Jurnal Pendidikan Sains Indonesia 11(1), p.191-205, (2023)
(Indonesian Journal of Science Education) e-ISSN: 2615-840X p-ISSN: 2338-4379
URL: http://jurnal.unsyiah.ac.id/JPSI/index DOI: doi.org/**10.24815/jpsi.v10i4.27984**

Development of Electronic Learning Chemistry Assessment Applications Through Project-Based Learning for Increasing Student Scientific Performance

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Article History:
Received date: September 6, 2022
Received in revised from: December 4, 2022
Accepted date: January 10, 2023
Available online: January 22, 2023

Citation:
Sari, R.P., Hasibuan, M.P., Oktaviani, C., & Nazar, M. 2023. Development of electronic learning chemistry assessment applications through project-based learning for increasing student scientific performance. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(1):191-205.

Abstract. Today the electronic learning has developed because in line with the demands of the that sorely on technology. Assessment is one of the important elements in instructional activities and to support e-learning appear the electronic assessment. This study aims to develop an electronic learning chemistry assesment (Element) digital application through project based learning (PjBL) on the concept of applied chemistry. The research method used is the research and development method. The research subjects for the product trial developed in this study were students of the class of 2019/2020 with a purposive sampling technique with a sample of 24 students. This research instrument uses a needs analysis questionnaire, expert validation before and after revision, student response and small-scale trials. The assessment component contained in the application consists of quiz assignments, practical, product, project and final. The validation results were analyzed using content validity ratio (CVR) analysis and each criterion was then calculated the content validity index (CVI) or average value. The results showed that the Element through PjBL on applied chemistry concepts had been validated by material and media experts with an average CVI of 0.9 or the very valid category. The results of the small-scale test of the electronic-virtual assessment for & of learning application for students obtained an average percentage of 93.9% with the criteria of "very interesting". Furthermore, the data on increasing students' scientific performance has increased by 0.70 with a high category and is strong effectively used to improve student scientific performance.
Keywords: Applied chemistry, project based learning, student scientific performance

Introduction

The development of technology that is so rapid at this time has a significant effect on the educational landscape. One of them is the use of learning technology which has developed in such a way as to answer today's demands. The use of technology in the learning process is considered more effective and efficient when collecting large data that can be accessed widely and one of them is assessment technology (Ana, et al., 2020). Assessment is an important element for the process of learning activities because

through assessment we are able to see the achievements both of teachers and students. At this time assessment using paper and pencil is considered outdated compared to the latest techniques in today's teaching method. To support e-learning technology, the term electronic assessment (e-assessment) emerged. The term e-assessment refers to any process carried out through information communication technology including the internet, learning management systems (LMS), communication tools such as forums or chats, and others (Alruwais, et al., 2018). This system provides information about student learning that is collected and analyzed in relation to the achievement of previous learning outcomes (Martinez, et al., 2015). Therefore electronic-based assessment technology needs to be developed to facilitate the process of achieving learning objectives. Electronic-based assessment is an evaluation tool developed in digital form (Jubaedah, et al., 2020). The use of this electronic-based assessment is a strategy for assessing student assignments or projects that contain task rubrics as an alternative that can be chosen in evaluating student work (Aji, et al., 2018).

In recent times many studies have shown the benefits of electronic-based assessments. Based on Alrfooh's analysis (2020) stated that the use of various learning methods or instruments that have been developed can support increasing the effectiveness of electronic-based learning, one of which is an assessment and feedback mechanism. Assessment using digital is significant and important because it can be used anywhere and anytime. The ease of accessibility of learning materials and the increased interaction of educators and students, making the e-learning assessment system preferred by everyone (Shaalan & Salloum, 2018).

