JPPIPA 9(10) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Development of Integrated LKPD Ethnoscience Batik Semarang to Improve Students' Chemical Literacy

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Received: April 6, 2023
Revised: July 4, 2023
Accepted: October 25, 2023
Published: October 31, 2023

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DOI: 10.29303/jppipa.v9i10.3604

Abstract: The problem of this research is developments in the 21st century that require someone to have special abilities, namely chemical literacy. This is in accordance with the 2013 curriculum which demands responsiveness to developments in science, culture, technology, and the arts. The aim of this research is to develop worksheets and improve students' chemical literacy skills in acid-base material. The method used uses a research and development approach with a research flow that adopts the 4-D development model, i.e. definition, design, development, and dissemination. However, this research was carried out up to the 3-D stage, i.e. definition, design, and development. The feasibility of the LKPD is seen through the assessment of material expert validators at 92.86% and media validators at 96.67% in the "Very Feasible" category. The effectiveness of the LKPD can be seen from the pretest-posttest results with an N-Gain of 0.81 in the high category. The results of chemical literacy analysis on the content, epistemic, and procedural knowledge aspects were 94.30%, 81.39%, and 64.45%. Meanwhile, context and competency aspects produced 84.07% and 92.22%. The developed LKPD was declared feasible by experts in the very feasible category and declared effective because it obtained a high N-Gain value.

Keywords: Chemical literacy; Ethnoscience; LKPD; Problem based learning

Introduction

The development of the 21st century or the era of globalization is an era where many changes are occurring in various fields, including science, technology, and education. With the rapid development of science and technology in the 21st century, this changing phenomenon has given rise to intense competition, so someone must have special skills to face this competition, one of which is scientific literacy skills. Scientific literacy is the ability to engage with scientific topics and scientific ideas, as well as the ability to think logically and reflexively (Aulia et al., 2018; Cahyana et al., 2019). Scientific literacy is also a skill that students need to analyze and apply scientific concepts to solve problems in everyday life (Ekantini et al., 2018; Jufrida et al., 2019; Vogelzang et al., 2020). Based on research by Mellyzar et al. (2022), the latest results of the 2018 Program for International Students Assessment (PISA) placed Indonesian students in 70th place in scientific literacy out of 78 PISA member countries. Literacy test results show that students in Indonesia still have a relatively low level of scientific literacy.

Chemistry learning has a responsibility towards students' chemical literacy. Chemical literacy is students' ability to identify, analyze, and process chemical concepts to solve everyday problems and scientifically communicate chemical phenomena that occur around them (Imansari et al., 2018). For this reason, chemical literacy skills are needed in learning so that students have the ability to answer scientific issues and have personalities who are responsible for the surrounding environment. Low chemical literacy is the result of various factors, including the use of boring teaching techniques and ineffective learning models and techniques in stimulating chemical literacy in students.

How to Cite:
Siami, F., Sumarni, W., Sudarmin, S., & Harjono, H. (2023). Development of Integrated LKPD Ethnoscience Batik Semarang to Improve Students' Chemical Literacy. *Jurnal Penelitian Pendidikan IPA*, *9*(10), 7784–7792. https://doi.org/10.29303/jppipa.v9i10.3604

Using an integrated ethnoscience approach is one method that can be used in the classroom. Ethnoscience learning is a learning strategy in the process of creating an environment and designing experiences by integrating culture into the learning process (Sudarmin & Sumarni, 2018). According to Sumarni (2018), ethnoscience learning can improve students' chemical literacy skills in class in terms of content, context, and competency or skills aspects. Ethnoscience-based learning will increase students' curiosity about chemistry in society, thus encouraging them to carry out investigations and discover concepts independently (Palupi et al., 2018). The application of ethnoscience learning is carried out because of the importance of cultural knowledge, beliefs, and practices in shaping an individual's understanding of the world. By incorporating ethnoscience into education, students are encouraged to explore and appreciate their own cultural heritage, as well as the cultural diversity around them (Rahmawati et al., 2023).

