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Development of Electronic Portfolio-Based Assessment Strategies in Chemistry Learning to Assess Students' Concept Mastery

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Abstract

This study aims at developing an electronic portfolio-based assessment strategy as valid and reliable assessment for learning on colloidal system material to measure student concept mastery. This study used a Design-Based Research (DBR) with a 4D development model that is carried out until stage 3 (Define, Design, and Development). The participant in this study were 10 students of class XI in one of High Schools in Bandung who were involved in the limited trial phase. The concept mastery ability measured in this study used the Revised Bloom's Taxonomy framework. However, the researcher only used the cognitive level of applying (C3) and analyzing (C4) based on the analysis of Core Competence and Basic Competence in the syllabus for colloidal system material. The tasks developed in this electronic portfolio assessment consist of three tasks, namely a concept map of the types of colloids; papers on the properties of colloids, the application of the properties of colloids in life, and how to make colloids; and a practical simulation report on the colloidal properties of the Tyndall effect. The results showed that the instrument was valid with a CVR value of 0.6 - 1.0 and reliable with a Cronbach Alpha value of 0.679 - 1.000. Based on the results of a limited trial of the developed electronic portfolio-based assessment strategy, it can measure student concept mastery on colloidal system material. Overall, the average level of student concept mastery is categorized as good. With details in the category of very good (30%), good (50%) and sufficient (20%).

Keywords: *Electronic Portfolio Assessment, Concept Mastery, Colloidal System.*

1. Introduction

The learning that is being done today is teacher-centered learning with an assessment process in the form of paper and pencil tests, which only emphasizes cognitive abilities without providing feedback. It caused students cannot make improvements in the learning process, which can reduce student error rates. Therefore, the ability of students' concept mastery has not improved perfectly [1]. Chemistry requires students to understand abstract concepts, calculations, and practicals, yet students frequently find chemistry challenging, which lessens their passion for studying [2]. According to Sirhan (2007), chemistry topics generally study the structure of a material, this makes chemistry a difficult subject for students to understand [3]. The abstraction of chemistry, combined with counterintuitive concepts, makes chemistry a complex subject, causing low student learning outcomes [4]. From research conducted by Viani (2017), it is known that the average results of the mid-semester 1 chemistry subject for class X Science at Senior High school 2 Bengkulu still have not reached the Minimum Completeness Criteria (KKM), which is 75. It shows that students' understanding of chemical concepts is still low, partly because most teachers still use conventional methods [5]. Students' concepts understanding is also lacking on various chemistry materials in class XI, one of which is colloid system material [6]. This material is usually taught by teachers using the lecture method (teacher center), making students are less active, bored, and disinterested to study in class [7]. Colloidal material is material that contains concepts so that it is easy to learn and remember. Moreover, an assessment is needed to be able to improve students' concepts understanding. Based on research conducted by Sartika, the results of the daily test scores for even semester XI IPA Senior High School 2 Pontianak in the 2013/2014 academic year on colloid material was found that students still cannot understand colloid concepts well [4]. Therefore, they only get a percentage of incompleteness with the minimum completeness criteria (KKM) of 75. To understand a concept, students must not only know or memorize the information but also understand what is being taught and communicated, as well as be able to utilize its content without having to connect it with other things [8]. Understanding is more than just recalling information; it is also the capacity to describe, explain, interpret, or capture the meaning of a concept. When a person can arrange and retell what they have learned, they are considered to comprehend the concept [9]. As a result, we require an assessment that is aligned with learning and capable of increasing students' comprehension of ideas in chemistry subjects. Authentic assessment or assessment for learning is an alternative assessment method that can be employed. It is because genuine assessment encourages students to use academic knowledge in real-world circumstances for meaningful purposes [10]. Portfolio assessment is one of the most often utilized genuine evaluations. It allows students to be flexible while also assisting them in the development of high-level assumption skills and meta-cognitive competencies. An assessment that can present students' abilities in more concrete and meaningful situations [10]. The specialty of portfolio assessment lies in providing a documents collection as evidence of student learning processes and outcomes. Therefore, when analyzing student results, educators are immediately able to realize the abilities, attitudes, strengths, and weaknesses of each student. In addition, the large number of tasks that must be assessed and observed causes the traditional portfolio assessment to have several weaknesses, including 1) Requiring a lot of space for document storage; 2) Requiring a lot of time to provide feedback; 3) Cannot be carried out in a short and immediate time; and 4) Demands the teacher's attention. Furthermore, the teacher must be diligent and patient in collecting student work, sorting it chronologically, and making their interpretation. It can be effective by turning the assessment into an electronic portfolio assessment [11]. An electronic portfolio assessment is an alternative assessment used to describe the process and results of portfolio assignments that are stored in an electronic format. In its implementation, to be able to carry out an electronic portfolio assessment, a media is needed that can support its activities. According to Kustandi and Bambang (2011), the media functioned as a means to achieve learning objectives [12]. In addition, the media must also involve students so that learning can occur. One of the media that can be used is Edmodo. Edmodo is a safe learning platform for teachers, students, and schools based on social

