JPPS (Jurnal Penelitian Pendidikan Sains)
Homepage : https://journal.unesa.ac.id/index.php/jpps
Email : jpps@unesa.ac.id

p-ISSN : 2089-1776 ; e-ISSN : 2549-1597
JPPS, Vol. 11, No. 1, November 2021 : 27-39

The 21st Century Skills on Chemistry Learning Based on Virtual Lab in Senior High School

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DOI : https://doi.org/10.26740/jpps.v11n1.p27-39

Sections Info

Article history:
Submitted: May 31, 2021
Accepted: November 20, 2021
Published: November 30, 2021

Keywords:
21st century skills
Chemistry learning
Senior high school
Virtual lab

ABSTRACT

Research aims to review 21st century skills in-based senior high school chemistry learning virtual labs. The components that will be studied include: (1) Barriers to high school chemistry learning; (2) 21st century skills; (3) The advantages and disadvantages of using virtual labs; and (4)implications of virtual labs on 21st century skills. The method used in writing the article is descriptive, qualitative by analyzing national and international articles related to 21st century skills in-based high school chemistry learning virtual labs. The results show that high school chemistry learning uses virtual The lab can integrate 21st century skills, visualize abstract concepts into concrete, support student-centered learning, reduce anxiety in facing real laboratories, and increase students' self-efficacy so that they can become a capable supporting unit for the chemistry learning process. However, in its implementation it needs to be adapted to content and activities that refer to various aspects of 21st century skills.

INTRODUCTION

The 21st century skills are important skills that must be mastered by everyone in order to face the challenges, problems, life, and careers of the 21st century. The 21st century skills are skills that include aspects of critical, creative and innovative thinking, communication, and collaboration. Education is an effective pathway to grow human resources capable of mastering 21st century skills, because 21st century skills are acquired based on student experience (Redhana, 2019). Therefore, teachers as educators have an obligation to coordinate learning with 21st century skills in order to teach all aspects of these skills (Alismail & McGuire, 2015).

Mardhiyah et al. (2021) believe that the 21st century is a century where technology, information and communication need to be used in everyday life, one of which is in the field of education. In the field of education, learning in the 21st century is very important to grow quality, superior, and competitive human resources. Not only that, learning that imparts knowledge and skills in the 21st century is also an important part of improving human resources. Therefore, learning skills are very important for developing the 21st century, because developing technology and information requires everyone to have skills that can be used in life in the 21st century. The 21st century people who can think critically, collaborate, create and innovate, and who can communicate. Since mid-2013, Indonesia has used the Curriculum 2013 as a substitute for the Education Unit Level Curriculum (i.e. KTSP). The learning process using the Curriculum 2013 focuses more on student learning activities. In addition, the Curriculum 2013 provides an opportunity for teachers to conduct evaluations based on basic competencies and characteristics of learning materials.

In the learning process based on the Curriculum 2013, teachers are required to adopt a scientific approach. According to Setiawan (2019), the scientific approach includes several stages of related activities, namely observing, asking questions, gathering information, conducting experiments, processing data, and communicating results. Besides, Andrian & Rusman (2019) revealed that in the 21st century, education is very important to ensure students have the skills to learn and innovate, use technology and information media, and work and survive through using life skills. In this era of globalization, various abilities needed by students are called 21st century skills. In order to achieve this goal, the government has worked hard to implement the Curriculum 2013 at the elementary to middle school levels and has made various improvements. The Curriculum 2013 contains 21st century skills, both in content standards, processes, and assessments. However, the facts on the ground show that most of the learning is still teacher-centered. As a result, students cannot master 21st century skills well (Redhana, 2019).

In view of these problems, Trilling and Fadel emphasize that to grow active students who can meet global social challenges, the 21st century future skills are needed to be able to innovate to solve complex problems and use the power of technology to make the world a better place (Alismail & McGuire, 2015). Wiggins and McTighe show that by combining key academic content and the necessary future skills, students can have a better future (Alismail & McGuire, 2015). Implementing 21st century curriculum and teaching is critical to developing learners with the basic skills that will help them to succeed in the future. Therefore, the renewal of learning that can change teacher-oriented learning into student-oriented learning is a response to efforts to develop students' abilities in the 21st century.