Chemistry tends to focus on scientific science, thus preventing students from seeing science as integrated with the environment, technology, and society (Fitria et al., 2018). Chemistry is a subject that cannot be separated from the environment. Chemistry is not just a collection of facts and principles but also includes methods for obtaining these facts and principles as well as attitudes. Everything must be understood not only through facts and principles but also through theoretical processes and applications in real life (Aisah et al., 2020). Acids and bases are very abstract and difficult to understand. This is due to difficulties in understanding the importance of acids and bases, acid-base interactions, the strengths and weaknesses of acids and bases, and ion balance in a solution (Gazali & Yusmaita, 2018). Linking local wisdom values with acid-base material issues can help facilitate understanding.

The ethnoscience approach needs to be implemented with a learning model that is in accordance with the 2013 curriculum, namely student-centered learning, one of which is a problem-based learning model using real-world problems as the context, a PBL learning model that helps students develop critical thinking and problem-solving skills and essential knowledge and concepts from academic subjects (Susbiyanto et al., 2019). Chemistry learning that uses a problem-based learning approach can increase students' chemical literacy levels (Sanova et al., 2021).

Implementing the learning model requires a learning tool that can develop high school students' skills. Research conducted by Khasanah et al. (2021) states that the use of LKPD with an ethnoscience approach can improve students' chemical literacy skills in buffer solution material. In connection with making student worksheets, LKPD is currently needed. The availability of learning aids in the classroom such as LKPD influences students' learning fluency.

Basically, to meet the needs of students in the 21st century, orientation is needed, and there must be LKPD integrated with ethnoscience with a Problem-Based Learning approach. The demands of the 2013 curriculum emphasize the development of important skill structures such as problem-solving, creativity, collaboration, and communication (Hasibuan et al., 2023). One area where local wisdom values can be found is in the city of Semarang. Semarang is famous for its unique culinary delights, tourist attractions, and thematic villages. Kampung Alam Malon is a thematic village as well as a tourist village because it is unique in producing batik with natural dyes. There are four batik centers in the village that produce batik with natural dyes with the typical motifs of Kampung Alam Malon. The rural nature with its unique flora and fauna is the inspiration for creating batik motifs typical of Kampung Alam Malon, such as crystal guava motifs, rice motifs, papaya leaf motifs, shoe flower motifs, and so on. The uniqueness and specialty of Semarang batik is that it depicts legendary stories such as the legend of the Seven Bidadari and Jaka Tarub and also motifs from Semarang city icons, such as the Tugu Muda motif, the Warak Ngendog motif, the Blenduk Church motif and so on. The uniqueness of Semarang batik motifs can be seen in Figure 1. Which depicts the Warag Ngendog motif.

Batik making in Kampung Alam Malon Gunungpati is related to one of the local wisdoms in the city of Semarang which can be linked to the study of chemistry, especially acid-base material. Natural dyes are used to color batik during the dyeing process. The natural dyes used have the potential to be used as a means of ethnoscience learning related to acid-base material. For example, the use of secang, mahogany, and turmeric dyes which are usually used by batik craftsmen to carry out the coloring process can be used as a natural acid-base indicator because it can provide color according to the pH conditions of the solution.

Figure 1. Warag ngendog batik motif

Public science explains that using natural mahogany dye on batik cloth can produce a brown color. It turns out that when reconstructed into scientific knowledge this is true. As according to research by Firyanto (2022), mahogany bark contains color components in the form of flavonoids and tannins. Mahogany bark, when extracted using distilled water, will produce a natural dye which is liquid and brownish red in color with a pH=6.