media. Edmodo provides a safe and easy way to connect with teachers and other students. Through Edmodo, teachers and students can share documents in the form of books or links. In addition, Edmodo can help teachers build a virtual class based on real class divisions at school, where there are assignments, quizzes, and scoring at the end of each lesson in the class. Based on the background of the problem above, the researcher is interested in researching one of the chemical materials in high school, namely "Development of Electronic Portfolio-Based Assessment Strategies in Chemistry Learning to assess Student Concept Mastery". The Electronic Portfolio Assessment is used by researchers because it provides feedback. In accordance with these problems, the research objectives are: 1) Develop a valid and reliable electronic portfolio-based assessment strategy to measure students' mastery of concepts in colloidal system material; 2) Analyzing the outcomes of student tasks before and after providing feedback in the developed electronic portfolio assessment strategy; 3) Analyzing the implementation of the electronic portfolio assessment strategy developed based on limited trials on colloidal material to measure students' conceptual mastery.

2. Materials and Methods

In this study, research and development (R&D) methods were used. The R&D model used is the 4D model proposed by Thiagarajan et al. (1974) [13]. The stages of the 4D model R&D method consist of four stages, namely, define, design, develop, and disseminate. In the research and development of this electronic portfolio assessment strategy, not all R&D stages were carried out, only up to the limited trial stage in the third stage of all 4D research and development stages. The participants of this study were 10 students of class XI Science in one of the senior high schools in Bandung who had studied colloid system material. The data collection instruments used in this study include interview guidelines, instrument validation sheets, task assessment sheets, assignments and assessment rubrics, as well as concept mastery test questions developed by Tusri (2017) [14]. The Content Validity Ratio (CVR) was used to test the validity of the task instrument used for electronic portfolio assessment. The scoring of item answers uses the following CVR formula:

$$CVR = \frac{n_e - \frac{N}{2}}{\frac{N}{2}}$$

Determination of the category of instrument validity using CVR refers to the minimum CVR value. The instrument is declared valid if the CVR value results are greater than the minimum CVR value. To test the reliability of the assessment instrument developed, it was determined using the inter-rater method and the Cronbach Alpha value using the IBM SPSS 25 software. Reliability was determined by interpreting the results of the Cronbach Alpha calculation. The interpretation of the Croncbach Alpha value on reliability is shown in Table 1.

Table 1. Croncbach Alpha Value Interpretation

Criteria	Description
$\alpha > 0.9$	Very good
$0.7 < \alpha < 0.9$	good
$0.6 < \alpha < 0.7$	acceptable
$0.5 < \alpha < 0.6$	poor
$\alpha < 0.5$	Not acceptable

Analysis of student task score data using Normalized Gain (N-Gain), which is the difference between task scores before and after giving feedback, shows an increase in students' abilities after learning is carried out. According to Hake in Meltzer [15,16], the N-Gain can be calculated by the formula:

N Gain ="after-score before-score /maximum-score before-score

The N-Gain values obtained are then categorized and interpreted according to the N-Gain criteria according to Meltzer (2002), as shown in Table 2.