Chemistry is one of the subjects at the high school/equivalent level that is able to interpret 21st century skills. in classroom learning. Chemistry is the study of the composition, structure, properties, changes, and energies associated with them. Chemistry studies natural phenomena which are then compiled into various concepts, theories, and laws. In explaining various phenomena that occur in nature, chemistry involves three levels, namely macroscopic, microscopic, and symbolic. Chemistry with these characteristics is an excellent subject for developing the skills of students in the 21st century (Redhana, 2019). So far, students have looked at chemistry as a difficult subject because of its characteristics that are full of mathematical terms; the use of specific language, the material is natural and abstract, and hierarchical (Munandar & Jofrishal, 2016). These characteristics make chemistry a difficult discipline compared to other disciplines. Some conceptual and abstract chemistry materials include atomic structures, periodic systems of elements, chemical bonds, electrolyte and non-electrolyte solutions, reduction and oxidation (redox) reactions, stoichiometry, and hydrocarbons (Dwiningsih et al., 2018). Based on these facts, teachers must be able to visualize abstract concepts into concrete ones so as to make it easier for students to understand chemical concepts as well as develop the 21st century skills in learning, where this is used as a means of supporting education. Without systematic planning and effort, this simplification of concepts and developing skills cannot be achieved. The development must be carried out consciously through a targeted design (Redhana, 2019).

In order to simplify abstract and tiered concepts and make it easier for students to understand them, it is necessary to have a planned activity in the form of a practicum

carried out in the laboratory. As stated by Lutfi & Hidayah (2019), building concepts is not the only goal of practicum activities, but also aims to develop science process skills which are reflected in their activities. The laboratory plays an important role in learning chemistry. Through practical activities in the laboratory, students are trained and given various skills such as observation, classification, measuring and calculating, communicating, interpreting data, and drawing conclusions. Practical activities are expected to make chemistry learning more interesting, fun, and meaningful.

The existence of laboratories in schools is important to support chemistry learning, because there are some chemistry materials that are easier to understand by observing and experimenting. Government Regulation Number 32 of 2013 concerning Amendments to PP Number 19 of 2005 concerning National Education Standards, explains that every education unit must have an infrastructure that can support an orderly and continuous learning process, one of which is a laboratory. Unfortunately, for several reasons, teachers rarely do practical activities. Lutfi & Hidayah (2019) stated that practicum activities are rarely carried out in chemistry learning in schools due to many obstacles such as lack of facilities, relatively high costs, limited duration of study time, and difficulties in preparing practicums. Another reason is the limited space, tools, and materials for the practicum, as well as some teachers who do not know how to work in the laboratory. The practicum activities carried out so far are only for students to carry out activities according to the instructions or work procedures contained in the practicum guide book. Often work procedures that are too detailed will result in students being less motivated to design an experiment and a lack of ability to solve the problems they face. This can cause students to become passive and their creative thinking skills are not honed properly.

To overcome this problem, innovations have emerged that take advantage of current technological developments so as to minimize the availability of materials, tools, places and funds, namely in the form of virtual laboratory media (virtual lab). In line with this, Sugiharti et al. (2019) added chemistry is easy to understand, where chemistry as a process is defined as every scientific step that aims to increase knowledge and acquire knowledge new. The chemistry learning process focuses on students' direct experience in developing skills so that they can research and understand the surrounding environment scientifically. Gaining experience in applying this scientific method can be through experimentation. This experiment can be in the form of testing hypotheses by assembling equipment, designing experiments, receiving, processing, and interpreting data, and presenting experimental results both orally and in writing. The limitations of tools and materials class chemical can be overcome by using a virtual lab.

