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Analysis of Students' Motivation in Learning Chemistry: Descriptive and Comparative Studies

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Abstract

Ionic liquids, known for their environmental friendliness and potential to enhance bamboo's mechanical properties, align with several SDGs, including No Poverty, Quality Education, and Climate Action. This study explores the potential of ionic liquids in improving bamboo's mechanical properties and integrating Environmental Sustainability and Development (ESD) into chemistry education. The instrument in this study was a questionnaire with a Likert scale. Data from 36 chemistry students were analyzed using a descriptive qualitative method. The results of the analysis revealed a lack of understanding among prospective teachers about ESD and its relationship to ionic liquids and chemical concepts. However, students recognized the sustainability potential of ionic liquids and agreed to incorporate these contexts into their learning. These findings highlight the need to integrate ESD into chemistry education further, emphasizing ionic liquids and their role in sustainable practices like bamboo processing.

1. INTRODUCTION

Since the mid-20th century, environmental problems have been a primary concern for nearly every country worldwide. These issues are influenced by a country's wealth, accessibility, education level, social conditions, and the community's environmental awareness (Arvanitakis & Hornsby, 2017). In Indonesia, persistent environmental, social, and economic issues have negatively impacted the environment, with factors such as poverty and low education levels playing a significant role (Suwarto et al., 2021). To tackle these challenges, countries have embraced the concept of sustainable development through the Sustainable Development Goals (SDGs), which are a continuation of the Millennium Development Goals (MDGs) and are designed to be implemented by various types of countries, including advanced, developing, and less developed ones. The United Nations works closely with the Government of Indonesia, civil society organizations, academic institutions, and the private sector to achieve the SDGs through an integrated approach (Fadil et al., 2023).

The Sustainable Development Goals (SDGs) emerged as the 2030 agenda for sustainable development, approved in September 2015 through the United Nations General Assembly. Essentially, the SDGs focus on three aspects: people, the planet, and prosperity, which are then broken down into 17 goals (UNESCO, 2017). In line with this, the Indonesian government also issued Presidential Regulation 59 of 2017 regarding implementing Sustainable Development Goal Achievement, guiding sustainable development in Indonesia (Kementerian Lingkungan Hidup dan Kehutanan, 2022).

Implementing sustainable development is not limited to a single aspect but encompasses various aspects of life, including education (Listyarini, 2019). The educational domain plays a significant role in achieving the other 16 sustainable development goals (Kioupi & Voulvoulis, 2019). Education for Sustainable Development (ESD) advocates for education as a key means to prepare the current generation to be responsible individuals, enabling them to continue contributing to shaping a sustainable society for future generations (Paristiowati et al., 2022). This makes ESD one of the approaches emphasized in the era of globalization, which also demands that students possess 21st-century skills and a good understanding of the environment, including engaging with the possibilities of change. Together, they can shape a sustainable future by introducing society to various aspects of sustainability (Hasibuan et al., 2021).

One approach to support sustainable learning is through the utilization of sustainable materials. Given their progressively diminishing availability, sustainable materials can be regarded as substitutes for natural resources. These materials contribute to attaining Sustainable Development Goals (SDGs) owing to their intrinsic, easily renewable, and sustainable characteristics. They necessitate minimal energy consumption in their utilization and do not generate pollution or other emissions that could impact human health and comfort (Mudzakir et al., 2022). Sustainable materials are frequently applied in industrial activities, particularly in construction. Illustrative examples of sustainable materials employed in the construction industry encompass certified lumber, geopolymer concrete, permeable paving, cellulose insulation, and bamboo (Patel & Patel, 2021).