Table 2. Categorization of N-Gain Score/Gain Index [16].

Range	Category
$N\text{-}Gain \geq 0.7$	high
$0.3 \leq N\text{-}Gain < 0.7$	medium
$N\text{-}Gain < 0.3$	low

Data analysis for students' mastery of concepts on colloidal system material uses test scores obtained by students and then converted into a scale of five levels of student mastery using the following guidelines (Table 3):

Table 3. Student Mastery Level [17]

Mastery Level	Standard Score	Description
90 % - 100 %	A	Very good
80 % - 89 %	B	good
70 % - 79 %	C	enough
60 % - 69 %	D	poor
< 59 %	E	Very poor

3. Results and Discussion

The results and discussion consist of: (1) development of an electronic portfolio-based assessment strategy; (2) instrument quality based on validity; (3) instrument quality based on reliability; and (4) limited trial.

3.1. Development of an Electronic Portfolio-Based Assessment Strategy

The development of this electronic portfolio assessment instrument was carried out in four stages based on the model developed by Thiagarajan et al. (1974), namely (1) Define, (2) Design, (3) Development, and (4) Disseminate [13]. In this study, not all the steps of the 4D development stage were carried out, but only up to the development stage. The define stage includes several stages, including library research, material analysis, and field surveys. Based on the results of the analysis in Permendikbud Number 37 of 2018 concerning Core Competencies (KI) and Basic Competencies (KD), the KD which is used as a reference in this study is KD 3.14. indicators for basic competencies used in developing the instrument were obtained through analysis of the chemistry syllabus for class XI curriculum 2013. KD 3.14 was chosen because the colloid system material consists of learning theory and practice so that the tasks given to students vary. A field survey was conducted through interviews with one of the chemistry subject teachers. The results showed that the written test was an assessment that was often used, including daily assessments, mid-semester assessments (PTS), and end-of-semester assessments (PAS). There is no giving feedback on the assignments because the time it takes to provide feedback to all students is too long. The design stage aims at compiling a framework for the contents of the electronic portfolio assessment instrument, which will be developed through KD analysis and indicators, making it easier during the development stage. From the results of the analysis carried out, three tasks will be used to develop electronic portfolio instruments. The task used is shown in Table 4. After the task is determined, the portfolio assessment instrument and its assessment rubric are then compiled. To measure students' mastery of concepts, a test instrument is used, which includes concepts in colloidal system material. The test instrument used is an instrument developed by [14].

In the Development stage, the instrument quality test is carried out, which includes content validity tests by experts and inter-rater reliability tests as well as limited trials. A limited trial was carried out after testing the quality of the instrument

and making revisions based on suggestions for improvement from experts. The data obtained from the limited trial includes students' task scores and students' concept mastery test scores. A limited trial was used to see the effectiveness of the electronic portfolio-based assessment strategy used to measure students' conceptual mastery of colloidal system material.

Table 4. Tasks used in Instrument Development

Basic Competencies	Indicator	Task
3.14 Classify the various types of colloid systems, and explain the uses of colloids in life based on their properties	3.14.1 Identify and classify the types of colloids	Concept map of types of colloids
	3.14.2 Connecting colloidal systems with their properties 3.14.3 Explain the application of the properties of colloids in life 3.14.4 Explain how to make colloids	Papers on the properties of colloids, the application of colloid properties in life, how to make colloids
	3.14.2 Connecting colloidal systems with their properties	Tyndall effect colloidal properties lab simulation report

3.2. Instrument Quality Based on Validity

The validity test of the electronic portfolio assessment instrument was carried out by a judgment expert involving five experts, consisting of three lecturers from the UPI chemistry education department and two high school chemistry teachers. This validity test used a validation sheet in the form of a table containing indicators, tasks, assessed aspects, rubrics, suitability of indicators with tasks, and suitability of tasks with developed rubrics. The results of the judgment expert were then processed using the Content Validity Ratio (CVR) value to determine the suitability of the domain as measured by items based on expert judgment for each aspect of conformity. The results obtained from the validity test using CVR can be seen in Table 5.