Virtual labs can be used to gain conceptual knowledge and develop science process skills (Hardiatun, 2019). A virtual lab is a computer-based media that contains simulations of activities in the chemistry laboratory. A virtual lab is an experiment that shows reactions that cannot be seen in real conditions (Totiana et al., 2012). A virtual lab is also known as a multimedia object that contains interactive activities in the form of text, hypertext, sound, images, animation, video, and graphics. Learning Virtual labs are more efficient because the execution of virtual learning management is faster than learning in a real laboratory, equipped with interactive digital forms with implicit or explicit learning objectives (Hardiatun, 2019). The virtual lab is made more flexible and helps in learning chemistry; it also fulfills the lack of facilities in the chemistry laboratory. Virtual labs can be used in distance learning because it can be used at any

time and place. Another advantage is that students can conduct experiments without hesitation and fear of work accidents (Ali et al., 2014). Virtual labs can be used as an alternative to motivate the learning process and train students in problem solving and critical thinking in learning or solving problems in everyday life (Hermansyah et al., 2015).

Students have different learning styles and the best learning media that can be used is media virtual reality, because it can integrate all aspects of the learning process and increase the efficiency, effectiveness, and motivation of students' learning (Wulandari & Vebrianto, 2017). Virtual reality is a component of multimedia computers that will become a new teaching trend and learning strategy for future learning systems. The presence of a virtual lab aims to increase students' motivation, understanding of concepts, and learning outcomes. In addition, the most important thing is to train 21st century skills as well as students' science process skills. Based on the explanation above, this article will review 21st century skills in-based senior high school chemistry learning virtual lab that is oriented to improving students' 21st century skills.

RESEARCH METHOD

The method used in this article is a descriptive qualitative method. Data collection adopted a research method in the form of literature studies (Wulandari & Vebrianto, 2017). This research data source was reviewed by 35 articles from various national and international scientific articles related to 21st century skills-based high school chemistry learning virtual labs. The initial stage of this research is to read data sources related to the topic of discussion, then analyze the contents of data sources related to 21st century skills in-based high school chemistry learning. virtual labs. After doing the analysis, then concluded the results of the analysis. This method aims so that articles can provide relevant information based on data sources and clear describe 21st century skills in-based high school chemistry learning virtual lab. The research procedure can be described as Figure 1.

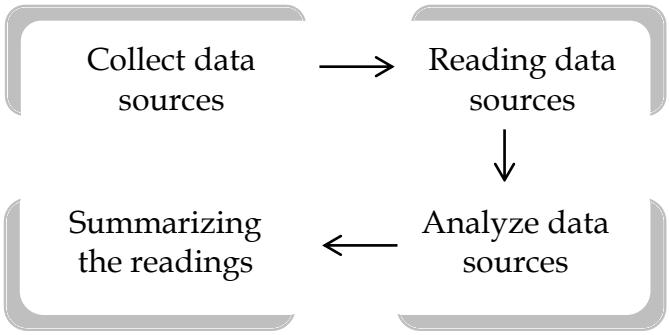

Figure 1. Research procedure.

RESULTS AND DISCUSSION

The learning outcomes of students from the learning process in the classroom using the lecture, discussion, question and answer method, and other practical methods are not considered ideal. The teacher's participation in the enthusiasm of students' learning is very large. Various new breakthroughs made by teachers in teaching methods can increase student motivation, especially if they follow trends. Therefore, the use of technological advances is believed to be able to stimulate students' comprehension and

understanding of chemistry. Chemistry cannot be done by theoretical study alone. Many chemistry topics are abstract, so it is necessary to do field work or practicums to hone thinking while increasing the enthusiasm of students in studying chemistry. This is in line with the opinion of Bortnik et al. (2017) which states that chemistry is a scientific discipline that is closely related to practicum activities in learning to enable meaningful learning experiences.

The laboratory is a place used for practicum and research. As a school support unit, the laboratory plays an important role in achieving educational goals. Supporting it, Zaturrahmi et al. (2020) stated that the laboratory owned by the school is a place where students learn to find problem solving; the right place to conduct experiments, exercises, demonstrations, or other methods; where students prove the truth, facts, principles, theories, and concepts; where students get the opportunity to work with certain tools and materials, collaborate with friends, and find satisfaction with the results obtained; as well as being a place to cultivate good habits and useful skills.