Bamboo is renowned as the fastest-growing plant globally and is abundantly found in Indonesia. Bamboo can exhibit a daily growth rate of 60 cm or more and reach heights of up to 40 m. This factor positions bamboo as the fastest-growing plant in the world. Bamboo finds applications in various fields, such as construction materials, textiles, and paper. In construction, bamboo is extensively utilized for its strong fibers, possessing compressive strength twice that of concrete, while its tensile strength is nearly equivalent to steel (Yadav & Mathur, 2021). However, bamboo's durability is relatively low, leading to a relatively short lifespan (Mirdayanti et al., 2023). Several factors can influence the mechanical properties of bamboo, including its age, height position, diameter, thickness of bamboo walls, load position (on nodes or internodes), radial position from the outer to inner part, and bamboo moisture content. These mechanical properties are crucial in designing bamboo as a construction material, determining its strength, suitability for specific construction positions, and overall feasibility. Furthermore, the environment where bamboo grows also affects its mechanical properties (Afifah et al., 2023).

According to Afifah et al. (2023), ionic liquids can address bamboo's weaknesses. Ionic liquids are salts with a melting point at room temperature and exceptional characteristics, including thermal stability, low viscosity, and negligible vapor pressure (Yokokawa et al., 2019). Based on Neyses et al. (2017), these ionic liquids serve as alternative solvents that can be recycled. They can be employed to preserve and enhance the anti-static properties of wood and improve its strength by dissolving cellulose. These ionic liquids can act as crosslinking media through activation reactions, extract lignin from cellulose, be used as plasticizers to enhance density on the wood surface, exhibit positive effects as antifungal, antimicrobial, and UV degradation agents, and minimize water absorption in wood (Miyafuji & Fujiwara, 2013). One ionic liquid composed of choline chloride and lactic acid or oxalic acid is reported to be effective in removing lignin and hemicellulose from wood (Wang et al., 2023).

Previous research has shown that ionic liquids can exhibit better solubility and improved properties in bamboo cellulose pulp (Zhang et al., 2016). Additionally, ionic liquids have been found to have potent inhibitory effects on bamboo mildew (Liu et al., 2023). However, there is a lack of research on integrating Environmentally Sustainable Development (ESD) concepts and ionic liquids in chemistry education. This study explores the potential of ionic liquid contexts to improve the

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quality of bamboo's mechanical properties and internal potential planning for ESD learning at universities. The research will focus on the following aspects:

1. Assessing student awareness regarding ESD and ionic liquids.
2. Analyzing ionic liquid to improve the mechanical properties of bamboo
3. Investigating the context ionic liquid on improving the mechanical properties for ESD-loaded earning.

By examining these aspects, the study aims to provide insights into the potential of ionic liquids in improving the mechanical properties of bamboo and promoting sustainable development in various fields, including construction, furniture, and packaging. The findings will also contribute to further integrating ESD into chemistry education, emphasizing ionic liquids and their potential role in sustainable practices like bamboo processing.

2. METHOD

The research method used in this study is descriptive qualitative (Kim et al., 2017), which aims to provide a comprehensive summary of the potential context of ionic liquids to improve the mechanical properties of bamboo and to integrate internal potential planning for Education for Sustainable Development (ESD) learning at universities. Data were collected through a structured questionnaire given to 36 chemistry education students who had completed all courses in the chemistry department at a university in Bandung, Indonesia. The questionnaire on the readiness of prospective teacher students in implementing ESD lectures was divided into three main components: (1) student awareness regarding ESD and ionic liquids, (2) ionic liquid on improving the mechanical properties of bamboo, and (3) context ionic liquid on improving the mechanical properties for ESD-loaded earning. Each statement in the questionnaire provides four alternative responses on a Likert scale (1–4), which are then analyzed using a descriptive qualitative method.

The instrument's validity was ensured through content validity, which involved consultation with experts in chemistry education and ESD. Meanwhile, the instrument's reliability was tested using Cronbach's Alpha, which produced a reliability coefficient of 0.79, indicating acceptable reliability in the reasonably high category (Taber, 2018). The data analysis includes grouping responses based on questionnaire categories, interpreting patterns and trends, and presenting results in tables and diagrams for easier visualization. The systematic series of research steps is visualized in Figure 1.

