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Sustainability Literacy to Vocational Students through Distance Learning with Experimental Demonstration: Ionic Liquid Experiment and Its Application as Fire Retardant

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Abstract: The purpose of this study is to introduce sustainability literacy to vocational students through distance learning with experimental demonstration as well as show the production process of ionic liquid and its application as a fire-retardant agent. The method was the implementation of distance learning with an experimental demonstration method to 40 vocational students through three stages, namely given a pre-test; given an instructional video, and given a post-test. The learning process carried out was assisted by a learning video containing basic theory, experiments, and the application of ionic liquids. In this case, we taught the concept of manufacturing ionic liquid and its application in the industrial world that will be useful for vocational students when they graduate. The results showed that the experimental demonstration method succeeded in improving student learning outcomes because of an increase in the score between the pre-test and post-test scores. This success is because students are taught through unique learning media such as a learning video. This learning video succeeded in increasing students' understanding because the information in the video was presented attractively to stimulate students' curiosity and interest in the subject. In addition, students' responses to the learning video were that they became more enthusiastic about learning because the content delivered relates to the vocational training that they are learning, the video display is attractive, and the videos are easily accessible. Furthermore, the impact of the learning video on industrial applications is that the information conveyed in the video can be an alternative to making environmentally friendly solvents and solutions to improve the quality of bamboo as one of the materials used in industry. The addition of an experimental demonstration using commercially available materials also attracts students more because it motivates them to try it themselves. This study shows that experimental demonstration is effectively used in learning and fosters sustainability values in students.

Keywords: Ionic liquid, sustainability literacy, bamboo, fire retardant agent, vocational students

1. Introduction

sustainable future and enable him to make the right decisions in developing a sustainable future. Sustainability literacy can help students to be more concerned and aware of the environment, hence the process of developing sustainability literacy needs to be carried out in learning. Sustainability literacy can be instilled in students through learning that utilizes sustainable materials. Sustainable material is a substitute material to replace natural resources whose availability is running low and supports the Sustainable Development Goals (SDGs) agenda. Sustainable materials are also known as materials derived from natural resources that are easily renewable, sustainable, do not require a lot of energy in their use, and do not cause pollution or other emissions that have an impact on human health and comfort. Sustainable materials can be in the

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form of natural resources whose availability is abundant but has not been utilized optimally. Currently, sustainable materials are often used in industrial activities, especially in the construction industry. Some examples of sustainable materials used in the construction industry are certified lumber, bamboo, geopolymer concrete, permeable pavement, and cellulose insulation (Patel & Patel, 2021). The use of sustainable materials is one way to reduce the impact of pollution on the construction process. Building development utilizing sustainable materials will prompt a decrease in contamination and improve the current circumstances of ecological issues (Patel & Patel, 2021). In addition, the use of sustainable materials in the construction industry can form a net zero building when the total energy consumed by the building is equal to or greater than the energy produced by the building (Patel & Patel, 2021). The benefits obtained from using sustainable materials in the industrial sector show that implementing sustainable materials in learning can be one way to introduce sustainability literacy to vocational students. This learning supports the ability of vocational students to create more environmentally friendly and sustainable industrial activities when they work in an industrial environment.

Bamboo is an example of sustainable material used in the construction industry. This material is abundantly available in Indonesia because 145 species of bamboo can be found there (Suriani, 2017). After all, bamboo is also a very versatile plant because bamboo can be applied to various things such as construction materials, textiles, and paper. As a construction material, bamboo has strong fibers, the compressive strength is twice that of concrete, and the tensile strength is almost the same as steel (Yadav & Mathur, 2021). In addition, bamboo requires little energy to maintain, can resist soil erosion, supply biofuels, serve as a shelter for animals, and produce a healthy food source for humans and animals (Yadav & Mathur, 2021). This shows that utilizing bamboo as a sustainable material can be applied in vocational learning because bamboo is a material that students often find in daily life and can be implemented in industrial activities. However, bamboo is flammable and has electrostatic properties that can trigger an explosion if used as a construction material for a room that stores flammable chemicals (Roessler & Schottenberger, 2014).

Using ionic liquid can overcome the weakness of bamboo. An ionic liquid is a liquid in which almost all of its constituents consist of ions and generally have a melting point below 100°C. The ionic liquid is non-volatile under normal conditions, non-flammable, and most stable at higher temperatures than conventional organic molecular solvents. The results of previous studies showed that ionic liquid can trigger the formation of dense charcoal residue during thermal degradation, prevent smoke formation, and reduce heat transfer to protect the coating. Another study conducted by Yokokawa, Miyafuji, Murakami, Shouho, & Yamaguchi (2019) showed that ionic liquid can be absorbed into wood cells and increase the fire resistance of wood. The use of ionic liquid as a fire-retardant agent can improve the quality of bamboo as a sustainable material. Therefore, the process of making and applying ionic liquid needs to be understood by vocational students to support their vocational training skills in utilizing sustainable materials.

To adjust the process of making and applying ionic liquid as a fire-retardant agent to bamboo in vocational learning, learning that can realize a real scientific process is needed. Experimental-based learning can be used as alternative learning that will be implemented for students because this learning provides an overview of the real process that can hone students' vocational training skills. However, experiment-based learning is difficult to implement when the physical distancing policy in Indonesia is implemented to prevent the spread of COVID-19. This policy makes academic activities diverted from the face-to-face method to online one. Therefore, experimental-based learning that can support distance learning is needed. This learning requires learning media that can explain the actual science process even though students are not directly involved in the experiment. In addition, the learning media used must be easily accessible to students. Table 1 shows several studies related to vocational learning. Problem-based learning (PBL) is one of the learning models used to implement experimental-based learning. However, learning using PBL cannot be applied to large-scale students. This learning style is also limited in certain learning styles and is hard to apply in distance learning. A virtual laboratory can be an alternative to experimental-based learning that is applied in distance learning. In addition, several learning media are also used in vocational learning such as augmented reality and animation video-based media. However, virtual laboratories and augmented reality are often difficult to be accessed by students, therefore they are less effective in distance learning. Animation video-based media or learning videos can be an alternative media for distance learning. However, no research uses this media as an experimental-based learning media to instil sustainability literacy in vocational students. The research in Table 1 also shows that no studies utilize experiments in making ionic liquids and their application as a fire-retardant agent on bamboo to instil sustainability literacy in vocational students. Previous research only explained the application of green skills to integrate sustainable learning.

The learning method that can be used to implement literacy sustainability for vocational students is the experimental demonstration method. The experimental demonstration method is a teaching method using demonstrations to clarify understanding or to show students how a certain formation process works. Implementing this method supported by a learning video can be an effort to facilitate more accessible learning materials for students. Previous research shows that this method can help students understand the lesson because student focus increases during learning (Maryanti, Hufad, Tukimin, Nandiyanto, & Manullang, 2020). Students with slow learning also find it helpful because this method trains them to be more focused on learning whereas before they do not feel left behind by other students (Widodo, Hufad, & Nandiyanto, 2020) In addition to increasing student focus, this method can also increase student interest and learning outcomes (Anggraeni, Maulida, Ragadhita, Hofifah, & Nandiyanto, 2020) therefore it can support the implementation of the process of making ionic liquids in vocational learning that has never been done before.

Based on the explanation above, the use of ionic liquid as a fire-retardant agent to improve the quality of bamboo as a sustainable material in vocational learning has never been done. This process can help instil sustainability literacy in students and increase students' vocational training skills. Introducing sustainability literacy to vocational students is important to realize more sustainable-based industries in the future. Therefore, the purpose of this study was to introduce sustainability literacy to vocational students through distance learning with experimental demonstration and show the production process of ionic liquid and its application as a fire-retardant agent. The novelty of this research is to teach the process of making and applying ionic liquid as a fire-retardant agent to improve the quality of bamboo as a sustainable material and to apply sustainable learning using sustainable materials. The study is expected to be useful for demonstrating specific skills, instilling sustainability literacy in students, improving student learning outcomes, and being an alternative to sustainability-oriented learning.