In line with the times, laboratories are divided into real laboratories (real) and virtual laboratories (virtual lab). Hermansyah et al. (2015) suggested that a virtual laboratory (virtual lab) is a computer-based media that contains simulations of laboratory activities. The purpose of the virtual lab is to visualize abstract concepts as more concrete images to describe reactions that may not be seen in real terms, thus making the teaching and assessment process of students easier and more meaningful. Bortnik et al. (2017) stated that the virtual lab is a pre-physical laboratory training tool that is efficient and able to provide opportunities for students to develop skills when practicing directly. Using virtual labs is quite popular and is the best alternative when distance learning and the impossibility of conducting chemistry experiments directly, both due to lack of facilities in the form of equipment, security measures, and time constraints. In addition, Redhana (2019) states that a constructivist learning environment with a laboratory using a virtual lab is able to make students active in a student-oriented learning process.

Bele & Made (2018) believe that increasing students' understanding of-based learning virtual lab and 21st century skills is in line with their view, namely the importance of 21st century skills for development in accordance with the National Education Association (NEA) recommendation, namely 4C skills. These skills mean four points, namely (1) Critical thinking and problem solving skills including effective debate, systematic thinking, defense and decision making, and problem solving skills; (2) Communication skills (communication), is able to effectively express ideas and concepts in a variety of forms, listening skills (listening skills), is able to use the equipment to communicate effectively and functional, and able to communicate with various groups, goals, and cultural background; (3) Skills to work together (collaboration), work effectively and flexibly in a team, willing to give leeway to achieve common goals, and able to share responsibilities and appreciate the contribution of team members; (4) Creative and innovative skills (creativity and innovation), refers to the ability to think innovatively, work creatively with others, and apply various innovative ideas.

Via virtual in the lab, students will not only master the concepts of chemistry well, but also their 21st century skills will also improve. Through-a virtual learning lab, students can communicate, think critically, be creative and innovative, collaborate and work together in a team, and work together in groups. The ability of students to find

learning resources, ask questions and formulate a problem, conduct analysis, and work together and collaborate in solving the problems they face is the current 21st century learning paradigm (Hardiatun, 2019). This was also added by Surbakti & Supartono (2016) that technology-based learning can foster character values in students.

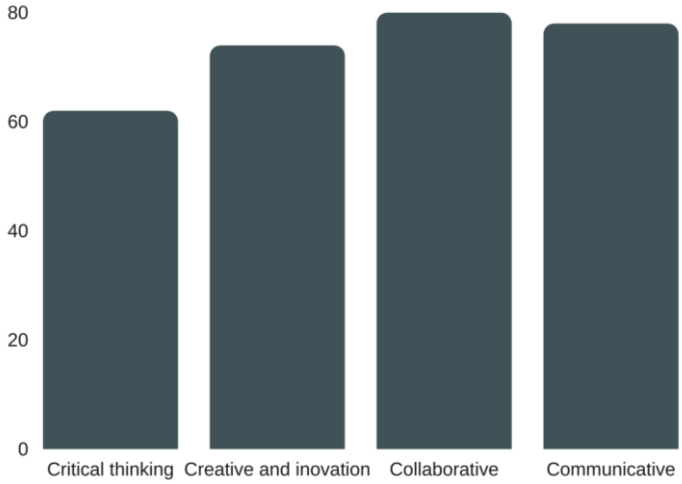

Figure 2. The average results of 21st century skills of students (Hardiatun, 2019).

According to the results of research conducted by Hardiatun (2019) related to applying learning virtual lab to improve students' mastery of 21st century concepts and skills in macromolecular chemistry subjects at State Senior High School 1 Tuban, students' 21st century skills on average are in the moderate to good range. The average 21st century skills analysis results obtained in this study are an average of 62 which is considered sufficient for critical thinking indicators, an average of 74 or classified as good for innovative indicators, an average value of 80 or good for collaborative indicators, and average -average 78 or good for communicative indicators. This proves that learning through virtual labs allows students to play an active role in learning. Students can critically and creatively find and express their own ideas through cooperation and collaboration. Furthermore, research conducted by Ekasari et al. (2016) showed that the value of linguistic and graphic creativity of participants before and after the test in the experimental class using the virtual lab was much higher than the control class, so it can be said that applying the-assisted direct learning model virtual lab had a positive effect on students's creativity.