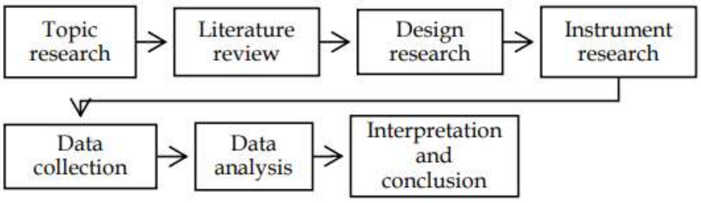

Figure 1. The research process (Ashari et al., 2023)

3. RESULTS AND DISCUSSION

Based on the qualitative descriptive analysis, the author divides several coded subtopics into distinct subjects, including the context of ionic liquids, the use of ionic liquids to enhance the mechanical properties of bamboo, and the application of these contexts in ESD-loaded learning.

Student Awareness Regarding Ionic Liquids and ESD

The questionnaire results regarding the understanding of ionic liquids can be seen in Figure 2.

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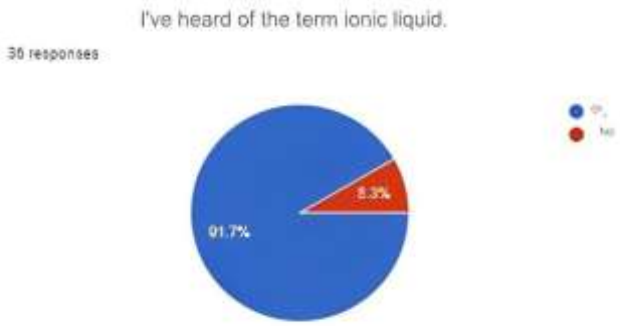

Figure 2. Responses Regarding Understanding of Ionic Liquids

Based on in-depth responses through open-ended questions, 91% of students aware of ionic liquids stated that they had heard about them in introductory chemistry, organic chemistry, physical chemistry, and inorganic chemistry courses. Students study various chemical concepts and theories in these courses, including ionic liquids. However, merely being acquainted with ionic liquids from coursework is insufficient. Students must also have a profound understanding of ionic liquids, including their properties, characteristics, and applications in various fields. Therefore, students must develop the ability to seek information and comprehend chemical concepts thoroughly to apply this knowledge in the future. Furthermore, students mostly agree that Ionic liquids can be an environmentally friendly alternative in various industrial applications; ionic liquids have great potential in sustainable chemistry lecture applications, and learning about ionic liquids is relevant to current environmental issues. The result can be seen in Figure 3.

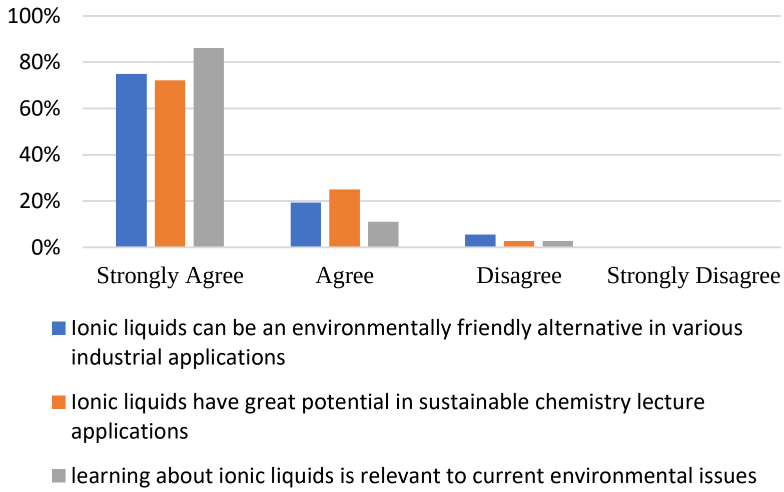

Figure 3. Context of Ionic Liquids

Ionic liquids (ILs) have gained attention as an environmentally friendly alternative in various industrial applications due to their unique properties and potential in sustainable chemistry (Khoo et al., 2021). As a student, it is essential to understand the significance of ionic liquids in the context of current environmental issues and their relevance to sustainability.