Table 1 - Previous research on vocational learning

No	Result Explanation	Reference
1	Learning using PBL provokes students to solve a real problem that exists in everyday life. Students responded favorably to the PBL teaching method with improved performance on both written and lab-based assessments. These results indicate that students who use PBL can benefit from experiential and student-centered learning. However, learning using PBL in this study cannot be applied to students who are large and limited in certain learning styles.	(Jabarullah & Iqbal Hussain, 2019)
2	Animation video-based media is used to operate machines in distance learning. Distance learning requires the support of learning media to assist students and teachers in achieving learning objectives. The animation video-based media is easily accessible by students so that it helps them in distance learning and increases students' interest and learning outcomes	(Kusuma, Sudira, Hasibuan, & Daryono. 2021)
3	Distance learning for vocational students can be done by utilizing a virtual laboratory. By using virtual laboratories, students learn to use industrial equipment through virtual forms. The results showed that the virtual laboratory supports learning and the transfer of knowledge in practical learning.	(Bima, Saputro, & Efendy. 2021)
4	Integrating continuing education into the vocational curriculum, especially green skills, will be beneficial for humans and the environment. Green skills that are applied in learning will produce a workforce that is competent and able to contribute to environmental conservation in the long term.	(Kamis, Alwi, Ismail, & Yunus. 2017)
5	The use of augmented reality (AR) increases the effectiveness of student learning. The approach of utilizing AR also effectively increases students' self-efficacy and reduces their cognitive load. Students with reflective learning styles have a higher cognitive load than students with active learning styles when using the AR approach. This study shows that the application of AR technology in vocational learning can be beneficial for student learning outcomes.	(Lee & Hsu, 2021)

2. Learning How to Make Ionic Liquid and Its Applications Using Experimental Demonstration Method

2.1 Ionic Liquid

Ionic liquids are materials that only consist of ionic species (organic cations and organic/inorganic anions), do not contain certain neutral molecules, have relatively low melting points, and located at temperatures < 100-150ºC (Hagiwara & Ito, 2000). In contrast to molten salt which usually has a melting point, high viscosity, and is highly corrosive, ionic liquids generally melt at room temperature, have a relatively lower viscosity, and are relatively non-corrosive (Toma, Gotov, Kmentová, & Solčániová, 2000). Ionic liquids have the characteristics of being nonvolatile, nonflammable, high stability and electrochemical (in some cases thermal stability up to 400ºC), negligible vapor pressure value, relatively high ability to dissolve organic and inorganic compounds, and environmentally friendly (Miyafuji & Fujiwara, 2013). Ionic liquids have a bulk structure so that the bonds between the ions are not very strong and the energy to break the bonds is lower. The solubilization ability and hydrophobic/hydrophilic character of ionic liquids can be adjusted well only by modifying the cations and anions (Davis, 2004).

The ionic liquid can be used as a wood preservative to improve the anti-electrostatic and fire-retardant properties of wood. Besides that, it is effective in increasing the strength and function of wood and dissolving cellulose (Neyses, Rautkari, Yamamoto, & Sandberg, 2017). The ionic liquid is also used as a solvent in chemical reactions that can be recycled (Neyses, Rautkari, Yamamoto, & Sandberg, 2017). The ionic liquid can act as a medium or crosslinking agent for activation reactions, extract lignin in cellulose, be used as a plasticizer that can increase the density in the wood surface; have a good impact on antifungal, antimicrobial, and UV degradation resistance activities; and minimize water absorption in the wood. The application of ionic liquids is not only for bamboo or wood but also very broad, including in the fields of electrochemistry, engineering, and the synthesis of chemical compounds. In engineering, ionic liquids are used as heat carrier fluids, lubricants, surfactants, and liquid crystals. Ionic liquids consisting of anionic cations also have the potential as corrosion inhibitors because they have the potential to act as adsorption amplifiers with their electrostatic forces (Miyafuji & Fujiwara, 2013). Ionic liquids that can be used as fire-retardant agents have characteristics; like colorless; odorless; and do not change the texture of goods or appearance; or color. Previous studies have shown that 1-ethyl-3-methylimidazolium tetrafluoroborate and 1-ethyl-3-methylimidazolium hexafluorophosphate can be fire-retardant agents in wood (Miyafuji & Fujiwara, 2013). Other studies have also shown that ionic liquids can be used as refractory agents in cellulose fibers (Liu, Jiang, Miao, Yu, & Zhang, 2017) and epoxy resins (Xiao et al, 2017).

2.2 Sustainability-Oriented Learning by Utilizing Sustainable Material

One way to instil sustainable literacy in learning is to make experiments using sustainable materials that are often used in industrial activities in learning. The process of making ionic liquids and their application as a fire-retardant agent on bamboo can be an example of an experiment applied to learning. The production of ionic liquids uses organic and environmentally friendly materials; therefore, they are in line with sustainable development goals (Mustafa, Banzinjy, Hamad, & Hamad, 2022). In addition, bamboo used in ionic liquid applications is an example of a sustainable material that has not been fully utilized (Mudzakir, Fatimah, Sanjaya, Anwar, & Miftahurrahman, 2021). The use of ionic liquids can be one way to instil sustainability literacy in students. Utilization of this ionic liquid can also improve the quality of bamboo which is often used in the construction industry; therefore, it can add new abilities that can be applied in the industrial world for vocational students. The learning method used to explain the ionic liquid production process and its application are experimental. This method is carried out by exemplifying and explaining the experimental process according to the procedure (Nandiyanto, Raziqi, Dallyono, & Sumardi, 2020). Video learning is one of the media that supports experimental learning methods to convey the experimental process clearly to students. The experimental process is recorded in the form of a video that is equipped with experiment-related scientific theories (Nandiyanto, Raziqi, Dallyono, & Sumardi, 2020). Previous research has shown that this method can improve students' understanding of learning (Maryanti, Hufad, Tukimin, Nandiyanto, & Manullang, 2020). In addition, the use of videos can stimulate students' curiosity and interest in learning (Maryanti, Nandiyanto, Manullang, Hufad, & Sunardi, 2020).

Based on Perdirjen Dikdasmen No. 464/D.D5/KR/2018 in 2018, learning by utilizing ionic liquids can be an alternative for vocational learning in the fields of technology and engineering expertise, especially in the construction engineering and property engineering expertise program in tenth grade. Skill competencies that can apply this learning are construction building, sanitation, and maintenance and design modeling and building information. In these two skill competencies, two subjects can apply the use of ionic liquids, namely chemistry and the basics of building construction and soil measurement techniques. The core competencies of related knowledge are understanding, applying, analysing, and evaluating factual, conceptual, basic operational, and metacognitive knowledge according to the field and scope of Simulation and Digital Communications, and Basic Technology and Engineering at the technical, specific, detailed, and complex, concerning science, technology, art, culture, and humanities in the context of developing self-potential as part of the family, school, world of work, and citizens of the national community. In addition to core knowledge competencies, core skills competencies that are also related to learning are as follows:

(i) Carry out specific tasks using tools, information, and work procedures that are commonly carried out and solve problems following the scope of Simulation and Digital Communication, and Basic Technology and Engineering.
(ii) Show performance under the guidance of measurable quality and quantity following work competency standards.
(iii) Demonstrate the skills of reasoning, processing, and presenting effectively, creatively, productively, critically, independently, collaboratively, communicatively, and selectively in the abstract realm related to the development of what he learns at school, and can carry out specific tasks under direct supervision.
(iv) Demonstrate skills in perceiving, readiness, imitation, getting used to, proficient movement, making natural movements in the concrete realm related to the development of what they have learned at school, and being able to carry out specific tasks under direct supervision.