Based on the problems mentioned above, researchers are interested in developing a learning media that in the process can make students actively involved. The development of this learning media will of course go through a series of regular scientific stages such as feasibility testing through validity testing by experts and effectiveness testing using students' pretest-posttest results, so that in the future a product will be produced that is good and can be accounted for and is able to correct deficiencies, pre-existing products. The learning media developed is "Integrated Worksheet on Batik Ethnoscience with a Problem-Based Learning Model to Improve Chemical Literacy on Acid-Base Material".

Method

This research was conducted at SMAN 12 Semarang in Gunungpati Regency, Central Java, which is located on Jalan Raya Plalangan. This research methodology follows a research and development strategy. The 4-D development model created by Thiagarajan et al. (1974) with research stages including definition, design, development, and dissemination used for the Research and Development research flow. However, this research only reached the 3-D stage consisting of definition, design, and development. In the small-scale trial, 15 students participated, while in the large-scale trial, 36 students participated.

Interviews, documentation, questionnaires, test methods, and non-test methods, including questionnaires and their validation, and validity of LKPD eligibility, were used as data collection techniques in this research. Data analysis techniques include validity analysis which includes media and material validity as well as effectiveness analysis. Expert validators assess the validity of LKPD based on the requirements of the National Education Standards Agency (BSNP) in terms of material and media. Meanwhile, the results of students' chemical literacy assessments are used to analyze effectiveness. Student test results are considered complete if they get a minimum score that meets the Minimum Completeness Criteria (KKM).

Results and Discussion

Feasibility of LKPD

LKPD is validated based on two aspects, namely the media aspect and the material aspect. Each aspect was verified by two validators consisting of chemistry lecturers and teachers. The validation sheet provided has a scale of 1-4, the results of the expert's quantitative assessment will later be converted into qualitative according to category. In material validation, Validator 1 gave a total score for the LKPD material aspect assessment of 99 with very feasible criteria and validator 2 gave a total score for the LKPD material aspect assessment of 109 with very feasible criteria. In the content quality aspect, validator 1 provides an average assessment with a percentage of 93.75% and validator 2 provides an average assessment with a percentage of 81.25%. The ethnoscience aspect of validator 1 provides an average assessment with a percentage of 75% and validator 2 provides an average assessment with a percentage of 100%. The chemical literacy aspect of validator 1 provides an average assessment with a percentage of 91.67% and validator 2 provides an average assessment with a percentage of 100%.

The presentation quality aspect of validator 1 provides an average assessment with a percentage of 85.71% and validator 2 provides an average assessment with a percentage of 100%. The linguistic quality aspect of validator 1 provides an average assessment with a percentage of 90.63% and validator 2 gives an average rating with a percentage of 100%. PBL (Problem-Based Learning) aspect validator 1 provides an average assessment with a percentage of 91.67% and validator 2 provides an average assessment with a percentage of 100%. Based on the results of product validation recapitulation, the average validation value for material aspects was 92.86% with very feasible criteria. The recapitulation of material validation results per aspect by each validator is presented via a diagram in Figure 2.