Learning about ionic liquids is relevant to current environmental issues and their potential applications in sustainable chemistry. By exploring green synthesis routes and understanding the environmental impact of these materials, students can contribute to developing more sustainable technologies and practices in various industries.

In the context of ESD (Education for Sustainable Development), understanding ionic liquids and how they influence the balance of the environment is crucial for developing sustainable solutions and maintaining the quality of life based on sustainability principles. Therefore, researchers and policymakers should consider the role of ionic liquids in various aspects of life, such as health, ecosystems, and sustainable development.

In line with the statement, Ionic liquids (ILs) are important in sustainable development due to their unique properties and potential applications in various scientific and technological domains (Choudhary et al., 2024).

Ionic Liquid on Improving the Mechanical Properties of Bamboo

Ionic liquids are considered designer solvents because they can organize and adjust their thermophysical properties depending on the variations of constituent ions. The properties of ionic liquids can be tailored based on variations in cation/anion, functionalized alkyl groups, substituent groups, and the length of the alkyl chain in their structure (Welton, 2018). Therefore, we can customize the properties of ionic liquids according to our preferences by varying the constituent cations and anions. In its application to bamboo, based on the questionnaire results regarding the use of ionic liquids to enhance the mechanical properties of bamboo, it can be observed in Figure 4.

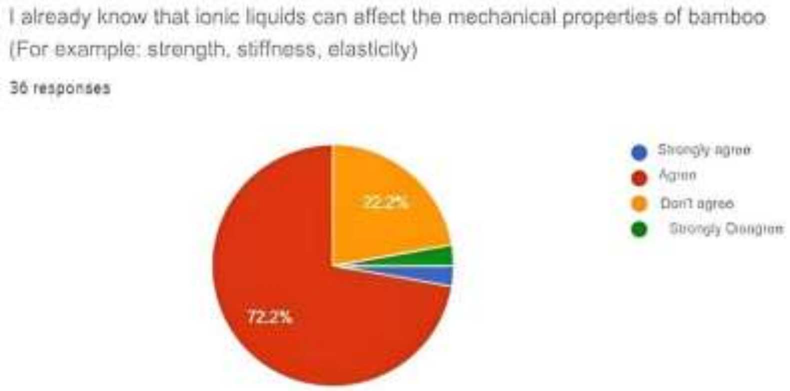

Figure 4. Application of Ionic Liquid on Bamboo

Regarding the question about knowledge regarding ionic liquids that can influence the mechanical properties of bamboo, 75 students stated their agreement, while the remaining 25% still disagreed. Further discussion through open-ended questions revealed that those who agreed mentioned their awareness because ionic liquids have strong bonds that enhance the bonding between bamboo fibers, affecting strength, rigidity, and elasticity. On the other hand, those who disagreed mentioned their lack of familiarity as they had just heard about it.

Ionic liquids have been explored to improve the mechanical properties of bamboo, a sustainable and renewable material, through various techniques such as impregnation, coating, and modification. Some studies have shown promising results in enhancing the properties of bamboo, making it more suitable for various applications. Some studies have investigated the use of ionic liquids in the regeneration of cellulose fibers from bamboo pulp, which can result in smoother surfaces, increased crystallinity, and thermal stability (Zhang et al., 2016). Ionic liquids, such as 1-butyl-3-methylimidazolium methyl sulfate, have been studied for their potential to improve the mechanical properties of bamboo. Although there is limited research on the direct application of this specific ionic liquid in bamboo, some related studies provide insights into using ionic liquids to enhance bamboo properties.