Electronic-based assessment offers features that useful in each task, such as easy access to download assignments and flexibility, because it allows students to access learning materials and assignments both inside and outside the classroom and can provide personal feedback (Almaiah & Mulhem, 2018). Even though the use of this electronic-based assessment system makes the learning process more flexible and much easier, there are still some problems related to the lack of understanding about the benefits of the electronic-based assessment system. Therefore, it is important to understand what factors influence student perceptions to motivate them to use actual e-learning. This is because the success of an e-learning system depends on its acceptance and actual use (Revythi & Tselios, 2019)

Based on the results of preliminary observations in the chemistry education study program, the interest of electronic assessment is still quite low. Lecturers of chemistry education still use assessments which are carried out at the end of lectures and there is no feedback. As is well known that assessment is part, not the end of learning. Furthermore, quoted by Mahande & Malago (2019) assessment is not only part of a learning activity, but assessment is for learning and its function is to advance students in learning. The lack of quality system and special training regarding e-learning and assessment systems are also becoming factors for the low implementation of this system. Charoenchai, et al. (2015) explained that the effectiveness of an assessment requires a common perception and attention of the assessor and those assessed related to the assessment criteria. Thus, valid and reliable assessment instrument is needed to assess competency achievement. Without the availability of valid and reliable instruments in accessing competencies when carrying out learning activities, the assessment is not based on appropriate and quality data.

The availability of electronic assessment is also supported by the material presented and available assessment rubrics. Applied chemistry material is one of the elective courses in the chemistry education study program that students like the most. The concept of applied chemistry is widely associated with everyday life and the final product is expected to be an example of a role model in the field of entrepreneurship. The concept of applied chemistry is closely related to the application of project based

learning (PjBL). Students are required to produce products by applying the skills of researching, analyzing and presenting learning products based on real experiences. The purpose of PjBL is to increase students' knowledge and skills in managing available sources of materials and tools. Through project learning, an educator can assess from the beginning to the end of the learning process and can apply feedback to the fullest. Therefore, the development of an electronic-based assessment application is expected to be one of the solutions for educators in providing assessments to students in an objective, flexible and measurable manner through the features provided.

Based on the background that has been described, the researchers developed the application of electronic learning chemistry assessment through PjBL to applied chemistry concepts in order to improve students' scientific performance. The purpose of this research and development is to test the feasibility validation of the electronic learning chemistry assessment application and its effectiveness in improving student scientific performance through PjBL.

Method

This study uses research & development (R&D) research methods which refer to the ADDIE model of development from the Dick and Carry design. In the ADDIE stage according to Dick & Carey (Ali & Maliki, 2021), namely: (1) Analyze (goal setting stage), (2) Design (design stage in the form of learning objectives, analysis of learning material, learning planning exercises, assessment instruments used) , (3) Development (stages of making application programs and production), (4) Implementation (stages of testing, redesigning, updating and editing applications so that they are more optimal), (5) Evaluation (careful final testing of what, how, why , when things were achieved (or not achieved) from the entire project. The product developed was in the form of the electronic learning chemistry assessmapplication through PjBL that was applied to chemistry concepts to increase student scientific performance through the Dick and Carry development model resulting in a digital-based assessment application that could makes it easier for lecturers in giving assessments to students. Development is carried out in three stages, namely analysis, the design stage, and the development stage. The research was only carried out up to the development stage due to the limited time the researchers had to get to the evaluation stage. This research focuses on producing a flexible electronic learning chemistry assessm application so that it can be used as the latest innovation for lecturers in providing assessments, especially in disclosing student scientific performance through PjBL.

The research subjects consisted of 5 lecturers of media experts and material experts consisting of 3 lecturers in Chemistry Education at Samudra University, 1 lecturer in Chemistry Education at Syiah Kuala University and 1 lecturer in Informatics and Technology at Samudra University while product trials saw an increase in student scientific performance. Consisting of 2019/2020 class students using a purposive sampling technique of 24 students which have already passed basic chemistry I and II courses. The data collection instruments obtained in this study consisted of two types of data, namely: expert validation data, which about the quality of application feasibility in the form of material and media expert validation results. The data includes assessment scores from material and media aspects. Furthermore, data from small-scale trials to measure the attractiveness of the electronic learning chemistry assessment application and see an increase in student scientific performance using a response questionnaire and the total results from the task rubric contained in the electronic learning chemistry assessment application.