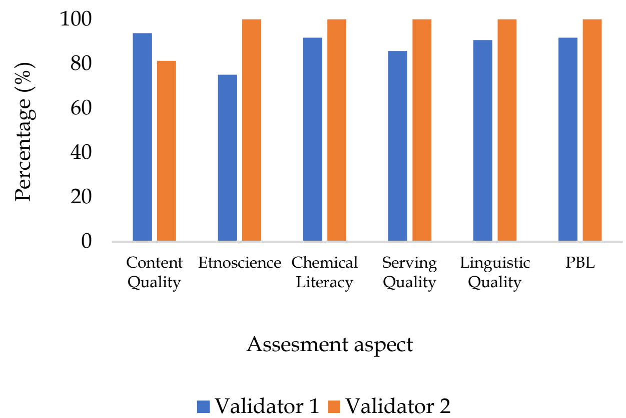

Figure 2. Validation results of LKPD material

In media validation, validator 1 gave a total score for the LKPD media aspect assessment of 60 with very feasible criteria and validator 2 gave a total score for the LKPD media aspect assessment of 56 with very feasible criteria. In the LKPD size aspect, validator 1 provides an average assessment with a percentage of 100% and validator 2 provides an average assessment with a percentage of 87.5%. The cover design aspect of validator 1 provides an average assessment with a percentage of 100% and validator 2 provides an average assessment with a percentage of 95%. The content illustration aspect of validator 1 provides an average assessment with a percentage of 100% and validator 2 provides an average assessment with a percentage of 91.67%. The content design aspect of the LKPD validator 1 provides an average assessment with a percentage of 100% and validator 2 provides an average assessment with a percentage of 95%. Based on the results of product validation recapitulation, the average validation value for media aspects was 96.67% with very feasible criteria. The recapitulation of media validation results per aspect by each validator is presented via a diagram in Figure 3.

Learning media is said to be feasible in a validation assessment by experts with at least a score of ≥ 60% with appropriate criteria (Pranatawijaya et al., 2019). Based on the average assessment results from media expert validators, material experts, and the results of the testability and student responses, it can be concluded that the LKPD developed is suitable for application in learning acid-base material.

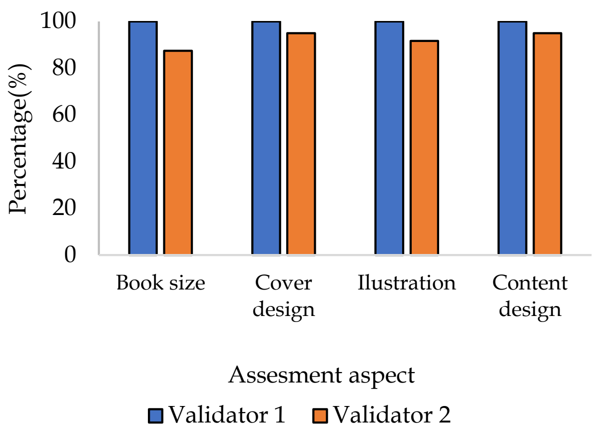

Figure 3. LKPD media validation results

Effectiveness of Ethnoscience Integrated LKPD

The effectiveness of the batik ethnoscience integrated worksheet to increase chemical literacy was analyzed using pretest-posttest questions completed by students. The results of the analysis of the N-gain value obtained an average of 0.81 or have high criteria. Overall, the average percentage of N-gain effectiveness is 81.03% in the Effective category. The results of the students' chemical literacy skills obtained a high criterion of 0.81, so it can be said that the batik ethnoscience integrated worksheet developed is effective for use in the chemistry learning process, especially in acid-base material. Chemical literacy skills are said to be good if the percentage obtained is 66% <X≤79%.

Before the LKPD is given to students, the scores obtained by students are classified as less than satisfactory than the minimum completion criteria (KKM). Where the KKM in chemistry subjects at SMA N 12 Semarang is 75. The results after being given LKPD in learning activities were 33 students who obtained a complete KKM score. If the percentage is calculated, there are 91.67% of students who have successfully completed the KKM. The designed integrated worksheet on batik ethnoscience had a passing score of 91.67% of students, so it can be said to be effective because 80% of students have completed the basic requirements for completion. A developed LKPD is said to be effective if > 80% of all test subjects meet the minimum completion requirements (Kirana & Nazihah, 2018).

Analysis of Students' Chemical Literacy Abilities

Students' chemical literacy abilities were measured using a 15-question essay test instrument that had previously been declared valid and suitable for testing. A total of 36 students from SMA Negeri 12 Semarang were the subjects of this research. Aspects of chemical literacy measured include aspects of knowledge (content, epistemic, procedural), context, and skills.