In chemistry subjects, basic competencies related to the use of ionic liquids are in Table 2. The materials used in the production of ionic liquids are examples of organic compounds that can be used in daily life. Ionic liquids are materials that only consist of ionic species (organic cations and organic/inorganic anions), do not contain certain neutral molecules, and have relatively low melting points, located at temperatures < 100-150ºC (Hagiwara & Ito, 2000). Therefore, the chemical bonds that occur in the formation of ionic liquids are ionic. This shows that learning by utilizing ionic liquids as a fire-retardant agent on bamboo is following basic competencies 3.4 and 4.4 because students can analyse one type of chemical bond (ionic bond) in organic compounds that are used daily and can integrate the process through this learning. In the subject of basic building construction and land surveying techniques, the related basic competencies are in Table 3. Bamboo is used as an example of sustainable material in the application of ionic liquids in learning. Bamboo has different physical characteristics from wood. However, bamboo is often used as a substitute for wood nowadays because it has several similarities. Bamboo is a lingo-cellulose, heterogeneous, and anisotropic material like wood. Bamboo also has some of the same chemical compositions as wood, such as cellulose, hemicellulose, and lignin. In addition, Miyafuji and Fujiwara (2013) reported that ionic liquids can also be applied as a fire-retardant agent on wood. Therefore, learning by applying this ionic liquid can be one way to introduce the characteristics of wood and alternative wood substitutes following basic competencies. Core competencies and basic competencies related to learning are contained in Perdirjen Dikdasmen No. 464/D.D5/KR/2018 in 2018.

Table 2 - The curriculum of chemistry subject in vocational schools related to the ionic liquids learning

Core Competency 3 (Knowledge)	Core Competency 4 (Skill)
1. Understanding, applying, analysing, and evaluating factual, conceptual, basic operational, and metacognitive knowledge according to the field and scope of Simulation and Digital Communications, as Basic Technology and Engineering at the technical, specific, detailed, and complex, concerning science, technology, art, culture, and humanities in the context of developing self-potential as part of the family, school, world of work, and citizens of the national community.	2. Carry out specific tasks using tools, information, and work procedures that are commonly carried out and solve problems following the scope of Simulation and Digital Communication, and Basic Technology and Engineering. Showing performance under the guidance of measurable quality and quantity following work competency standards. Demonstrate the skills of reasoning, processing, and presenting effectively, creatively, productively, critically, independently, collaboratively, communicatively, and selectively in the abstract realm related to the development of what he learns at school, and can carry out specific tasks under direct supervision. Demonstrate skills in perceiving, readiness, imitation, getting used to, proficient movement, making natural movements in the concrete realm related to the development of what they have learned at school, and being able to carry out specific tasks under direct supervision.
Basic Competency	**Basic Competency**
3.4 Analysing the process of forming chemical bonds in several compounds in everyday life and basic competencies	4.4 Integrating the process of forming chemical bonds in several compounds in everyday life with the valence electrons of atoms and their constituents.

Table 3 - The curriculum of basic building construction and land surveying techniques subject in vocational school related to ionic liquids learning

Core Competency 3 (Knowledge)	Core Competency 4 (Skill)
3. Understanding, applying, analysing, and evaluating factual, conceptual, basic operational, and metacognitive knowledge according to the field and scope of Simulation and Digital Communications, and Basic Technology and Engineering at the technical, specific, detailed, and complex, concerning science, technology, art, culture, and humanities in the context of developing self-potential as part of the family, school, world of work, and citizens of the national community.	4. Carry out specific tasks using tools, information, and work procedures that are commonly carried out and solve problems following the scope of Simulation and Digital Communication, and Basic Technology and Engineering. Showing performance under the guidance of measurable quality and quantity following work competency standards. Demonstrate the skills of reasoning, processing, and presenting effectively, creatively, productively, critically, independently, collaboratively, communicatively, and selectively in the abstract realm related to the development of what he learns at school, and can carry out specific tasks under direct supervision. Demonstrate skills in perceiving, readiness, imitation, getting used to, proficient movement, making natural

	movements in the concrete realm related to the development of what they have learned at school, and being able to carry out specific tasks under direct supervision.

Basic Competency	Basic Competency
3.3 Understanding wood specifications and characteristics and basic competencies	4.3 Presenting wood specifications and characteristics.

3. Methodology

3.1 Experiment Procedure

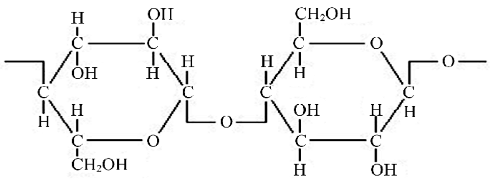
This research used a quantitative approach with a pre-experimental design. Creswell (2003) concisely defines quantitative research as a type of research that explains phenomena by collecting numerical data and analysing them using mathematically based methods. The results are typically presented using statistics, tables, and graphs. The design of the experiment is the pre-test - post-test control group design. It involves an experiment class pre-test (O_1), a control class pre-test (O_2), a treatment (X), an experiment class post-test (O_3), and a control class post-test (O_4) (Yusuf, Yusuf, & Nadya, 2017).

The treatment in the experiment class is teaching students how to make ionic liquid and its application as a fire-retardant agent on bamboo using an experimental demonstration method. Learning videos are used as learning media during the treatment. The content in the learning video refers to the national curriculum, syllabus, and lesson plans for the tenth grade of vocational high school. The source of content in the video comes from vocational chemistry books and research journals related to the use of ionic liquids. Meanwhile, the treatment in the control class is learning using conventional methods without using learning videos. The material taught is the same as the material in the experiment class, namely the manufacture of ionic liquids and their application as a fire-retardant agent on bamboo.

Data were collected from a pre-test and a post-test. Pre-test and post-test were given to students before and after the learning session. We used a short question-type test with yes or no answer choices. We provided 15 questions related to the sustainability aspect, such as the bamboo properties and ionic liquid concept. These questions are adapted from research conducted by Yulianti, Hamidah, Komaro, and Mudzakir (2021). This research has tried to apply the process of making ionic liquids to the learning of polytechnic students. However, in this study, the questions were made to adapt to the vocational learning materials. In addition, the questions are also arranged based on the level of thinking in the revised Bloom's taxonomy. The suitability between the questions and the cognitive dimensions of Bloom's taxonomy is shown in Table 4. Each question has a score of 1. The maximum score the student gets is 15×100: 15 = 100 (the score obtained is multiplied by 100 divided by fifteen).