The data analysis technique is divided into three stages, the first stage is in the form of analysis data from interviews with lecturers of Chemistry Education, Samudra

University in a descriptive way. The second stage is the validation test data for the developed electronic learning chemistry assessment application. According to Sugiyono (2015), content validity relates to the ability of an instrument to reveal the content that must be measured. At this stage, five expert validators were involved. After being analyzed by the validator, content validity ratio (CVR) analysis was carried out. If all validators state that the indicators for each aspect and the indicators with the items are compatible, then the CVR value obtained is 1, meaning that this is valid or acceptable. At this stage, the validator also provides suggestions for the questions posed. Therefore, it is necessary to make improvements based on the suggestions submitted by the validator both in the procedure for writing, using sentences, and pictures on the items. The aspects assessed at the application validation stage refer to the development aspects written by the Ministry of National Education in 2008 which include the feasibility of content, language, presentation, and appearance. Assessment is carried out with a Likert scale, which Yes is score 1 and No is score 0. The validation results are analyzed using CVR analysis according to Lawshe (1975) with the following formula:

$$CVR = \frac{ne - \frac{n}{2}}{\frac{N}{2}} \qquad (1)$$

Description:
Ne : the number of validators who said yes and no or gave a score of 1 or 0
N : the number of members of the validator or team of experts.

After calculating the CVR value for each criterion, the content validity index (CVI) value or average value is calculated. Overall CVR and average CVI scores for each aspect. The application is declared valid if the average CVI value is 0.99. Then the third stage is in the form of questionnaire data on student responses to the attractiveness of the electronic learning chemistry assessment application being developed and the final results of the assignment that have been collected based on aspects of student scientific performance. The data listed on the response questionnaire was analyzed by calculating the percentage. Analysis of response questionnaire data and assignment rubrics using the formula:

$$\mathbf{NP} = \frac{R}{NS} \boldsymbol{x}\ \mathbf{100\%} \qquad (2)$$

Description:
NP : The percent value sought or expected
R : The number of scores obtained by students or groups
NS : Maximum total score

The improvement of students' scientific performance can be seen from the initial and final performance scores using the N-Gain formula. To find out the increase in scientific work, the N-Gain formula is used as follows:

$$\text{N-}Gain = \left[\frac{N_{B-}\ N_A}{N_{MAX-}\ N_A}\right] X\ 100 \qquad (3)$$

Description:
N_A : early scientific work
N_B : final scientific work
N_{MAX} : ideal scientific work

Table 1. N-Gain Average Score Criteria

Average Score	Category
0.71-1.00	High
0.31-0.70	Medium
0.00-0.30	Low

Test the effectiveness of electronic learning chemistry assessment application using the effect size test using the formula (Hake, 2002):

$$d = \frac{(Mb-Ma)}{Sd} \quad (4)$$

Description:

d : effect Size

Mb : average posttest score

Ma : average pretest score

Sd : standard deviation

A clearer explanation of the Effect Size Interpretation is presented in Table 2.

Table 2. *Effect Size* Score Criteria

Size	Criteria
0.00-0.20	low effect
0.21-0.50	Enough effect
0.51-1.00	Medium effect
>1.00	High effect