Table 5. Validity Test Results

Indicator	Aspect assessed	Validator declare "Yes"		Suitability Indicator and *Task*		Suitability *Task* and Rubrick	
		suitability Indicator and *Task*	suitability*Task* and Rubrik	CVR	Validity	CVR	Validity
			Task 1				
3.14.1	1.1	4	4	0.6	not valid	0.6	not valid
3.14.2	1.2		4			0.6	not valid
3.14.3	1.3		4			0.6	not valid

3.14.4 3.14.5	1.4		4			0.6	not valid
			Task 2				
3.14.1 3.14.2 3.14.3 3.14.4 3.14.5	2.1	4	4	0.6	not valid	0.6	not valid
	2.2		4			0.6	not valid
	2.3		4			0.6	not valid
	2.4		4			0.6	not valid
	2.5		4			0.6	not valid
	2.6		4			0.6	not valid
	2.7		4			0.6	not valid
	2.8		4			0.6	not valid
			Task 3				
3.14.3	3.1	5	5	1	not valid	1	Valid
	3.2		5			1	Valid
	3.3		5			1	Valid
	3.4		5			1	Valid
	3.5		5			1	Valid
	3.6		4			0.6	Tidak valid

Table 6. Results of Cronbach Alpha values

Indicator	*Task*	Aspect Assessed	Value *Cronbach Alpha*	Reliability Category
3.14.1	Concept map of types of colloids	1.1	0.794	good
		1.2	1.000	Very good
		1.3	0.703	good
		1.4	0.679	acceptable
3.14.2 3.14.3 3.14.4	Colloidal system paper (types of colloids, their application, manufacturing methods)	2.1	1.000	Very good
		2.2	0.820	good
		2.3	1.000	Very good
		2.4	1.000	Very good
		2.5	0.750	good
		2.6	1.000	Very good
		2.7	0.775	good
		2.8	0.893	good
3.14.2	Colloidal properties lab simulation report (Tyndall effect)	3.1	1.000	Very good
		3.2	0.814	good
		3.3	1.000	Very good
		3.4	0.860	good
		3.5	1.000	Very good
		3.6	0.886	good

Lawsche (1975) [18] reveals that only aspects that meet the minimum CVR value can be maintained and used. Meanwhile, for aspects that do not meet the minimum CVR value, improvements are made to these aspects and rubrics based on suggestions from the validator [19].

3.3. Instrument Quality based on Reliability

The reliability test with the inter-rater method was used in this study to examine the consistency of various raters in assessing the tasks completed by students. Three participants served as raters in this study. The Cronbach Alpha value was used to determine the inter-rater reliability value using the IBM SPSS Statistics 25 application. The Cronbach Alpha value obtained was then categorized using the Cronbach Alpha value category described [20]. Table 6 shows the Cronbach Alpha values that were obtained. Overall, the electronic portfolio assessment instrument developed has a good reliability category. It is possible because the assessment rubric used is clear for scoring so that raters are easy to assess or students' abilities on colloidal system material tend to be the same.

3.4. Limited Trial

A limited trial involved 10 high school students in class XI Science who had studied colloidal system material. This trial used one type of LMS (Learning Management System) that is widely used in schools, namely Edmodo. In this study, Edmodo was chosen as an electronic portfolio media because it has many features that support students in organizing their tasks and make it easier for teachers to provide feedback.

3.5. Task 1 Limited Trial Results

Based on the work collected by students, most students are still lacking at making concept maps. Concept maps that are still incorrect are returned to students to be corrected according to the feedback given. After the concept map was improved, there was an increase in the average score of students.The increase in score that occurs is then interpreted into the N-gain value. The results of calculating the N-gain value in task 1 is shown in Table 7.

Table 7. Value of N-gain Task 1

Aspect assessed	Score average		*N-gain*	category
	before	after		
1.1	2,6	3,2	0,4	Medium
1.2	2,0	3,0	0,5	Medium
1.3	1,9	2,9	0,5	Medium
1.4	3,0	3,7	0,7	high
Average	2,6	3,2	0,5	medium

3.6. Task 2 Limited Trial Results

In task 2, students were instructed to write a paper about the characteristics of colloids, their applications in life, and how to make colloids by gathering information from various sources and adapting to the procedures for writing papers. Papers that still have shortcomings are then returned to students to be corrected according to the feedback given. Following the correction of the paper, there was an increase in the average score of students (Figure 2).