Table 4 - Question instruments based on Bloom's Taxonomy

No	Question Indicator	Question	Cognitive Dimension	Test Form	Answer	Score
1	Know the definition of sustainable materials	To reduce environmental damage, many researchers suggest using sustainable materials in everyday life. Are environmentally friendly materials included in sustainable materials?	C1 (conceptual)	Yes or no	Yes	1
2	Define the characteristics of sustainable materials	Material is included as a sustainable material if the material can be an alternative to existing materials. If there is a material that is an alternative to other materials, but its availability is limited, is it not a sustainable material?	C1 (conceptual)	Yes or no	Yes	1
3	Know an example of sustainable materials	Bamboo is a versatile material and is very abundant in Indonesia. Is bamboo a sustainable material?	C1 (factual)	Yes or no	Yes	1

4	Identify the main components of bamboo	 Cellulose Is the above compound one of the main components of bamboo?	C1 (conceptual)	Yes or no	Yes	1
5	Know the composition of bamboo affects the mechanical properties of bamboo	Does the composition of bamboo affect its mechanical properties of bamboo?	C1 (conceptual)	Yes or no	Yes	1
6	Identify the weakness of bamboo	If bamboo is used as a construction material for a chemical storage room, does it pose a risk of explosion?	C1 (conceptual)	Yes or no	Yes	1
7	Know the nature of bamboo that limits its application	A factor that limits bamboo's application is its flammability. Is bamboo flammable because of its cellulose content?	C1 (conceptual)	Yes or no	Yes	1
8	Define the definition of ionic liquid	Ionic liquids are salts composed of cations and anions. Do ionic liquids not contain neutral molecules?	C1 (conceptual)	Yes or no	Yes	1
9	Know the difference between ionic liquid and molten salt	Is ionic liquid different from molten salt?	C1 (conceptual)	Yes or no	Yes	1
10	Find out the difference between ionic liquid and salt solution	Is ionic liquid different from salt solutions?	C1 (conceptual)	Yes or no	Yes	1
11	Know the physical and chemical properties of ionic liquids	Ionic liquids are composed of a variety of cations and anions. Do variations in cations and anions affect the physical and chemical properties of ionic liquids?	C1 (conceptual)	Yes or no	Yes	1
12	Know the application of ionic liquid to overcome the weakness of bamboo	Can ionic liquids be used to make bamboo fireproof and prevent explosions?	C1 (conceptual)	Yes or no	Yes	1
13	The process of applying ionic liquid to overcome the weakness of bamboo	Does the ionic liquid absorb into the bamboo fiber so that the bamboo is protected from fire?	C1 (conceptual)	Yes or no	Yes	1
14	Effect of ionic liquid on the mechanical properties of bamboo	Do the mechanical properties of bamboo change after the ionic liquid is added?	C1 (conceptual)	Yes or no	Yes	1
15	Effect of ionic liquid on the electrostatic properties of bamboo	Can ionic liquids affect the electrostatic properties of bamboo?	C1 (conceptual)	Yes or no	Yes	1

Validity and reliability tests were conducted to assess the accuracy of the question instruments used in assessing the concepts being taught. This test was conducted on 40 students with 15 questions. The validity of the questions is determined by the product moment correlation formula, while the reliability of the questions is determined by the Kuder Richardson-20 (KR-20) formula. The test results are listed in Tables 5 and 6.

Table 5 - Validity test on the item questions

Number of questions	15 items
Number of students	40 students
Valid question number	1, 2, 3, 4, 5, 6, 8, 9, 11, 12, 14, 15
Number of valid questions	12

Table 6 - Reliability test on the item question

r_{count}	0.682
Category	The level of reliability on the item questions is high.

In addition, difficult analysis on pre-test and post-test questions were also carried out based on the difficulty level of Thorndike and Hagen's calculation. Tables 7 and 8 show the difficulty analysis for the pre-test and post-test questions and the classification of the results of data analysis level difficulty in detail, respectively.

Table 7 - The difficulty level of pre-test questions

Question number	Number of correct answers	Total students	Difficulty index value	Question category
1	40	40	1	Easy
2	40	40	1	Easy
3	40	40	1	Easy
4	26	40	0.67	Medium
5	39	40	0.975	Easy
6	40	40	1	Easy
7	39	40	0.975	Easy
8	34	40	0.85	Easy
9	40	40	1	Easy
10	38	40	0.95	Easy
11	37	40	0.925	Easy
12	34	40	0.85	Easy
13	37	40	0.925	Easy
14	31	40	0.775	Easy
15	34	40	0.85	Easy

Table 8 - Classification and Percentage of Difficulty Level

Category	Question Items	Total (items)	Percentage (%)
Easy	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15	14	93.33
Medium	4	1	6.67

3.2 Participants

The participants involved in this study were 40 students from vocational high schools in West Java, Indonesia. They were divided into two classes, namely class A as the experimental class and class B as the control class. Class A consists of 11 male students and 9 female students. Meanwhile, class B consists of 12 male students and 8 female students.

3.3 Treatment Procedures

3.3.1 Experimental Group

The learning method used in the experimental class is an experimental demonstration method. The learning process using the experimental demonstration method in the experiment class begins with a short question and answer session regarding the physical and chemical properties of a material. The lesson continued by explaining sustainable materials and focusing on bamboo as an example of sustainable materials and their weaknesses. The ionic liquid is one solution to overcome the weakness of bamboo. Therefore, a video of making ionic liquids in learning is shown. In addition, in the learning video, there is also a further explanation of the process of making ionic liquids, fire resistance tests, and dust adhesion tests on bamboo. The learning process takes place following the learning implementation plan in Table 9.

Table 9 - The summary of the experimental demonstration method teaching delivery

Delivery method	Description	Role action
Pre-teaching	• Explaining core competences, basic competences, indicators, and learning objectives that are expected to be achieved, listening to information about the stages of learning activities that will be carried out • Asking questions about the chemical and physical properties of a material • Asking questions about whether students know about sustainable materials. • Provide a pre-test to determine students' prior knowledge about the topic to be studied	Teacher and Students
Content delivery	• Ask students if they know about sustainable materials. • Asking what information the students got after doing the pre-test • Explain sustainable materials one example is bamboo	Teacher and Students
Group discussion	• Discuss how to overcome the weaknesses of bamboo • Discuss innovations that can be made to overcome the weaknesses of bamboo • Directing innovations to be made with the use of ionic liquids	Teacher and Students
Content delivery	• Explain the concept of ionic liquid • Show a video demonstration of the manufacture of ionic liquids and explain each step of its manufacture • Show a video of the application of ionic liquid on bamboo and provide an explanation of each process that occurs • Provide opportunities for students to ask questions	Teacher
Evaluation	Students are given a post-test to evaluate their learning	Teacher and Students

3.3.2 Control Group

The learning method used in the control class is the conventional method. The learning process using conventional methods in the control class is carried out by providing an explanation of sustainable materials, ionic liquid, and its application as a fire retardant agent using power points. Finally, a post-test was given to determine the sustainability literacy of students and evaluate students' understanding after the learning process through experimental demonstration was carried out. The learning process takes place following the learning implementation plan in Table 10.

Table 10 - The summary of the conventional method of teaching delivery

Delivery method	Description	Role action
Pre-teaching	• Explaining core competences, basic competences, indicators, and learning objectives that are expected to be achieved, listening to information about the stages of learning activities that will be carried out • Asking questions about the chemical and physical properties of a material • Asking questions whether students know about sustainable materials. • Provide a pre-test to determine students' prior knowledge about the topic to be studied	Teacher and Students

Content delivery	• Ask students if they know about sustainable materials. • Asking what information the students got after doing the pre-test • Explain sustainable materials one example is bamboo	Teacher and Students
Group discussion	• Discuss how to overcome the weaknesses of bamboo • Discuss innovations that can be made to overcome the weaknesses of bamboo • Directing innovations to be made with the use of ionic liquids	Teacher and Students
Content delivery	• Explain the concept of ionic liquid, the manufacture of ionic liquids, and its application through a presentation	Teacher
Evaluation	Students are given a post-test to evaluate their learning	Teacher and Students

3.4 Data Analysis

To support the research instrument, students' demographic data are collected before the learning process. Students' basic information on average scores in Mathematics, Chemistry, Physics, Biology, Vocational training, and students' IQ scores as the demographic data were obtained to support the research instrument. The first descriptive analysis conducted was to analyse the students' correct answers during the pre-test and post-test. This analysis was conducted to determine the number of students who answered each concept correctly. An increase in the number of students who answer each concept can correctly indicate mastery of the concept in students. After that, descriptive statistical analysis was carried out through analysis of the average value and gain. Gain data can be used to determine whether there was an increase in learning outcomes and mastery of concepts after participating in learning. After knowing the gain value of each student, the normalized gain analysis (*N*-Gain) can be done. This analysis is used to determine the gain criteria obtained. The gain is obtained from the pre-test and post-test score data, which is then processed to calculate the normalized average gain. The average normalized gain is calculated through Equation (1) (Hake, 1998).

$$< g > = \frac{\% < G >}{\% < G > max} = \frac{\% < sf > - \% < si >}{100 - \% < si >} \quad (1)$$

Where <*g*> is the normalized average gain, <*G*> is the actual average gain, <*G*>*max* is the maximum possible gain, *%*<*sf*> is the post-test average percentage, and *%*<*si*> is the mean percentage of the pre-test. The normalized gain value criteria are listed in Table 11.