Result and Discussion

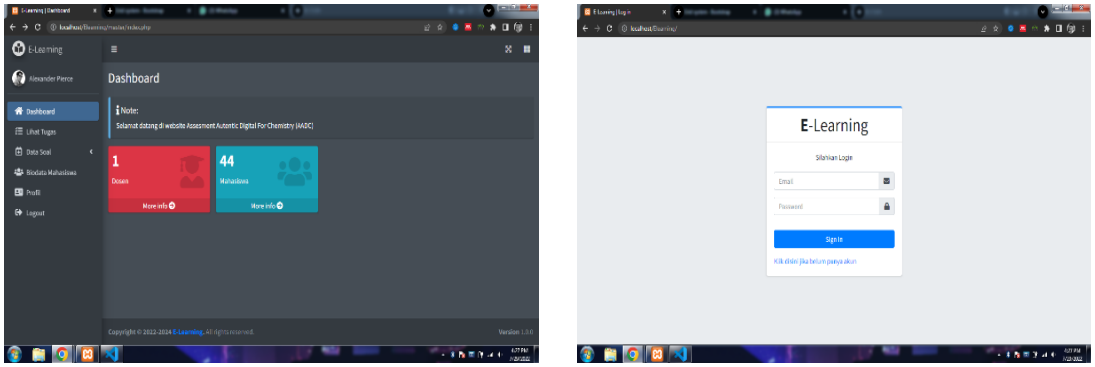
Analysis Phase

In the analysis stage, the results show that there are the need to develop a digital assessment application. Based on interviews conducted with five lecturers of the chemistry education study program that the development of electronic assessment applications is urgently needed to changes in learning patterns due to the pandemic and the demands of 21st century learning. This is in accordance with Nurjannah (2018) needs analysis is carried out by gathering information about abilities, skills, and constraints faced by students in learning so that the media produced is in accordance with the needs needed by students to carry out learning. Fajri, et al. (2021) suggests that needs analysis is used for the purpose of the product to be developed. Changes in online learning patterns have an effect on giving quizzes or assignments where most of the students are not effective in submitting assignments. This causes an undisciplined assessment process. Some learning materials are difficult for students to understand, the use of learning media will enable students to work independently and be responsible in carrying out their duties. What's more, the addition of videos or images that match the material. In the concept of applied chemistry is a chemical material that can be applied in everyday life both in the fields of industry, the environment and food. The learning process produces many useful products for life. Therefore, it is expected that there will be a project activity that can bring out critical thinking and scientific performance of students

through this course. As a result of working on the project, students will build their knowledge independently, improve problem solving skills, develop thinking and communication skills. The research results of Beier, et al. (2019) showed that PjBL is effective in increasing student academic achievement. PjBL is able to develop active learning and reflect understanding in real world practice (Safaruddin, et al., 2020).

Results of the Design Stage

The design stage includes making the initial design of the application and making the feasibility instrument. Making the initial design of the electronic learning chemistry assessment application is done by creating a domain and hosting, selecting the application and designing the initial design of the appearance of the electronic learning chemistry assessment application that will be made. The electronic learning chemistry assessment application can be accessed via the link https://kimiaunsam.com. Creating a domain and hosting is made from cloud hosting with the CPanel panel from Niagahoster. Making applications using the PHP programming language version 8.0 combined with javascript, html and modifications using CSS via Bootstrap 4. The initial design design for the electronic learning chemistry assessment application appearance was created to describe the appearance that will be developed. The design is in the form of a sketch framework from the appearance of the electronic learning chemistry assessment application that will be developed. The initial design of the electronic learning chemistry assessment application display can be seen in Figure 1.



(a) (b)

Figure 1. Initial design of the electronic learning chemistry assessment application design, (a) dashboard view (b) login display

Development Stage

The electronic learning chemistry assessment application utilizes learning with computers or smartphone devices and learning with certain patterns. The electronic learning chemistry assessment application is an application based on PHP v 7.0. The background for the development of this web application is implementation in support of technology 4.0 where the use of the internet is an alternative in distance education. The development stage of the electronic learning chemistry assessment application includes the process of making logins and sign-ups for lecturers, making view assignment menus, assignment data menus, practices, products, projects and portfolios. Furthermore, assessment of assignments from students, in this application for assessment of practice, product, project, portfolio, and final assignments is carried out in the same steps.