Aspects of Content Knowledge

The content knowledge aspect is an aspect of chemical literacy that contains an understanding of scientific ideas in general and an understanding of chemical characteristics/key ideas (explaining macroscopic phenomena in the molecular structure of matter, investigating the dynamics of processes, reactions, and energy changes during reaction processes, describing life in terms of the chemical structure and processes of living systems) (Prasemmi et al., 2021). Indicators for aspects of content knowledge related to acid-base solutions consist of four indicators, namely the degree of ionization of acid-base solutions, the pH of acid-base solutions, natural acid-base indicator experiments, and acid-base indicators. The achievements in each indicator are presented in Figure 4. The content knowledge aspect in indicator I obtained a percentage of 99.44% in the "Very Good" category, in indicator II the achievement obtained was 97.22% which was included in the "Very Good" category, then for indicator III the achievement obtained was 92.22% which was included in the "Very Good" category, and for indicator IV the achievement obtained was 88.33% which was also included in the "Very Good" category.

Of these four indicators, all of them are included in the "Very Good" category, but the one with the highest achievement is indicator I (degree of ionization of the acid-base solution). Indicator I is found in question number 2b, where in this question students are asked to determine the degree of ionization of an acid/base solution based on the data that has been presented. So, the overall results of chemical literacy skills in the content knowledge aspect produce an average percentage of 94.30% in the "Very Good" category. In the aspect of content knowledge, the N-Gain value obtained is 0.92 or if converted into a qualitative value, it is in the high criteria.

Students are able to apply their knowledge in relevant situations in everyday life, which can be seen from their excellent achievement in indicator I (Permatasari & Fitriza, 2019). This shows how students can be prepared to understand the material being taught by using the ethnoscience context of batik dye waste residues bound to acid-base materials. The achievement of chemical literacy in the lowest aspect of content knowledge is in the acid-base indicator material contained in question 6b.

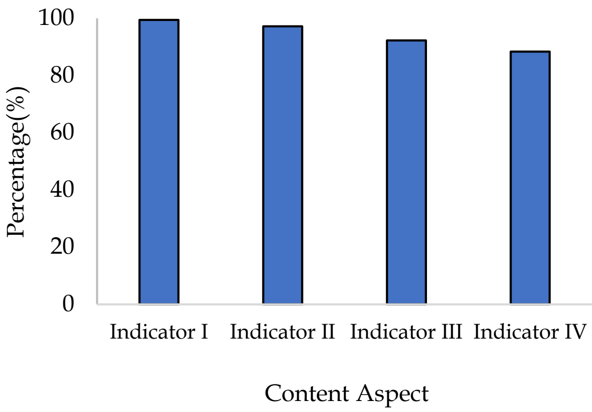

Figure 4. Percentage of chemical literacy posttest results for content aspects per indicator

As research states, students' learning difficulties in the sub-main of acid-base indicators are caused by students' ignorance about the factors that can influence color changes on the indicators. Apart from that, it also lies in students' ignorance in interpreting the color change trajectories of various acid and base indicators (Fajrin et al., 2020).

Aspects of Epistemic Knowledge

Epistemic knowledge is an understanding of the reasons underlying the procedures by which ideas or thoughts are generated and the justification for their use. In the aspect of epistemic knowledge, there is only one indicator related to acid-base solutions. This indicator is about the concept of acid-base theory according to the acid-base theory contained in questions number 1a and 1b. The achievements in each indicator are presented in Figure 5.

Chemical literacy in the epistemic knowledge aspect in question number 1a was 83.89% in the "Very Good" category, in question number 1b the achievement obtained was 78.89% which was included in the "Good" category. Chemical literacy, the highest aspect of epistemic knowledge with indicators of the concept of acid-base theory according to acid-base theory, is found in question number 1a. Where in this question, students are asked to explain the properties of the material used to remove more starch from batik cloth by relating it to Arrhenius's theory.

Overall the results of chemical literacy skills in the epistemic knowledge aspect produce an average percentage of 81.39% in the "Very Good" category. In the aspect of epistemic knowledge, the N-Gain value is 0.71 or if converted into a qualitative value, it is included in the high criteria.