Table 11 - N-Gain Value Criteria

Limit	Category
0,7 < <g>	High
0,3 ≤ <g> ≤ 0,7	Medium
<g> < 0,3	Low

The inferential statistical analysis begins with a normality test. The normality test was conducted to determine the distribution of the data and to determine the statistical test. The normality test used is the skewness test. Skewness is a statistical quantity that shows the slope of the data. This Skewness shows the data tends to be centered or skewed to one side. Normal distributed data has a skewness ratio value in the range of -2.00 to 2.00. The skewness ratio is calculated by Equation (2).

$$Skewness\ ratio = \frac{Statistic\ of\ skewness}{Std\ error\ of\ skewness} \quad (2)$$

If the results of the normality test show that the data is normally distributed, then a parametric statistical test is performed. The selected parametric statistical test is the paired sample *t*-test. This analysis was conducted to see the growth of students' sustainability literacy based on the differences in student learning outcomes before and after learning (Afifah, Mudzakir, and Nandiyanto, 2022). In addition, this analysis was carried out to determine the significance level of the experimental demonstration learning method. If the results of the normality test indicate that the data are not normally distributed, then a non-parametric statistical test is performed. The chosen non-parametric statistical test is the Spearman-level correlation test (Rank-Correlation Method) (Sarwono, 2015).

4. Results and Discussion

4.1 Students Demographic

Table 12 shows the demographic data of students' scores in subjects related to the natural sciences such as Mathematics, Chemistry, Physics, Biology, and vocational training. These values are needed to determine the readiness of students in participating in ionic liquid learning. Based on Table 12, the average value of science in all subjects is greater than 80, which means that students have good knowledge and skills in science so that they can participate in learning.

Table 12 - Students' average scores based on students' school report

No	Subject	Mean Score	Standard Deviation
1	Mathematics	82.5	0.71
2	Chemistry	84.5	3.54
3	Physics	83.75	1.77
4	Biology	90	4.24
5	Vocational Training	81.5	0.71

Figure 1 shows the demographic data of 20 students in the experiment class which contains information about students' IQ scores. Students' cognitive abilities can be seen from IQ scores. IQ score data shows how students' cognitive abilities can apply to learning. In the graph, it is known that 3.33% of students have IQ scores in the range of 130-144 which are classified as gifted or very advanced. Students belonging to the advanced group generally have very high cognitive abilities so students are usually very fast in understanding and processing learning. Students have IQ scores in the range of 110-119 as many as 20.00%. Students in this range are classified as high average, which means students have cognitive abilities above average and can process learning quickly. A total of 40.00% of students have IQ scores in the range of 90-109. Students in this range are classified as average, which means students have average cognitive abilities. At last, there are 3.33% of students have IQ scores in the range of 80-89. Students in this range are classified as low average, which means students in this range have cognitive abilities below the average so students tend to be slow in processing learning.

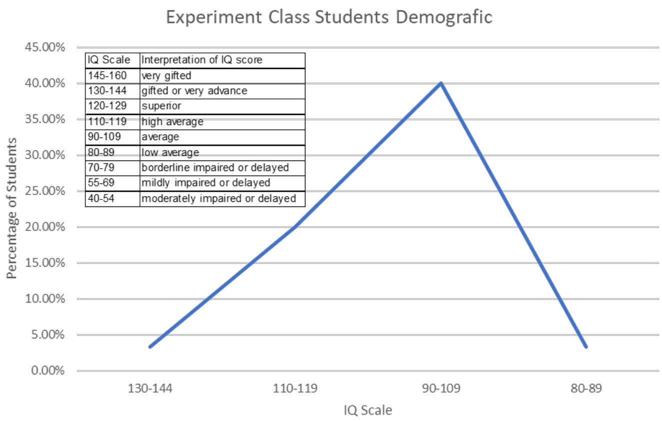


Fig. 1 - Students' IQ scores in the experiment class (The range of IQ scores based on the Stanford Binet scale)

Figure 2 shows the demographic data of 20 students in the control class which contains information about students' IQ scores. In the graph, it is known that 3.33% of students have IQ scores in the range of 130-144 which are classified as gifted or very advanced. Students belonging to the advanced group generally have very high cognitive abilities so students are usually very fast in understanding and processing learning. Students have IQ scores in the range of 120-129 as many as 6.67%. Students belonging to the superior group generally have high cognitive abilities so students are usually fast in understanding and processing learning. Students have IQ scores in the range of 110-119 as many as 20%. Students in this range are classified as high average, which means students have cognitive abilities above average and can process learning quickly. A total of 33.33% of students have IQ scores in the range of 90-109. Students in this range are classified as average, which means students have average cognitive abilities. At last, there are 3.33% of students have IQ scores in the range of 80-89. Students in this range are classified as low average, which means students in this range have cognitive abilities below the average so students tend to be slow in processing learning. Based on this data, overall students have good cognitive abilities and are expected to be able to follow and process learning well. The interpretation of this range of IQ scores is based on the Stanford Binet scale.

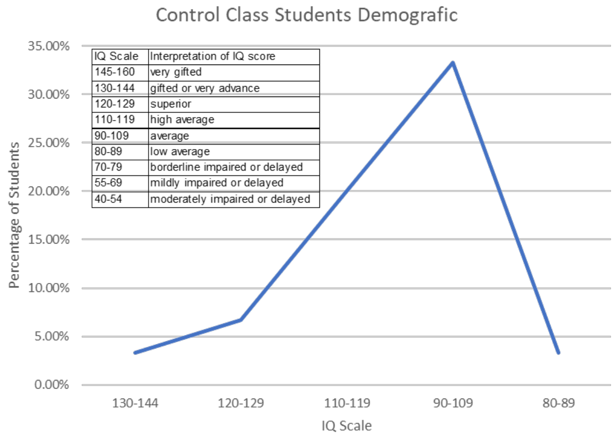


Fig. 2 - Students' IQ scores in the control class (The range of IQ scores based on the Stanford Binet scale)

4.2 Results and Discussion

The results of the descriptive analysis were obtained from the analysis of students' correct answers and the calculation of gain. Table 13 shows the results of the analysis of students' answers regarding the concepts of making and applying ionic liquids that have been taught. The results of this analysis came from the post-test answers of the experimental class and control class students. The concepts taught in learning contain the values of sustainability literacy.