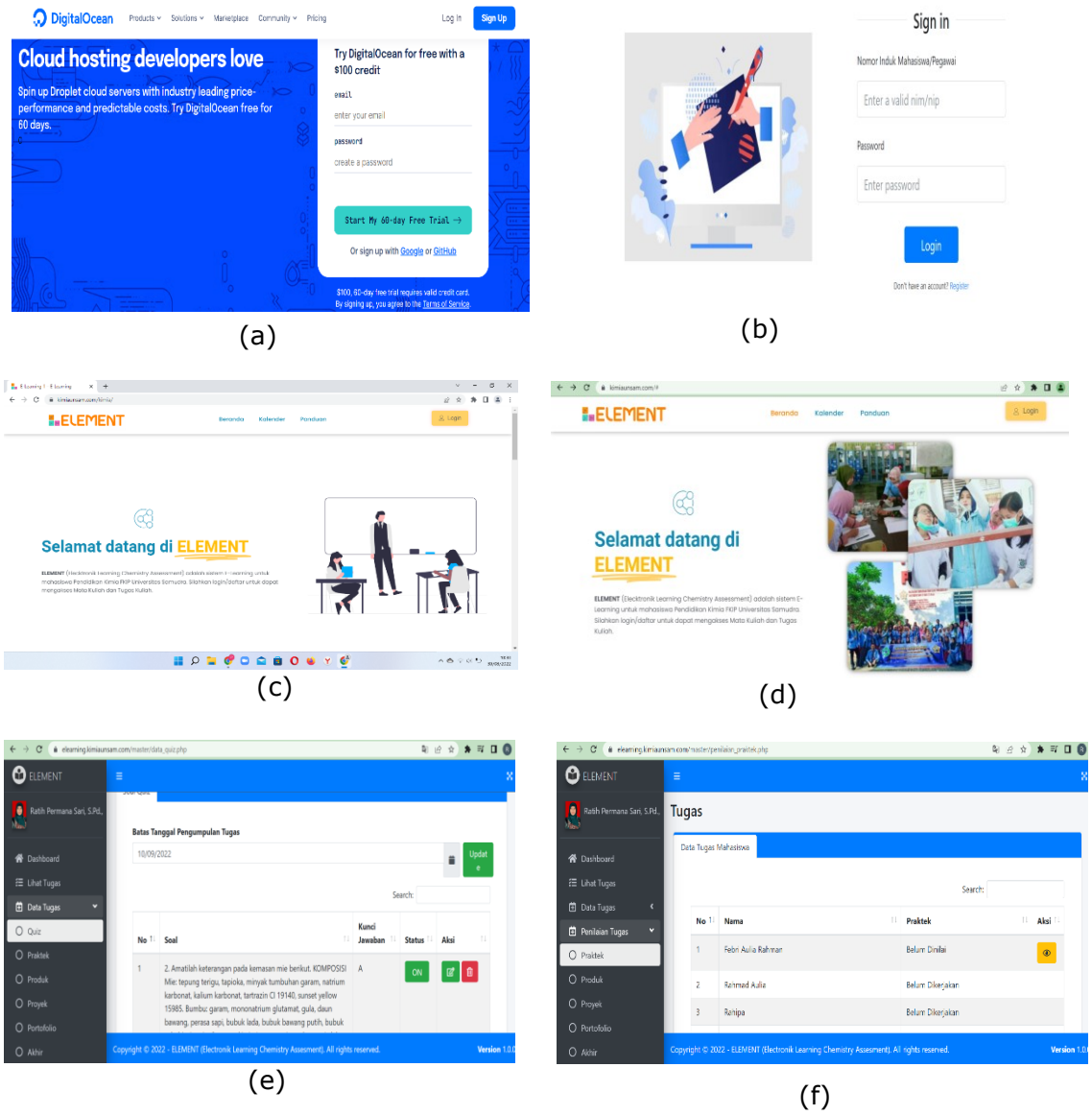


Figure 2. Results of electronic learning chemistry assessment application development before and after expert revision, (a) display of the initial homepage of the login, (b) display of the homepage of the final login, (c) display of the initial homepage of the application, (d) display of the final homepage of the application, (e) initial display of task data, (f) display of task assessment

Validation is carried out to find out weaknesses and strengths and get suggestions for improving the application from media and material experts (Sugiharni, 2018). The electronic learning chemistry assessment application that has been produced is then validated by several expert validators, five validators for media experts and five validators for material experts. Media expert validation was carried out to assess the appearance of the electronic learning chemistry assessment that had been made based on three aspects, namely appearance, access and programming. The results of calculating the validity test with the CVR method for electronic learning chemistry assessment are shown in Table 4.

Table 4. Calculation Results of CVR Validity of Media Experts Before and After Revision

Aspect	Before Revision		After Revision	
	Validator score 1 2 3 4 5	CVR	Validator Score 1 2 3 4 5	CVR
Feasibility of presentation / display design	1 1 1 1 0	0,6	1 1 1 1 1	0,9
Application Eligibility Components (assignment forums, videos and images)	1 1 1 1 0	0,6	1 1 1 1 1	0,9
Technological feasibility and up-to-date	1 1 1 1 1	0,9	1 1 1 1 1	0,9
CVI average		0,7		0,9
Description	Invalid		Very Valid	

Based on Table 4, it can be seen that the assessment criteria achieved after revision are very valid with an average CVI of 0.99. Some of the suggestions and input provided by media experts to improve the electronic learning chemistry assessment application are summarized in Table 5.