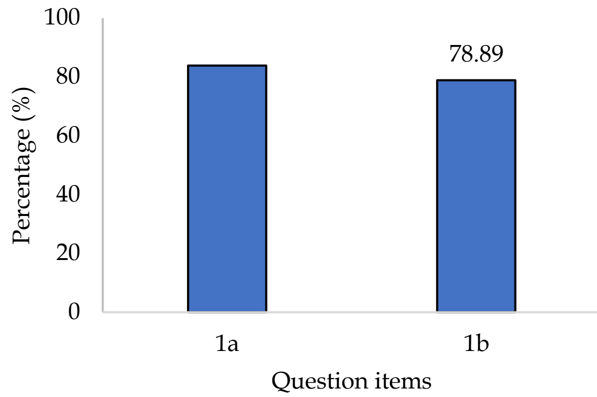

Figure 5. Percentage of chemical literacy posttest results on epistemic aspects

The high achievement of students on these questions indicates that students are able to apply acid-base theory to reaction equations. Students are able to correlate chemical material obtained during learning and relate it to the concept of acid-base theory provided in the LKPD which has been adapted to local batik wisdom products. According to Primadianningsih et al. (2023) that increasing chemical literacy skills must be supported by learning that fosters student creativity and activeness, one of which is by using an ethnoscience approach.

Indicators of the concept of acid-base theory are also found in question 1b and are still in the "Good" category. As for question 1b, Lewis's theory is used. Students' learning difficulties in the sub-main indicators of the concept of acid-base theory are caused by students' inability to apply acid-base theory to reaction equations. In line with research by Fajrin et al. (2020), students only try to remember information or memorize it, without connecting what they already know and have encountered in real life. So, there is no meaningful learning process, but only rote learning.

Aspects of Procedural Knowledge

In the procedural knowledge aspect, there are two indicators related to acid-base solutions, namely identifying acid-base indicators, and experimenting with natural acid-base indicators. The achievements in each indicator are presented in Figure 6.

The achievement of the procedural knowledge aspect in indicator I was 65.56% in the "Sufficient" category, in indicator II the achievement obtained was 63.33% also included in the "Sufficient" category. Of these two indicators, all of them are included in the "Sufficient" category, but the one with the highest achievement is indicator I (identification of acid-base indicators).

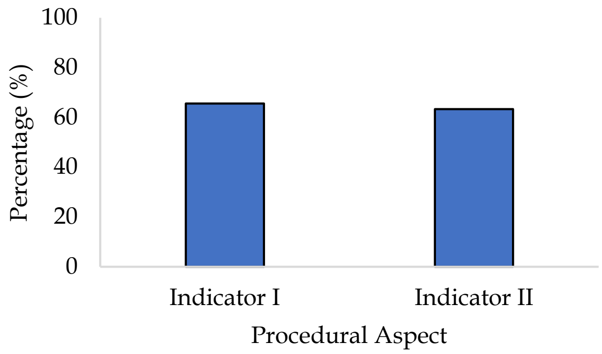

Figure 6. Percentage of procedural aspect chemical literacy posttest results per indicator

Indicator I is found in question number 4a, where in this question students are asked to explain the correct way to measure the waste resulting from batik making to determine whether the waste is classified as an acidic or basic solution. Overall the results of chemical literacy skills in the procedural knowledge aspect produce an average percentage of 64.45% in the "Enough" category. In the aspect of procedural knowledge, the N-Gain value obtained is 0.56 or if converted into a qualitative value, it falls into the medium criteria.

Both indicators were achieved in the "Sufficient" category, which shows that students have not fully applied the knowledge they have acquired in the context of the batik making process which is associated with acid-base material. This causes students to have difficulty connecting it with procedural knowledge. The developed ethnoscience worksheet is not optimal in facilitating students to improve aspects of epistemic knowledge. According to Fadly et al. (2022) procedural and epistemic knowledge are always in line with the process of building scientific knowledge. The process of acquiring procedural knowledge must be practiced in chemistry learning where students can be asked to carry out laboratory activities to understand chemical concepts by observing, collecting data, analyzing and making decisions.