Table 13 - The results of the analysis of student answers

No	Question	Students Who Answered Correctly (%)		Average (%)
		Experiment	Control	
1	Definition of sustainable materials	100	100	100
2	Characteristics of sustainable materials	100	100	100
3	Examples of sustainable materials	100	100	100
4	The main components of bamboo	80	50	65
5	The composition of bamboo affects the mechanical properties of bamboo	100	95	98
6	Weaknesses of bamboo	100	100	100
7	The nature of bamboo that limits its application	100	95	98
8	Definition of ionic liquid	90	80	85
9	Difference between ionic liquid and molten salt	100	100	100
10	Difference between ionic liquid and salt solution	95	95	95
11	Physical and chemical properties of ionic liquids	95	90	93
12	Application of ionic liquid to overcome the weakness of bamboo	90	80	85
13	The process of applying ionic liquid to overcome the weakness of bamboo	95	90	93
14	Effect of ionic liquid on the mechanical properties of bamboo	85	70	78
15	Effect of ionic liquid on the electrostatic properties of bamboo	90	80	85

The results in Table 13 show that the number of experimental class students who answered correctly on each question was more than the control class students. This is indicated by the large percentage value of the experimental class students who answered each concept on the question correctly, which is above 80%. In the experimental class, 7 concepts can be understood by 100% of students, namely concepts 1, 2, 3, 5, 6, 7, and 9. Meanwhile, 5 concepts can be understood by 100% of control class students, namely concepts 1, 2, 3, 6, and 9. In the control class, there is one concept that only 50% of students understand, namely the concept of the main components of bamboo. This happens because students find it difficult to remember the names of the chemical components in bamboo. This means that learning using the experimental demonstration method is more effective in improving students' conceptual understanding compared to conventional methods. This also indicates that the experimental class students' understanding of concepts is better than the control class students and the experimental demonstration method using learning videos conducted in the experimental class can increase students' understanding of the concept of making and applying ionic liquids to encourage the implantation of sustainability literacy in students.

Student learning outcomes can be known through the analysis of the results of the pre-test and post-test. The results of the pre-test and post-test analysis of experimental class students and control class students are shown in Table 14 and 15 below.

Table 14 - Student learning outcomes in the experiment class

Student	Experiment Class Score		Gain	N-Gain
	Pre-test	Post-test		
1	60.00	86.67	26.67	0.67
2	93.33	100.00	6.67	1.00
3	80.00	86.67	6.67	0.33
4	86.67	100.00	13.33	1.00
5	66.67	100.00	33.33	1.00
6	73.33	100.00	26.67	1.00
7	80.00	86.67	6.67	0.33
8	73.33	100.00	26.67	1.00
9	86.67	100.00	13.33	1.00
10	73.33	93.33	20.00	0.75
11	80.00	93.33	13.33	0.67
12	60.00	86.67	26.67	0.67
13	80.00	100.00	20.00	1.00
14	80.00	100.00	20.00	1.00
15	73.33	100.00	26.67	1.00
16	93.33	100.00	6.67	1.00
17	86.67	100.00	13.33	1.00
18	80.00	86.67	6.67	0.33
19	60.00	86.67	26.67	0.67
20	80.00	86.67	6.67	0.33
Mean of Experiment Class	77.33	94.67	17.33	0.76
Standard Deviation	9.75	6.18	8.79	0.26

Table 15 - Student learning outcomes in the control class

Student	Control Class Score		Gain	N-Gain
	Pre-test	Post-test		
1	53.33	93.33	40.00	0.86
2	53.33	80.00	26.67	0.57
3	53.33	80.00	26.67	0.57
4	53.33	93.33	40.00	0.86
5	86.67	93.33	6.67	0.50
6	86.67	93.33	6.67	0.50
7	66.67	93.33	26.67	0.80
8	60.00	80.00	20.00	0.50
9	73.33	93.33	20.00	0.75
10	80.00	86.67	6.67	0.33
11	80.00	93.33	13.33	0.67
12	66.67	80.00	13.33	0.40

13	60.00	93.33	33.33	0.83
14	86.67	93.33	6.67	0.50
15	73.33	93.33	20.00	0.75
16	80.00	86.67	6.67	0.33
17	60.00	80.00	20.00	0.50
18	60.00	80.00	20.00	0.50
19	80.00	93.33	13.33	0.67
20	80.00	86.67	6.67	0.33
Mean of Control Class	69.67	88.33	18.67	0.62
Standard Deviation	12.01	5.92	10.67	0.17

Based on Tables 14 and 15, detailed data relating to the number of respondents, the highest score, the lowest score, the ideal value, and the minimum score are summarized in Table 16.

Table 16 - Detail data regarding respondents, highest, lowest, ideal, and minimum scores

Data Type	Pre-test Experiment Group	Post-test Experiment Group	Pre-test Control Group	Post-Test Control Group
Respondent	20	20	20	20
Highest score	93.33	100.0	86.67	93.33
Lowest score	60.00	86.67	53.33	80.00
Ideal score	100.0	100.0	100.0	100.00
Minimum score	70.0	70.0	70.0	70.00
Average score	77.33	94.67	69.67	88.33
Standard Deviation	9.75	6.18	12.01	5.92

The data in Table 16 shows that the minimum score that must be achieved by students is 70. Based on the results of the experimental class pre-test, 4 students have scores below the minimum score. After taking part in the study using the experimental learning method, none of the students had a post-test score below the minimum score. Meanwhile, 10 students had a pre-test score below the minimum score in the control class. After participating in learning using conventional methods, all students have post-test scores above the minimum score. If we look at these results, there is no significant difference between the two learning methods used. However, the lowest pre-test score in the experimental class was 60.00 and the highest pre-test score was 93.33. Then, the lowest post-test score in the experimental class was 86.67 and the highest post-test score was 100.00. In the control class, the lowest pre-test score was 53.33 and the highest pre-test score was 86.67. Then, the lowest post-test score in the control class was 80.00 and the highest post-test score was 93.33. In addition, the average pre-test and post-test scores for the experimental class were 77.33 and 94.67 while the average pre-test and post-test scores for the control class were 69.67 and 88.33. These results indicate that the experimental class students have a higher increase in learning outcomes than the control class students. Student demographic data shows that the control class has more students with a high IQ score range than the experimental class hence they are generally responsive in listening to learning and get high learning outcomes. Therefore, the increase in higher learning outcomes in the experimental class cannot be separated from the use of experimental demonstration methods in learning. Although the cognitive abilities of the experimental class students were slightly lower than the control class students, the experimental demonstration method applied in learning was able to improve their learning outcomes and increase their understanding of the concept of making and applying the ionic liquid.

The next descriptive analysis is to calculate the average increase in student test results using the gain value. Gain data can be used as data to find out the improvement of student learning outcomes. Student learning outcomes are said to increase if there is a positive change before and after learning (positive gain). Both of experiment class and control class have positive gain values. After knowing the gain value of each class, the normalized gain analysis (N-Gain) can be done. This analysis is used to determine the gain criteria obtained. The gain is obtained from the pre-test and post-test score data, which is then processed to calculate the normalized average gain (Hake, 1998). Based on Table 14, the N-gain value of the experimental class is 0.76 and is included in the high category. While the N-gain value for the control class in Table 15 is 0.62 and is included in the medium category. This means that the N-gain value of the experimental class is greater than that of the control class. Therefore, the experimental demonstration method applied in learning is more effective in learning. The results of the N-gain value also showed an increase in learning outcomes using the experimental demonstration method which was relatively high. This means that students' knowledge of sustainability literacy that is embedded in learning also increases, therefore, this learning method can be used to increase students' understanding of sustainability literacy.

After conducting descriptive analysis, the next analysis is statistical analysis. The statistical analysis selected is paired sample *t*-test. Paired sample *t*-test is used to analyse the improvement of student learning outcomes through the mean difference between the pre-test and post-test. Before the paired sample *t*-test was performed, the normality test must be carried out first as a condition of whether the data obtained can be analysed by t-test (Afifah, Mudzakir, & Nandiyanto., 2022). The results of the normality test using the skewness test are in Table 17.