Table 5. Media Expert Validation Suggestions and Improvements

No	Aspect	Suggestions	Revision Result
1	Feasibility of presentation / display design	The background display is adjusted to the purpose of making the application ▪ Remove photo background	Display background has been adjusted ▪ Photo background has been removed
		▪ Job description needs to be added	▪ Job description has been added
		▪ Emphasize the explanation about the application of electronic learning chemistry assessment	▪ The definition of electronic learning chemistry assessment has been clarified
2	Application Feasibility Components (assignments forum, videos and images)	▪ Add login menu for student ▪ Add learning videos in the homepage section ▪ The task forum is explained by adding assignment collection intructions.	▪ Login menu for student has been added ▪ Applied chemistry learning videos added ▪ There is a description of assignment collection guidelines in each form of assesment

Material expert validation is carried out to assess the accuracy of the material in the electronic learning chemistry assessment application which has been made based on three aspects, namely the quality of the content, presentation and language. Validation was carried out by five material expert lecturers. The results of validity test calculations using the CVR method for material expert assessment in the electronic learning chemistry assessment application before and after revision can be seen in Table 6.

Table 6. Results of the validity test with the CVR method on the Material Expert Assessment Before and After the Revision

Aspect	Before revision		After Revisi	
	Validator Score 1 2 3 4 5	CVR	Validator Score 1 2 3 4 5	CVR
Content Eligibility	1 1 0 1 0	0,6	1 1 1 1 1	0,9
Serving Components	1 1 0 1 1	0,6	1 1 1 1 1	0,9
Language Assessment	1 1 1 1 1	0,9	1 1 1 1 1	0,9
CVI average		0,7		0,9
Description	Invalid		Very Valid	

Based on Table 6, above, it can be seen that the assessment criteria achieved after revision are very valid with an average CVI of 0.9. Some of the suggestions and input given by material experts to improve the applications that have been made are summarized in Table 7.

Tabel 7. Suggestion and Input Material Expert Validation

No	Aspect	Suggestions/Input	Revision Result
1	Content Eligibility	▪ The job description form is still lacking ▪ electronic learning chemistry assessment explanation has not been displayed on the homepage ▪ Each feature of the assessment form has no explanation on the homepage	▪ Added task description form ▪ electronic learning chemistry assessment explanation has been added to the initial homepage ▪ Each feature of the assessment form has been explained in the form of a pop up
2	Presentation Component	▪ The initial assignment is still in the form of 3 questions and needs to be added and accompanied by questions in essay and case forms ▪ Add learning resources from learning videos and power points	▪ Questions have been added for essay and case forms ▪ Learning resources have been added in the form of power points on the homepage
3	Language	▪ The writing of words and other languages is checked, it is clearer and simpler	▪ The writing and other languages in the material have been improved

In this study, before the electronic learning chemistry assessment application was given to students, a validation process was carried out by several media and material experts to determine the feasibility of the digital assessment application that had been prepared. The validation results using the CVR method found a value of 0.9 which means it is valid to use. In the use of language, it must straightforward and clear. As revealed

by Daryanto (2013), the grammar used in making learning media must be simple, not use scientific sentences, and be presented in a simple form.

This electronic learning chemistry assessment application is equipped with applied chemistry teaching materials. Learning materials are made according to the indicators that have been made. Learning materials are made in the form of powerpoint files which are uploaded to YouTube. The presentation of the material is divided into two divisions of material, namely applied chemistry concepts and examples of applied chemical products. Learning materials are provided in the form of videos taken from youtube. According to Salehudin & Sada (2020) multimedia presentations are used to explain material that is theoretical in nature, the advantage of presentation media is that it combines all elements of text, video, animation, images, graphics and sound into a unified presentation. The delivery of learning material is more interesting and fun, for example supported by audio-visual media, films, and supporting images. The addition of an explanation page icon about the material is done in order to assist lecturers in explaining and conveying more interesting and in-depth lessons, because they can directly access the internet for additional material to students so that they get broader knowledge. After the preparation of learning materials has been completed, then a task forum and forms of assessment are created. Assignments consist of practice, product, project, portfolio, and final assignments. The electronic learning chemistry assessment application is equipped with facilities that can encourage students to study independently and provide opportunities for students to manage their own learning. This is in accordance with the research of Luthfiyyah, et al. (2021) that assessment using technology can provide information flexibly and is proven to be able to make decisions and inform students where they are and how they can achieve learning goals.