Context Aspect

The context aspect in chemical literacy is the ability to recognize the importance of chemical knowledge in explaining everyday phenomena. Students can use their knowledge of chemistry in everyday life, as consumers of new products and technologies, in making decisions, and participating in chemistry-related issues (Rahmawati et al., 2021; Muntholib et al., 2020). The context aspect has two indicators related to acid-base solutions, including analyzing substances that are acid-base in everyday life, and experimenting with natural acid-base indicators. The achievements in each context aspect indicator are presented in Figure 7.

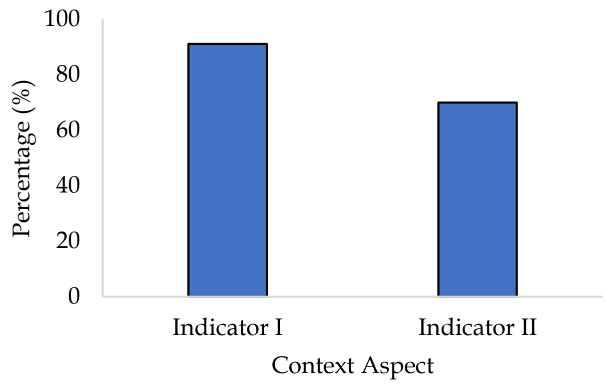

Figure 7. Percentage of chemical literacy posttest results for context aspects per indicator

Based on Figure 6, it is known that chemical literacy in the context aspect in indicator I is 91.11% in the "Very Good" category, and achievement in indicator II is 70% which is included in the "Good" category. Of these two indicators, the highest achievement was in indicator I, which is related to analyzing acid-base substances in everyday life. Indicator I is found in essay questions number 2a and 3a, where in question 2a students are asked to explain the purpose of adding caustic soda to the synthetic naphtol dye. Meanwhile, in essay question number 3a, students are asked to explain the purpose of adding hydrochloric acid to the synthetic indigosol batik dye. Overall the results of chemical literacy skills in the context aspect produce an average percentage of 84.07% in the "Very Good" category. In the context aspect, the

N-Gain value obtained is 0.81 or if converted into a qualitative value, it is in the high criteria.

Students have chemical literacy skills in aspects of the ethnoscience context in the good to very good category. The developed ethnoscience worksheet can increase motivation, foster curiosity and enthusiasm among students in learning and improve learning outcomes (Widiastuti & Priantini, 2022). Learning science by involving local culture will help students learn science that is in line with students' beliefs without being separated from the standard concepts that apply (Ariningtyas et al., 2017). The ethnoscience worksheet used is able to provide learning experiences to students, making it easier for them to understand chemical materials contextually (Jumalia & Suryelita, 2022). Students have the ability to provide assumptions related to the context of chemistry which is connected to its role as a science that has a function in everyday life (Andayani et al., 2021; Cigdemoglu & Geban, 2015).

Competency Aspects

The competency aspect in this research has three indicators, namely competence to evaluate scientific inquiry related to acid-base material, competence to interpret data and scientific evidence related to acid-base material, and competence to explain scientific phenomena to solve problems related to acid-base. The achievements in each indicator are presented in Figure 8.

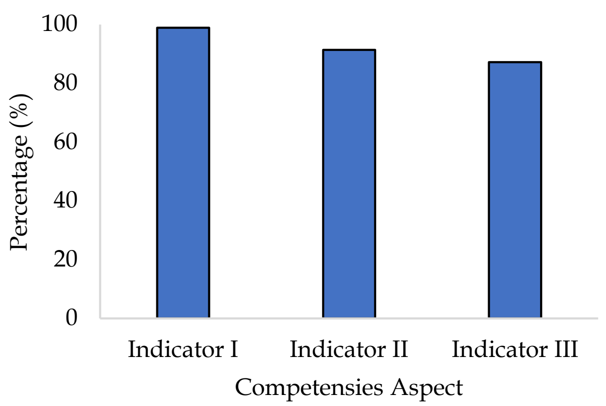

Figure 8. Percentage of chemical literacy posttest results for competency aspects per indicator