Table 17 - The statistic skewness normality test result

Class	Statistic of Skewness	Std. Error of Skewness
Pre-test Experiment Class	-0.369	0.512
Post-test Experiment Class	-0.440	0.512
Pre-test Control Class	-0.023	0.512
Post-test Control Class	-0.553	0.512

The skewness test results show that the skewness ratio of the experimental class for pre-test data is -0.72 and the experimental class's post-test data skewness ratio is -0.86. Meanwhile, the skewness ratio of the control class's pre-test data is -0.045 and the control class's post-test data skewness ratio is -1.08. The four data have a skewness ratio between -2.00 and 2.00. This means that the pre-test and post-test data of the experimental class and the control class are normally distributed. The results of the normality test showed that the sample data obtained showed conformity with the normal distribution because it had great statistical values. Therefore, the requirements to perform a paired sample *t*-test are met. Paired samples *t*-test was conducted by comparing the mean values of the pre-test and post-test. Table 18 shows paired sample *t*-test results.

Table 18 - Paired sample t-test result

Pair	Mean (*M*)	Std. Deviation (*SD*)	Difference of Mean	t	df	Sig (2-tailed) (*p*)
Pre-test Experiment	77.33	10.00	-17.33	-8.592	19	5.709×10^{-8}
Post-test Experiment	94.67	6.34				
Pre-test Control	64.99	17.01	-23.33	-6.596	19	3×10^{-6}
Post-test Control	88.33	6.06				

The results of the pre-test and post-test of experimental class students were used to compare student learning outcomes before and after participating in learning using the experimental demonstration method. On average, student learning outcomes before participating in the lesson were lower ($M = 77.33$, $SD = 10.00$) than after participating in the lesson ($M = 94.67$, $SD = 6.34$). This improvement, 17.33, was statistically significant, $t(19) = 8.592$, $p < 5.709 \times 10^{-8}$. Meanwhile, the results of the pre-test and post-test of control class students were used to compare student learning outcomes before and after participating in learning using conventional methods. On average, student learning outcomes before taking lessons were lower ($M = 64.99$, $SD = 17.01$) than after taking lessons ($M = 88.33$, $SD = 6.06$). This improvement, 23.33, was statistically significant, $t(19) = 6.596$, $p < 3 \times 10^{-6}$.

If the values of *t* and *df* are known, then a decision can be made by comparing the value of the *t* statistic with the *t* table. The basis for decision-making is that if the *t*-statistical value is greater than the *t*-table value, then H_0 is rejected (no significant difference) and H_a is accepted (there is a significant difference), and vice versa. The statistical *t*-value of the experiment class is 8.592 and for the control, class is 6.596. While the *t* table value is 2.903, which is known through the *t* distribution table with a value of *df* the 19. This shows that there is a difference in the average student learning outcomes in the experimental class and the control class. This means that the two learning methods used have a significant influence on student learning outcomes. However, learning using the experimental demonstration method has a more significant effect than the conventional method because the *t*-value of the experimental class is greater than the *t*-value of the control class.

In addition to the *t*-value, significance can also be determined from the significant value or *p*-value in the table. The basis for decision-making determines that if the significance (Sig. (2-tailed)) is less than 0.05, the hypothesis of H_0 (no relationship between two paired groups) is rejected and H_a (there is a relationship between two paired groups) is accepted. The results of the paired sample t-test showed the significant value of the experimental class was 5.709 x 10^{-8} and the significance value of the control class was 3 x 10^{-6}. This means that H_0 was rejected and H_a was accepted. Therefore, these results also show that the two learning methods used have a significant effect on student learning outcomes and the experimental learning method has a more significant effect because the experimental class has a smaller significance value than the control class.

Table 19 shows the results of the independent sample t-test. An Independent sample t-test was conducted by analysing the post-test results of the experimental class and control class students. This test is carried out to determine the learning method with a more significant effect and proves the results in Table 18. The results show the significance value (2-tailed) of the independent sample T-test is < 0.05. It means there is a significant difference between the post-test results of the experimental class students and the control class, and the experimental demonstration method is better than the conventional method.

Table 19 - Independent sample t-test results

	Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of The Difference	
Results	**F**	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**Lower**	**Upper**
Equal Variances with "Assumption"	0.301	0.587	3.228	38	0.003	6.33550	1.96260	2.36242	10.30858
Equal Variances with "no Assumption"			3.228	37.926	0.003	6.33550	1.96260	2.36216	10.30884

The conventional method applied in learning is teacher-centered based learning. The teacher gives a theoretical explanation and students listen to the teacher's explanation or also known as one-way learning. As the teacher holds the ultimate authority, the students do not collaborate. The content is decided and the teacher structures the learning tasks. Teachers who are dedicated to teacher-centeredness prefer textbook-dominated instruction. It should be borne in mind that textbook-dominated pedagogy limits students' problem-solving and decision-making skills (Serin, 2018). If this learning is applied in distance learning, students' learning motivation will decrease and students will find it difficult to focus on understanding knowledge (Mascolo, 2009). Learning using the experimental demonstration learning method is quite effective to be applied in distance learning. By using this method, each stage in the experimental process can be explained in more detail even though students are not directly involved in the experiment. This method also helps students relate the experiments carried out to the science concepts being taught. Therefore, the concept of science becomes more relatable to the surrounding environment for students and they will more easily understand the concept. The results of the descriptive analysis showed that students who took part in the learning using the experimental demonstration method had a higher average post-test score, which was 94.67. The results of the N-gain analysis also showed an increase in learning outcomes using the experimental demonstration method which was relatively high. In addition, the results of the paired sample t-test state that the use of experimental learning methods is more significant in improving student learning outcomes. Student learning outcomes are closely related to students' understanding of the concepts being taught. This shows that the experimental demonstration method applied helps students understand the concepts of making ionic liquids and their applications. This concept was initially a foreign concept to students because it generally did not exist in science learning. This concept is one example of the development of science concepts that they have learned. This method helps students relate new concepts about ionic liquids with industrial science concepts that they have learned. Thus, student's understanding of concepts increases after learning (Nandiyanto, Raziqi, Dallyono, & Sumardi, 2020).

Experimental demonstration learning that is applied through learning videos can explain the concept of making and applying ionic liquids well to students. The process of making ionic liquids and their applications can be presented interestingly so that students focus more on understanding and implementing the manufacturing process in vocational training. This is following the research of Maryanti, Hufad, Tukimin, Nandiyanto, & Manullang (2020) and Widodo, Hufad, & Nandiyanto (2020) which explains that the experimental demonstration method can increase student focus on learning. In addition, an experimental demonstration was carried out using commercially available materials so that it made students more attracted because made students want to try it themselves.

Learning videos containing the concept of making ionic liquids and their applications are effective learning media used in learning using experimental learning and distance learning methods. Students cannot be directly involved in experiments if they do distance learning so learning by using this learning video will help them to give a real picture of the experimental process without having to experiment itself. The instructional videos provide an interesting display and help explain the process of making ionic liquids more clearly. In addition, students can repeat the video continuously if they do not understand the lesson and the material presented applies to the industrial world (Kusuma, Sudira, Hasibuan, & Daryono, 2021). Learning videos are also easily accessible by students, making it easier for them to distance learning (Kusuma, Sudira, Hasibuan, & Daryono, 2021).

The concept of making ionic liquid and its application is one of the concepts that can be used to instil sustainability literacy in students. Learning using this concept can provide students with new knowledge and skills to build a sustainable future. Ionic liquids used in learning use environmentally friendly materials and are an alternative solvent in industry. In addition, ionic liquids can be applied to overcome deficiencies in bamboo, which is an example of a sustainable material that has not been fully utilized. The results of the analysis show that the experimental demonstration method of utilizing learning videos can improve students' focus, students' understanding, and make them interested in learning this concept. Therefore, learning using an experimental demonstration method by utilizing learning videos can be alternative learning to introduce sustainability literacy to students. However, this study only uses questions with a low level of thinking so that students only get a basic understanding of sustainability literacy. Therefore, it is necessary to do further research using questions that can hone higher-order thinking skills (HOTS) in students so that students can apply sustainability literacy well.

