the use of life."* (Expert 1)

Project-based learning can facilitate student learning by integrating statistical learning and global environmental sustainability education. Questioning techniques, reasoning, problem-solving, guided inquiry, and constructivist learning are teaching strategies designed to interest students in learning. Note that questioning is a key teaching strategy used to determine students' knowledge of statistics and global environmental sustainability issues. This creates a two-way learning environment (questions and answers between teachers and students) based on specific topics.

At the same time, Expert 9 mentioned that project-based learning is suitable for training students to think statistically. Through a project-based learning approach, all statistical thinking processes can be implemented, starting from explaining data, collecting, organizing, representing data, analyzing, and interpreting data. Projects that are built are definitely related to sustainability issues and are expected to develop statistical thinking and improve knowledge and awareness of sustainability better than before. For group assignments, Expert 3 stated that collaboration between students provides knowledge in the field of statistics and forms other skills, such as 21st-century skills, which are 4C skills (collaboration, communication, critical thinking, and creativity), and fosters soft skills among students.

The integration of statistics education and sustainability education is performed to unify and merge the learning of several disciplines in a whole unit to form the attitude and behavior of students. The integration curriculum allows teachers to

deal with two or more disciplines to explore the best topics that can be taught simultaneously and can design the best teaching activities (Al-Mutawah et al., 2022). Accordingly, this opens up opportunities for teachers to understand various problems around them in a meaningful way (Khozin et al., 2021). This situation allows teachers to teach students using an integration curriculum that makes learning more reasonable, helping students master more skills such as calculation, problem-solving, critical thinking, decision-making, and being thinkers in a creative and collaborative atmosphere (Akib et al., 2020; Tzagkaraki et al., 2021). Alternatively, Fu and Sibert (2017) highlighted that planning an integrated curriculum is not easy since it requires a relatively long time allocation and cooperation from teachers from various disciplines. Meanwhile, teachers' inability and lack of motivation to integrate sustainability education into subjects are the most significant obstacles faced by teaching institutions in providing teachers who are able to apply elements of global sustainability in the classroom (Li & Tsai, 2022).

The best method to improve sustainability practices among students is to conduct various activities directly related to sustainability (Mahat et al., 2019). Sustainability education mostly advocates critical thinking and calls for more student-centered learning (Zguir et al., 2021). Students also need to be given the opportunity to act responsively concerning global issues that attract their attention to cultivate global citizens who love peace and the formation of a sustainable society (Akkari & Maleq, 2020). Notably, individual orientation towards the value of sustainability allows them to act responsibly towards the world around them by combining personal identity, local identity, and global identity (Bascope & Reiss, 2021). Knowledge, skills, and understanding of statistical thinking and elements of global sustainability contribute to the development of citizens' foundations to understand global problems, justifying sustainable practices and understanding values (Pahnke et al., 2019). To achieve this goal, teaching and learning materials that integrate statistical thinking and global environmental sustainability education need to be added immediately.

6. Conclusion

This study provides recommendations based on expert views for integrating sustainability education and statistics education. Based on the findings and analysis in this study, all experts hold a positive view on incorporating sustainability education into statistics classrooms. The experts' views on the factors to consider in integrating sustainability education and statistics education can be summarized into four key areas: (i) statistics education, (ii) sustainability education, (iii) statistics data, and (iv) learning strategies. Notably, ESD in statistics education can stimulate sustainable development by providing curriculum content suitable for current needs and allowing students to acquire the necessary skills to understand concepts related to sustainable development from a global perspective.

In the current situation, ESD is still isolated within the statistics education curriculum in Malaysia. Thus, the development of sustainability education in statistics education needs to be re-mixed to evolve the traditional philosophy in the statistics classroom to encompass social, economic, and environmental

dimensions. In this way, statistics education can contribute to society's understanding of sustainable development. Therefore, through learning in statistics classrooms, students will enhance their statistical thinking skills and be well-prepared to face global issues they will encounter throughout their lives. However, the main goal of statistics education should still be emphasized: to improve students' statistical thinking and to produce statistically literate students equipped with the ability to think sustainably, in line with the needs of the international community.

7. Implication and Recommendation

The findings of the study prove that statistical education can be diversified by linking the use of statistics to global environmental sustainability issues. According to the expert's views in this study, integrating statistics education with environmental sustainability education is recommended using real data and big data on global environmental sustainability issues in statistics classes.

Changes to the statistical education curriculum that are applied with elements of global environmental sustainability should be implemented in line with the educational goals for sustainable development according to the educational curriculum in Malaysia, which is equipped with globalization values. The experts' opinions are perceived as agreeing with the need to develop teacher quality and combine high-level thinking skills. The study proves that experts agree that the main emphasis in statistics education is identifying effective pedagogical approaches to improve statistical thinking skills, even when integrated with sustainability education. Meanwhile, the main objective of applying elements of sustainability education in statistics education is to increase student's knowledge and awareness of global sustainability.

The discussion of research findings revealed that statistical education needs to be changed to keep up with the needs of the current generation. The existence of teaching materials that integrate statistical education and sustainability education opens teachers' minds to the need to plan statistical teaching strategies that focus on the formation of a society capable of thinking statistically. This is in addition to equipping students with knowledge and awareness of global sustainability. Indirectly, the study's findings provide ideas for the formation of statistical pedagogy that focuses on the development of statistical thinking and is able to open students' minds to the application of statistics in life, especially to the needs of sustainability education in every person.

8. Limitations

The analysis of the research findings clearly indicates that experts agree that sustainability education should be integrated with statistics education. Expert help is required to aid teachers, especially when applying elements of sustainability in statistics classes. However, it is crucial to identify the limitations of the study. The sample for this exploratory study consisted of 13 experts, who were selected based on their experience in the fields of mathematics, statistics, and sustainability education. Participation was voluntary and the experts were chosen for their specialized knowledge and expertise relevant to the study's focus.

Therefore, this sample cannot be considered a representative of the entire case. Another limitation is that the study sample was small. Thus, the analysis of the interview transcripts with 13 experts in the field of statistics education and sustainability education, as well as curriculum development experts, is unlikely to produce a theory. Therefore, this study should be expanded to investigate the emergence of themes in more depth.

9. References

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