Other studies have explored the use of ionic liquids in the pretreatment of bamboo biomass, which can increase the activity of the material and reduce the activation energy of the regenerated cellulose-rich material (Muhammad et al., 2010). Additionally, to improve their mechanical properties, ionic liquids have been used as additives in recycled high-density polyethylene-reinforced bamboo filler composites (Kamal et al., 2020). While the use of ionic liquids in improving the mechanical properties of bamboo is still an area of active research, these studies suggest that ionic liquids have potential in this application.

Context Ionic Liquid on Improving the Mechanical Properties for ESD-Loaded Learning

The superior properties of ionic liquids align with several Sustainable Development Goals (SDGs), including No Poverty, Quality Education, Industry, Innovation and Infrastructure, Sustainable Cities and Communities, Climate Action, and Life on Land. Ionic liquids have been found to possess attractive solvent properties, such as high thermal stability, high polarity, nonflammability, and good electrical conductivity, making them suitable for various applications, including improving materials' mechanical, thermal, and chemical properties. For instance, ionic liquids have been shown to accelerate the vulcanization of natural rubber, promote the dispersity of carbon black, and improve tensile strength and extensibility. Additionally, they can be customized as researchers require, offering a wide range of possibilities for enhancing the properties of materials. Therefore, integrating the concept of ionic liquids in Education for Sustainable Development (ESD) can provide valuable insights into sustainable material development and contribute to achieving the aforementioned SDGs.

Chemistry education significantly promotes sustainable development by integrating sustainability principles and green chemistry into the curriculum. This integration can help students understand the environmental impact of chemical processes and products, encouraging them to develop more sustainable practices. By incorporating sustainability into chemical education, students can learn how to design and evaluate chemical processes and products safely, efficiently, and environmentally friendly. This can help prepare the next generation of chemists to address global challenges such as resource depletion, pollution, and climate change. Furthermore, promoting sustainability in chemical education can contribute to raising awareness of the Sustainable Development Goals (SDGs) outlined by the United Nations (Sjöström et al., 2015; Suwarto et al., 2021; Wissinger et al., 2021; Zuin et al., 2021).

The use of ionic liquids in improving the mechanical properties for ESD-loaded learning offers new insights into the potential of these compounds in understanding the mechanisms involved in the learning and knowledge process. Ionic liquids are a new group of chemical compounds with unique properties, such as low melting points, significant liquid phase, and ease of melting. They have been introduced in various applications, including nanocellulose synthesis, where they are used as solvents to reduce the interaction between donor and acceptor molecules in the extraction process. Ionic liquids can affect molecular interactions, such as intermolecular interactions, ionic bonding, and colloids. The study offers an opportunity to use ionic liquids to observe the mechanisms involved in ESD-loaded learning systems. This may help develop new methods to optimize the learning and knowledge process. Therefore, incorporating the context of ionic liquids in improving the mechanical properties for ESD-loaded learning is important in exploring new possibilities for enhancing the learning process.

4. CONCLUSION

In conclusion, the research showed that students understand ionic liquids well, particularly in the context of their potential as environmentally friendly alternatives in various industrial applications. Students also recognized the relevance of learning about ionic liquids to environmental issues and their potential applications in sustainable chemistry. The study found that students were aware of the potential of ionic liquids to influence the mechanical properties of bamboo. The use of ionic liquids in improving the mechanical properties of bamboo was seen as a promising approach, with students acknowledging the potential of ionic liquids to enhance the bonding between bamboo fibers, affecting strength, rigidity, and elasticity. It also revealed the importance of integrating Education for Sustainable Development (ESD) principles into chemistry education. This integration can help students understand the environmental impact of chemical processes and products, encouraging them to develop more sustainable practices. By incorporating sustainability into chemical education, students can learn how to design and evaluate chemical processes and products safely, efficiently, and environmentally friendly. This can contribute to raising awareness of the Sustainable Development Goals (SDGs) outlined by the United Nations..

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