Another study was carried out by Lutfi & Hidayah (2019) through an experimental method in order to train students' scientific process skills using a virtual lab in the learning of acids, bases, and salts. As a result, student activities during the learning process are included in the good category. During the learning process, students participate in learning according to the plan, students can learn through virtual labs; students are enthusiastic and enthusiastic in learning, and the desire to ask questions and find data during the learning process begins. Regarding the ability of science process skills, the highest aspect obtained is in measuring, followed by observation, inference, classification, and drawing conclusions. Theresults post-test show the realization of classical mastery, meaning that the use of a virtual lab for learning acids, bases, and salts can improve students' understanding of scientific process skills. The results of interviews with students also prove this, where respondents say that learning using a virtual lab makes it easier for students to understand acids, bases, and salts. The results of student responses showed positive results were as many as 87.5-100%

responded positively to each statement in the questionnaire. This shows that students feel helped by the virtual lab in the learning of acids, bases, and salts. Students believe that learning activities carried out through virtual labs can make it easier for them to understand the material being taught, provide enthusiasm for learning chemistry, and make it easier for them to learn the tools used in chemical experiments. Students assume that learning using a virtual lab is easy, fun, more interesting, and most of the participants understand it better, as evidenced by the learning outcomes obtained after learning are in a good range. According to Jaya (2012) virtual labs help activities in the laboratory to be interactive, dynamic, animated, and have a virtual environment so that it is fun and can bring the user's desire to learn and understand productive subject matter.

Furthermore, Alneyadi (2019) gave questions to teachers in order to explore how science teachers in the United Arab Emirates view the goals and reasons for conducting practical activities using a virtual lab. The aim is classified into five core ideas and themes, including knowledge (knowledge), process and scientific skills (scientific skills), intellectual ability (intellectual skills), attitude (attitudes), and innovation (innovation). About knowledge (knowledge), more than half of the respondents agree that the use of virtual labs can improve students understanding of materials science. Regarding scientific skills, about 56% of respondents stated that the use of virtual labs can improve students' science skills. In the aspect of intellectual skills, about 60% of respondents said that the use of virtual labs can improve students' intellectual skills. Furthermore, in the aspect of attitudes (attitudes), approximately 60% of respondents said that the use of virtual lab can foster a positive attitude towards the activity of the lab, including growing interest of students in science and science learning, motivating the students to use science in life, and makes learning interesting, fun, and interactive. Lastly, in the aspect of innovation (innovation), approximately 65% of respondents said that the virtual lab is able to improve the skills and innovative capabilities of learners, encourage learners to become an inventor, helping learners find innovation and talent, and to promote originality and creativity in the workplace practice. It is more important to help students act based on innovative ideas so that they can make a real and useful contribution.

Further researching linkages virtual Lab with 21st century skills according to a study conducted by Zaturrahmi et al. (2020), there is influence virtual lab by 6.67% for critical thinking skills and 3.33% for communication skills, and shows that chemistry ranks second in the field of science that uses virtual lab with a presentation of 16.67%. Virtual labs have many advantages when used in practical activities, including being more useful for explaining abstract concepts, making the learning process more interesting, more interactive and flexible in the use of space and time, improving the quality of experiments, being more efficient, and increasing practical experience. problem solving, motivation, and understanding and learning outcomes. In addition, the use of virtual labs can increase work safety and security, mobility, as well as freedom and free and wide reach (Brinson, 2015; Chien et al., 2015; Ekmekci & Gulacar, 2015; Hermansyah et al., 2015; Potkonjak et al., 2016; Saleh et al., 2009). Added by Sari et al. (2019) that the presence of a virtual lab accompanied by demonstrations causes students to have an overview of the practicum that is carried out directly, the practicum in the virtual lab can be accessed again to increase understanding, and students can easily find out the materials used in the practicum which ultimately makes it easier for

them to understand the process of the practicum, so that from the results of the research the virtual lab contributes to critical thinking skills. This is in line with the opinion of Rokhim et al. (2020) that a virtual lab designed with an attractive appearance can have a positive effect on users where students become more enthusiastic; and that the virtual lab can be used as an alternative learning resource for students. The various advantages possessed by the virtual lab can be a support for student activities in independent learning as students can repeat the practicum as often as desired until they really understand, given that the speed or type of learning for each student is different. The virtual lab which is equipped with an evaluation from the teacher, can make it easier for the teacher to know the results of the students' understanding. Further, Kolil et al. (2020) in his article mentions that in facing a real laboratory many students experience high anxiety and low self-efficacy. Through data analysis, students who take part in virtual Labs assisted by increasing understanding with direct learning are proven to be able to increase students' experimental self-efficacy with a minimum gain of 88% and a maximum of 233%. Then Sugiharti et al. (2019) describes the learning outcomes of applying problem-based learning models combined with virtual lab is better than the direct learning model.