A small-scale trial was conducted to find out the attractiveness of the electronic learning chemistry assessment application that has been produced. The recap results of the response questionnaire data conducted on 24 semester VI students of the 2019/2020 class. The attractiveness of the electronic learning chemistry assessment application is known by giving response questionnaires to students. Based on the results of calculating student responses, it can be seen that the level of attractiveness of the electronic learning chemistry assessment application by 24 students is 93.9% in the "very interesting" category. The results of a small-scale assessment of the electronic learning chemistry assessment application which is named element seen from the aspects of media attractiveness, access attractiveness and application attractiveness can be seen in Figure 3.

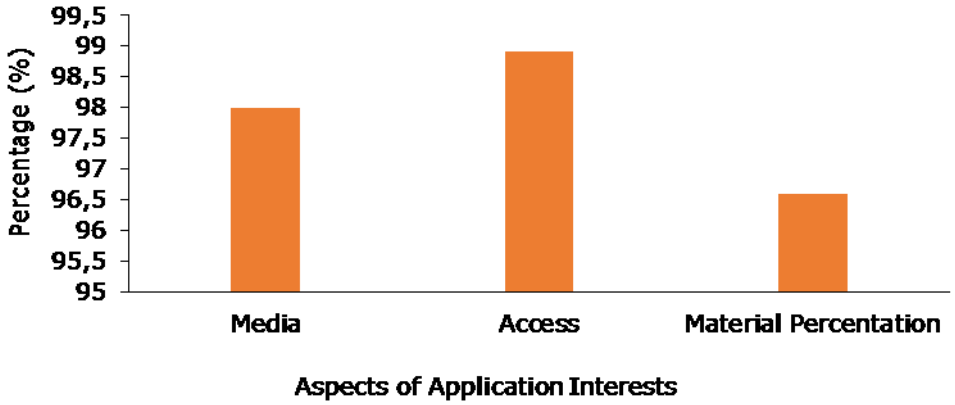


Figure 3. The results of the electronic learning chemistry assessment application's attractiveness assessment

The results of the assessment of the small/limited scale test on the attractiveness of the electronic learning chemistry assessment application for students obtained an average percentage of 93.9% with the criteria of "very interesting". This is in accordance with the opinion (Wang, 2010) that the e-learning learning environment provides more learning resources compared to traditional learning environments. Based on the analysis of Hwang & Chang (2011) they state that various learning methods or learning instruments have also been developed to support increasing the effectiveness of web-based learning, one example that has been developed is an assessment and feedback mechanism. In addition, based on research conducted by Ramlawati, et al. (2014) that the implementation of electronic assessment such as portfolios has a positive influence on improving students' generic skills, especially in explaining symbolic language, visual spatial and chemical modeling. In addition, the existence of learning methods using technology is able to solve learning problems and is able to stimulate visual representation abilities, symbolically and student learning motivation (Hurrahman, et al., 2022).

Small-scale trials of improving student scientific performance were carried out for students in the 2019/2020 batch by looking at the initial and final scientific performance scores. To find out the level of success of students in developing thinking skills and performance and solving, an evaluation tool is needed by looking at the entire assessment process (Susetyo, et al., 2021). The results of the percentage of student scientific performance, N-gain data and effect size can be seen in Figure 4 and Table 8.