Based on Figure 7, it is known that chemical literacy in the competency aspect in indicator I is 98.89% with the "Very Good" category, indicator II achievement obtained is 91.39% in the "Very Good" category, and indicator III achievement obtained is 87 .22% in the "Very Good" category. Of these three indicators, the highest achievement was in indicator I, namely evaluating scientific inquiry related to acid-base material contained in essay question number 3c. Where in question 3c, students are asked to calculate the pH of a mixture of acid or base solutions based on the case study presented in the question. Overall the results of chemical literacy skills in the competency aspect produce an average percentage of 92.22% in the "Very Good" category. In the competency aspect, the N-Gain value obtained is 0.90 or if converted into a qualitative value, it falls into the high criteria.

Achieving chemical literacy in the highest competency aspect is the indicator for evaluating scientific inquiry contained in essay question number 3c, where students are asked to calculate the pH of an acid-base mixture solution from the problem presented in the question. The indication of the scientific inquiry assessment contained in question number 3c, where students are asked to calculate the pH of a mixture of acid-base solutions from the difficulties presented in the question, is the achievement of chemical literacy in the highest competency aspect. Based on these results, students have the ability to apply formulas, demonstrate operational mastery of mathematics, plan problem solving, and understand and evaluate calculation problems. These results were achieved because the exercises included in the ethnoscience integrated student worksheet were designed to help students better understand mathematical concepts.

Meanwhile, the achievement of chemical literacy in the lowest competency aspect is in the indicator of explaining scientific phenomena. This is in line with research by Khoiriza et al. (2021) which shows that students' ability to explain scientific phenomena is in the low category, namely one of the contributing factors is students' poor reading ability so that students' understanding is incomplete regarding the material being taught. . Research by Khasanah et al. (2021) which states that local wisdom is more applicable because it prioritizes usefulness and is supported by scientific findings supports improving the results of chemical literacy skills assessments, especially in the competency component. This is in accordance with the PISA 2006 statement which establishes three aspects of competency or process to increase scientific literacy in students using an ethnoscience approach (Pertiwi et al. 2019).

Conclusion

Based on the research results, it can be concluded that the integrated worksheet on batik ethnoscience that was developed has been declared suitable for use and received positive responses from students. Feasibility can be seen through material validation results of 92.86% and media validation of 96.67% in the "Very Feasible" category. The use of the developed LKPD provides an increase in students' chemical literacy skills with an N-gain test result of 0.81 in the high category. Overall, the average percentage of N-gain effectiveness is 81.03% in the Effective category. Every aspect has also improved. Analysis of students' chemical literacy in the content knowledge aspect obtained results of 94.30%, epistemic knowledge of 81.39%, and procedural knowledge of 64.45%. Analysis of students' chemical literacy in the context aspect obtained a result of 84.07%. Analysis of students' chemical literacy in the competency aspect obtained a result of 92.22%.

Acknowledgments

The author would like to thank SMA Negeri 12 Semarang for providing permission as a place to conduct research.

Author Contributions

The first author, Fitri Siami contributed to research design, instrument preparation, research implementation, data collection and analysis, and article writing. The fourth author, Harjono, was also involved in research design, data analysis, and writing the article. The second and third authors, Woro Sumarni and Sudarmin, guided throughout the research process and contributed to writing the article.

Funding

This research is part of research funded by DIPA Semarang State University in accordance with the 2022 UNNES DIPA Fund Research Implementation Agreement Letter Number 10.8.3/UN37/PPK.3.1/2022, March 8 2022.

Conflict of Interest

The authors declare no conflict of interest.

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