In addition to the advantages, the virtual lab also has limitations, including the use of a virtual lab which will lead to a lack of psychomotor aspect training, and the success of learning is highly dependent on the independence of students and the available facilities. If students do not understand how to use it, it will cause a negative response (Alneyadi, 2019; Valdehita et al., 2019). Not all practical activities have the potential to equip students with 21st century skills. Content and activities must be structured and designed with reference to all aspects of 21st century skills that require students to have abilities that should be possessed in life. Students must have five basic skills, namely the ability to think critically and solve problems (critical thinking and problem solving skills) which can be trained by giving assignments to students regarding the problems that students must face and it is necessary to find methods for solving them. Second, teachers can train creative and innovative aspects (creativity and innovative skills) by giving assignments to students related to problem solving, where students are given problems and they are required to provide alternative solutions (Malik et al., 2017). Third, training communication and collaborative skills (communication and collaborative skills) can be done through assignments such as conducting data analysis using multi-representatives, presenting the results of practicum activities in groups, or analyzing data from an experimental result by discussing and then proceeding with presenting the results. the discussion. Fourth, the literacy aspect of information and communication technology (information and communication technology literacy) has been integrated into learning in the laboratory, which makes learning not dependent on limited real laboratories. But can use virtual labs as learning media (Sujanem et al., 2019). Fifth, situational (learning skills, contextual learning skills) are applied in laboratory activities, where material that is real can use a real laboratory, while material that is abstract can use a virtual lab (Nanto et al., 2017).

Along with technological advances and the needs of students in the future, especially with the provision of scientific performance and character, the use of virtual labs can support achieving 21st century skills of students with the ability to present visualization forms of a series of laboratory equipment and other equipment as well as to simulate activities in the laboratory (Thees et al., 2020). The development of this

virtual lab needs to be followed up by advancing a greater number of applications so that various materials with other practical characteristics can be accommodated, where the effect will be to reduce the gap between the number of students and the number of existing laboratories (Manikowati & Iskandar, 2018).

In the research results of Nurrokhmah & Sunarto (2013) it is said that learning with a virtual lab makes learning activities more interesting and helps students become more enthusiastic and proactive in understanding the concepts taught by the teacher. This is reinforced by previous research conducted by Dwiningsih et al. (2018) that-based learning media are virtual labs are practical and efficient when applied in teaching and learning activities. This statement is based on the results of observations of student activities and responses. Based on the results of the study above, virtual lab-based high school chemistry learning allows students to develop 21st century skills of students to be better. It is because aspects of 21st century skills in the form of critical thinking and problem solving skills, communication, collaboration, as well as creativity and innovation are well trained in implementing-based chemistry learning. virtual labs. More, virtual labs coupled with hands-on learning have been shown to reduce anxiety about real laboratories and increase self-efficacy. Therefore, the consistency of-based chemistry learning virtual lab is expected to be able to produce students who are competent to the needs of the times.

CONCLUSION

Senior high school chemistry learning using media virtual labs able to integrate 21st century skills, visualize abstract concepts into concrete, support student-centered learning, reduce anxiety in facing real laboratories, and increase students' self-efficacy so that they can become a capable supporting unit for the chemistry learning process. The implementation of senior high school chemistry learning using a virtual lab has a positive impact as a support for learning activities because it is practical and efficient regarding space, cost, and time. However, the implementation needs to be adjusted to the content and activities that refer to various aspects of 21st century skills. As for the limitations of this article, the author only examines the results of previous studies so that the supporting data are very minimal. It is hoped that in the future there will be valid data that is able to describe the real relationship between 21st century skills and computer-based high school chemistry learning virtual labs.

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