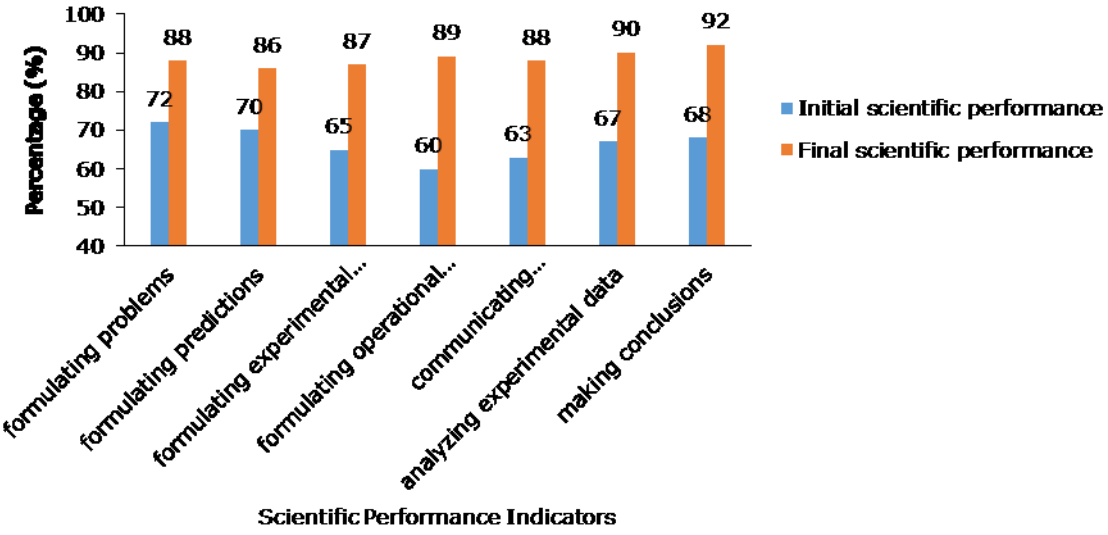


Figure 4. Small scale/limited trials of student scientific performance

Table 8. Data on the average increase in student scientific performance

Group	Avarage Start	Average Final	N-Gain	Category	Effect Size	Category
Experiment	66	88	0.70	High	1.00	High Effect

Based on Figure 4, the highest percentage value is found in the indicator which makes a conclusion of 92% with an N-gain value of 0.7 (high category). Furthermore, data on improving student scientific performance has increased by 0.70 in the high category and is effectively used to improve student scientific performance with an effect size value of 1.00. Based on the results of the analysis obtained, it can be concluded that

the electronic learning chemistry assessment application developed is able to improve students' scientific performance from the highest to the lowest ability. This is because performance appraisal is able to assess students' knowledge, attitudes, and skills. Assessment of the skills of interpreting scientific data and evidence in schools is carried out to improve students' comprehension skills in reading data in various representations, analysing and evaluating scientific data, claims and argumentsin various representations and drawing appropriate conclusions (Deratama, et al., 2022). Assessment is a form of assignment that requires students to demonstrate some meaningful real-world performance which is the application of the essence of knowledge, understanding and skills (Mueller, 2016). Performance appraisal allows students to show what they can do. This can be seen in terms of student answers where students are able to distinguish how to do practicum in real and virtual. The results of this study are in accordance with Syahria's research (2019) that the application of electronic-based assessment provides benefits in the teaching and learning process where assessment in this way saves a lot of teacher time, bridges the distance between teachers and students in terms of meeting time and at the same time also helps reduce student anxiety during assessment. In line with Syahria's research (2019), the research results of Masluhah & Afifah (2022) also found that assessment using digital technology can make assessment of student learning and achievement more effective, efficient, and more practical.

Conclusion

Based on the results of the research, it can be concluded that the electronic learning chemistry assessment application PjBL is developed through three stages, namely the analysis stage, the design stage, and the development stage. The electronic learning chemistry assessment application through PjBL has been validated by material and media experts with an average CVI of 0.9 or the very valid category. The results of the small-scale test assessment of the 2019/2020 class student electronic learning chemistry assessment application obtained an average percentage of 93.9% with the "very interesting" criteria. Furthermore, data on improving student scientific performance has increased by 0.70 in the high category and is effectively used to improve student scientific performance with an effect size value of 1.00.

Acknowledgement

We would like to thank the Chancellor of Samudra University and also the Institute for Research, Community Service and Quality Assurance (LPPM) for facilitating funding and participation of researchers in the 2022 Excellent Basic Research (PDU) research grant program using DIPA Unsam funds and Chemistry Education Lecturers at Samudra University and Lecturer in Chemistry Education at Syiah Kuala University who has supported the implementation of this research.

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