5. Conclusion

Based on the research that has been done, distance learning using an experimental demonstration method through videos of making ionic liquids and their applications can be alternative learning to instil sustainability literacy in students because learning uses sustainable materials and ionic liquids that can be used as alternative solvents in industry.

The results of the analysis show that the experimental demonstration method applied can improve student learning outcomes and significantly affect the increase. This also affects the understanding of concepts in students. As many as 80% of students can answer the concept correctly after participating in learning using the experimental demonstration method. It means that the experimental demonstration method can improve students' understanding of concepts in learning and make students more attracted because they want to try experiments on their own. The benefit of using video on making ionic liquid and its applications is to help students to give a real condition of the experimental process without having to experiment itself. The learning video provides an interesting display and helps explain the process of making ionic liquids more clearly. In addition, students can repeat the video continuously if they do not understand the lesson and the material presented applies to the industrial world.

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References

Afifah, S., Mudzakir, A., & Nandiyanto, A. B. D. (2022). How to calculate paired sample t-test using SPSS software: from step-by-step processing for users to the practical examples in the analysis of the effect of application anti-fire bamboo teaching materials on student learning outcomes. *Indonesian Journal of Teaching in Science*, 2(1), 81-92.

Anggraeni, S., Maulida, R., Ragadhita, R., Hofifah, S. N., & Nandiyanto, A. B. D. (2020). Teaching the effect of liming concentration on mechanical characteristics of cowhide crackers for senior high school students. *Journal of Engineering Education Transformations*, 34(Special Issues), 108-114.

Bima, M., Saputro, H., & Efendy, A. (2021). Virtual laboratory to support practical learning of micro power generation in Indonesian vocational high schools. *Open Engineering*, 11(1), 508-518.

Décamps, A., Barbat, G., Carteron, J.-C., Hands, V., & Parkes, C. (2017). Sulitest: A collaborative initiative to support and assess sustainability literacy in higher education. *The International J. of Management Education*, 15(2), 138–152.

H. Davis, Jr., J. (2004). Task-specific ionic liquids. *Chemistry Letters*, 33(9), 1072–1077.

Hake, R. R. (1998). Interactive engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66(1), 64–74.

Hagiwara, R., & Ito, Y. (2000). Room temperature ionic liquids of alkyl imidazolium cations and fluoro anions. *Journal of Fluorine Chemistry*, 105(7), 221-227.

Jabarullah, N. H., & Iqbal Hussain, H. (2019). The effectiveness of problem-based learning in technical and vocational education in Malaysia. *Education + Training*, 61(5), 552–567.

Kamis, A., Alwi, A., Ismail, B. L. H., & Yunus, F. A. N. (2017). Integration of green skills in sustainable development in technical and vocational education. *Journal of Engineering Research and Application*, 7(12), 8-12.

Krisanti, E. A., Saputra, K., Arif, M. M., & Mulia, K. (2019). Formulation and characterization of betaine-based deep eutectic solvent for extraction of phenolic compound from spent coffee grounds. *AIP Conference Proceedings*, 2175(1), 20-40.

Kusuma, W. M., Sudira, P., Hasibuan, M. A., & Daryono, R. W. (2021). The perceptions of vocational school students of video animation-based learning media to operate lathes in distance learning. *J. of Education Technology*, 5(2), 200-206.

Lee, C.-J., & Hsu, Y. (2021). Sustainable education using augmented reality in vocational certification courses. *Sustainability*, 13(11), 34-64.

Li, G., Xie, Q., Liu, Q., Liu, J., Wan, C., Liang, D., & Zhang, H. (2020). Separation of phenolic compounds from oil mixtures by betaine-based deep eutectic solvents. *Asia-Pacific Journal of Chemical Engineering*, 15(6), 1-10.

Liu, Y., Jiang, Z., Miao, J., Yu, Y., & Zhang, L. (2017). Properties of flame-retardant cellulose fibres with ionic liquid. Fibres *and Polymers*, 18(5), 915–921.

Maryanti, R., Hufad, A., Tukimin, S., Nandiyanto, A. B. D., & Manullang, T. I. B. (2020). The importance of teaching viscosity using experimental demonstration from daily products on the learning process, especially for students with special needs. *Journal of Engineering Science and Technology*, 6(Special Issue), 19-29.

Nandiyanto, A. B. D., Raziqi, G. Y., Dallyono, R., & Sumardi, K. (2020). Experimental demonstration for enhancing vocational students' comprehension on heat transfer through conduction and radiation of light bulb. *Journal of Technical Education and Training*, 12(3), 189-195.

Neyses, B., Rautkari, L., Yamamoto, A., & Sandberg, D. (2017). Pre-treatment with sodium silicate, sodium hydroxide, ionic liquids or methacrylate resin to reduce the set recovery and increase the hardness of surface-densified Scots pine. *IForest - Biogeosciences and Forestry*, 10(5), 857-864.

Patel, P., & Patel, A. (2021). Use of sustainable green materials in the construction of green buildings for sustainable development. *IOP Conference Series: Earth and Environmental Science*, 785(1), 012009.

Roessler, A., & Schottenberger, H. (2014). Antistatic coatings for wood floorings by imidazolium salt-based ionic liquids. *Progress in Organic Coatings*, 77(3), 579–582.

Toma, Š., Gotov, B., Kmentová, I., & Solčániová, E. (2000). Enantioselective allylic substitution catalyzed by Pd0–ferrocenylphosphine complexes in [bmim][PF6] ionic liquid. *Green Chemistry*, 2(4), 149–151.

Wang, Y., Xie, T., Zhang, J., Dang, B., & Li, Y. (2022). Green fabrication of an ionic liquid-activated lignocellulose flame-retardant composite. *Industrial Crops and Products*, 178 (Special Issue), 114602.

Widodo, A. P. A., Hufad, A., & Nandiyanto, A. B. D. (2020). Collaborative teaching in heat transfer for slow learner students. *Journal of Engineering Science and Technology*, 1(Special Issue), 11-21.

Yadav, M., & Mathur, A. (2021). Bamboo as a sustainable material in the construction industry: An overview. *Materials Today: Proceedings*, 43, 2872-2876.

Yokokawa, M., Miyafuji, H., Murakami, Y., Shouho, S., & Yamaguchi, A. (2019). Comparative study on the fire resistance of wood treated with various ionic liquids. *Journal of the Society of Materials Science*, *Japan*, 68(9), 712–717.

Yulianti, I., Hamidah, I., Komaro, M., Mudzakir, A., & Alias, M. (2021). Web-based ionic liquids learning media to measure the competence of the polytechnic student. *Journal of Technology and Science Education*, 11(2), 284-294.

Xiao, F., Wu, K., Luo, F., Guo, Y., Zhang, S., Du, X., Zhu, Q., & Lu, M. (2017). An efficient phosphonate-based ionic liquid on flame retardancy and mechanical property of epoxy resin. *Journal of Materials Science*, 52(24), 13992-14003.

Yusuf, Q., Yusuf, Y. Q., & Nadya, A. (2017). Skimming and scanning techniques to assist EFL students in understanding English reading texts. *Indonesian Research Journal in Education*. 1(1), 43-57.

Zhang, W., Wu, H., Meng, W., Zhang, M., Xie, W., Bian, G., & Qu, H. (2019). Synthesis of activated carbon and different types of phosphomolybdate ionic liquid composites for flame retardancy of poly(vinyl chloride). *Materials Research Express*, 6(7), 75-303.