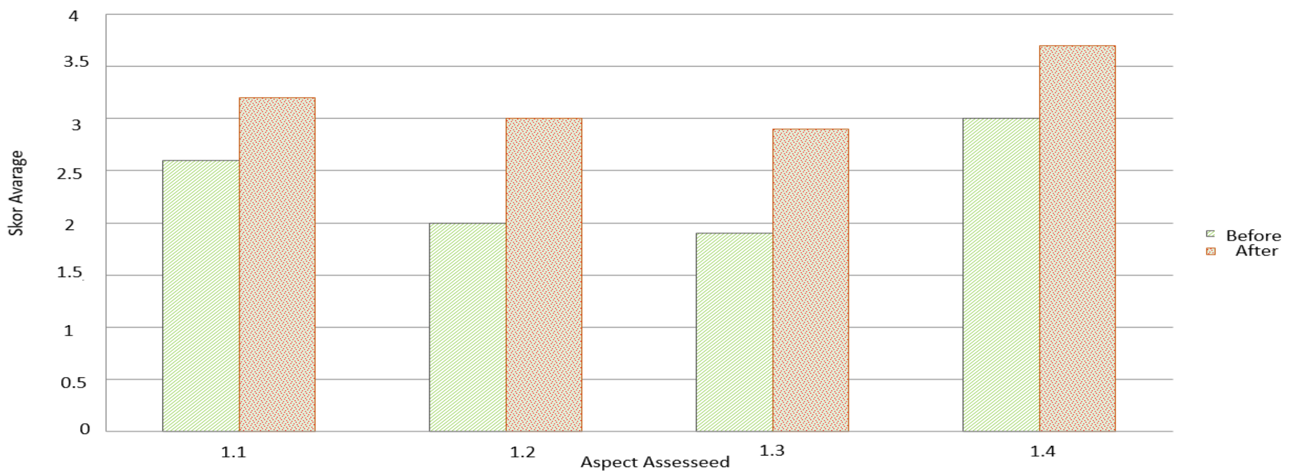

Figure 1. Average score of each Aspect Task 1

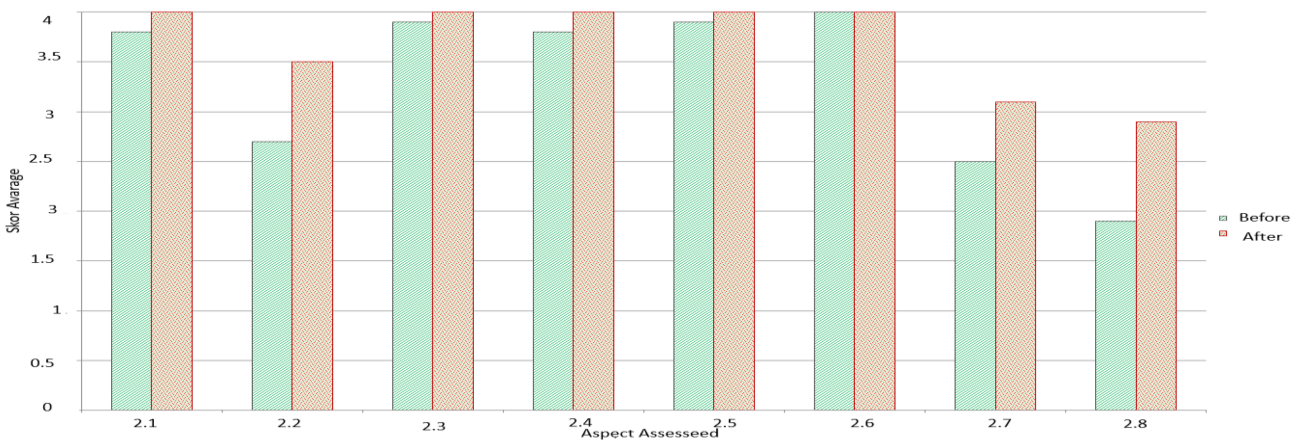

Figure 2. Average score of each aspect on Task 2

The increase in score that occurs is then interpreted into the N-gain value. The results of the calculation of the N-gain value in task 2 is shown in Table 8.

Table 8. Value of N-gain Task 2

Aspect assessed	Score average		*N-gain*	category
	before	after		
2.1	3.8	4.0	1.0	high
2.2	2.7	3.5	0.6	medium
2.3	3.9	4.0	1.0	high
2.4	3.8	4.0	1.0	high
2.5	4.0	4.0	1.0	high
2.6	4.0	4.0	-	-
2.7	2.5	3.1	0.4	medium
2.8	1.9	2.9	0.5	medium
avarage	3.3	3.7	0.6	medium

3.7. *Task 3 Limited Trial Results*

In task 3, students were asked to observe a practical simulation video of one of the colloid properties of the Tyndall effect through a video uploaded on the Edmodo page. After observing the simulation video, students were asked to write down their observations in the form of a practical simulation report. The practicum report that still has shortcomings is returned to the student to be corrected according to the feedback given. After the report was corrected, it was seen that there was an increase in the average score of students (Figure 3).

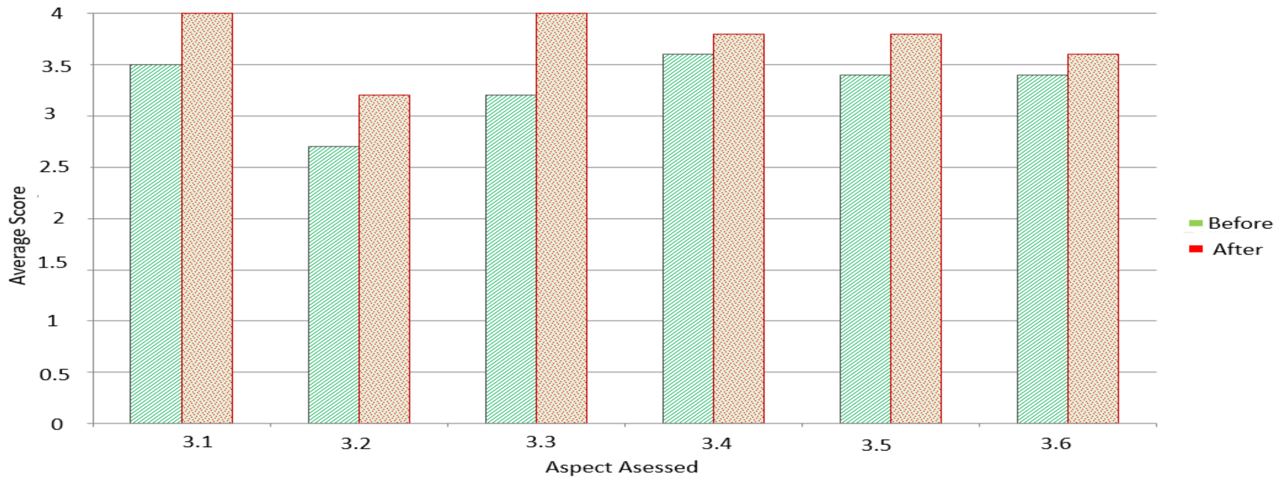

Figure 3. The average score of each aspect on Task 3

The increase in score that occurs is then interpreted into the N-gain value. The results of the calculation of the N-gain value in task 3 is shown in Table 9.

Table 9. Value of N-gain Task 3

Aspect assessed	Score average		*N-gain*	category
	before	after		
3.1	3.5	4.0	1.0	High
3.2	2.7	3.2	0.4	Medium
3.3	3.2	4.0	1.0	High
3.4	3.6	3.8	0.5	Medium
3.5	3.4	3.8	0.7	High
3.6	3.4	3.6	0.3	Medium
average	3.3	3.7	0.6	medium

3.8. *Student Concept Mastery Test Results*

After all the tasks have been completed and corrected, students are asked to work on a colloidal material concept mastery test to measure the extent to which students' conceptual mastery level is after a limited trial. The student's concept mastery test consists of 17 multiple choice questions that contain all indicators used in all tasks. The test is carried out through the Edmodo page using the available quiz feature. Students are given 30 minutes to answer all the questions provided. The concepts that students must master include the types of colloids, the properties of colloids, the application

of colloid properties in life, and how to make colloids. These concepts are divided into four indicators. The student's concept mastery test results for each indicator are presented in Figure 4.

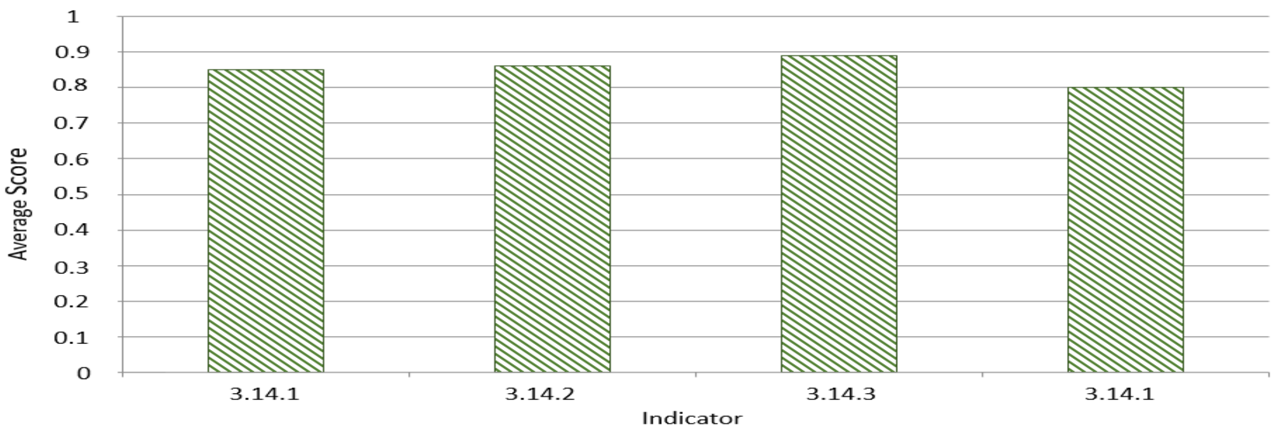

Figure 4. Student Concept Mastery Test Results

From the results obtained, it is categorized into a 5-scale mastery level according to [17]. Categorization of test results is shown in Table 10.

Table 10. Level of Student Mastery on Each Indicator

Indicator	Score average	Mastery level	Category
3.14.1 Identify and classify the types of colloids	0.85	85 %	good
3.14.2 Connecting colloidal systems with their properties	0.86	86 %	good
3.14.3 Explain the application of the properties of colloids in life	0.89	89 %	good
3.14.4 Explain how to make colloids	0.80	80 %	good
average	**0.85**	**85 %**	good

Based on the percentage of students' concept mastery level, the four indicators have a value of 80-89%. Therefore, all indicators are categorized as good. Furthermore, the overall level of mastery of students' concepts of colloidal system material is good. This study is in line with previous reports [21-26].

Conclusion

The quality of the electronic portfolio assessment instrument developed based on the content validity test by five validators met the valid requirements with a CVR value in the range of 0.6 – 1.0 in all assessed aspects. The quality of the electronic portfolio assessment instrument developed based on the inter-rater reliability test by three raters has a Cronbach Alpha value in the range of 0.679 – 1,000 so that it is declared reliable in all aspects assessed. The limited trial results on each task showed an increase in the average score before and after giving feedback. Judging from the N-gain value obtained, task 1 has an N-gain value of 0.5 in the medium category, task 2 has an N-gain value of 0.5 in the medium category, and task 3 has an N-gain value of 0.6 in the medium category. The results of the limited trial of the

developed electronic portfolio-based assessment strategy can measure students' conceptual mastery of colloidal system material. Overall, the average level of mastery of students' concepts is categorized as good.

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