pISSN 2685-0761
eISSN 2685-0850

JURNAL INOVASI PEMBELAJARAN KIMIA
(Journal of Innovation in Chemistry Education)
https://jurnal.unimed.ac.id/2012/index.php/jipk
email: Jinovpkim@unimed.ac.id

Recieved : 26 July 2026
Revised : 02 October 2026
Accepted : 27 October 2026
Published : 31 October 2026
Pages : 426 – 432

# Culturally Responsive Teaching (CRT) Approach to Improve Science Literacy on Carbohydrate Materials

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***Abstract:*** *Science literacy remains a persistent challenge in Indonesian chemistry education, particularly in Papua, where teaching materials rarely connect with students' local culture. This study aimed to analyze the improvement of students' science literacy after learning carbohydrate topics through a Culturally Responsive Teaching (CRT) approach contextualized in Papuan sago (Metroxylon sp.). The research employed a one-group pretest-posttest design involving 20 twelfth-grade students of SMA Negeri 2 Serui, selected through purposive sampling. Science literacy was measured using a 15-item multiple-choice test, validated through Pearson Product Moment correlation ($r > 0.388$) and Kuder-Richardson 20 reliability testing ($r11 = 0.757$). Data were analyzed using Normalized Gain (n-Gain) across three learning sessions. The results showed a consistent increase in science literacy scores, from an average pretest score of 26.3 to a posttest score of 76.3, with an overall n-Gain of 0.69 (moderate category), and the highest gain (0.82, high category) achieved in the session addressing sago innovation and future application. It is concluded that the CRT approach, contextualized through Papuan sago culture, is effective in improving students' science literacy on carbohydrate material, although a longer intervention period is recommended to reach a high-gain category.*

***Keywords:*** *Culturally Responsive Teaching; science literac; carbohydrate*

## INTRODUCTION

One of the main goals of science learning in the 21st century is to equip students with science literacy skills, namely the ability to use scientific knowledge to explain phenomena, evaluate information, and make responsible decisions in daily life (OECD, 2023). However, the science literacy achievement of Indonesian students is still relatively low. The results of the Program for International Student Assessment (PISA) 2022 show that Indonesia's science literacy score is 383 points, far below the OECD country average of 485 points (OECD, 2023). This condition is also reflected in education units in Papua, which based on the Indonesian Education Report Card is still in the category that requires strengthening literacy (Ministry of Education and Culture, 2024).

The low science literacy of Papuan students is related to the limited use of teaching materials that are contextual and in accordance with the cultural characteristics of students. Most of the chemistry teaching materials used in Papuan schools are still dominated by examples from outside Papua, so students find it difficult to connect chemistry concepts with their life experiences (Jumriati & Allo, 2024). One of the relevant pedagogical approaches to bridge this gap is Culturally Responsive Teaching (CRT). According to Gay (2018), CRT is a learning approach that utilizes students' experiences, cultural values, language, and social background as the basis for designing and implementing learning, so that the material learned is connected to the students' real experiences and learning becomes more meaningful.

Papua is known as the region with the largest sago (Metroxylon sp.) resources in the world, with around 85% of Indonesia's sago forest potential being in Papua and West Papua (Bintoro et al., 2018). Sago has a high starch content (84-85% dry matter) composed of amylose and amylopectin, so it is very relevant to explain the concept of carbohydrates, such as polysaccharide structure, glycosidic bonds, and gelatinization processes (Karim et al., 2008). For students in Yapen Islands Regency, sago is not just a food, but part of a cultural identity that is inherited from generation to generation (Asmuruf et al., 2018). However, students in general are not able to relate the experience of consuming and processing sago with the chemical concepts learned in school, so carbohydrate matter is still seen as abstract material.

Several previous studies have shown that approaches based on local wisdom and ethnoscience are able to improve student learning outcomes (Siregar et al., 2022; Jumriati & Allo, 2024). Although research on CRT in science education has grown, empirical evidence regarding its application to specific chemistry content remains limited. A study by Rozi et al. (2025) showed that the CRT approach significantly improved students' science literacy by connecting cultural contexts to learning; however, that study focused on the higher education level and did not specifically address carbohydrate material. In addition, research by Salsabila Allissa Fitri and Wiyarsi (2025) found that the implementation of CRT oriented toward green chemistry on the stoichiometry topic was able to improve high school students' chemical literacy with a high n-gain category, particularly when local cultural contexts such as the use of natural dyes in batik were integrated. These two findings reinforce the urgency of the present study, namely to empirically test the effectiveness of CRT within the Papuan sago cultural context on carbohydrate material, which has not been investigated previously. However, research that specifically analyzes the effectiveness of the CRT approach in improving students' science literacy on carbohydrate materials in the context of Papuan sago culture is still limited. This gap shows the need for empirical studies on the extent to which the CRT approach contextualized with local culture can measurably improve students' science literacy. The novelty of this research lies in the application of CRT that is explicitly integrated with the context of Papuan sago ethnoscience and the measurement of its achievements using two dimensions of PISA science literacy, namely the ability to explain phenomena scientifically and the ability to analyze the local socio-cultural context (OECD, 2018).

Based on this description, this study aims to analyze the increase in science literacy of grade XII students of SMA Negeri 2 Serui after learning carbohydrate materials through the Culturally Responsive Teaching (CRT) approach which is contextualized with the local wisdom of Papuan sago.

## LITERATURE REVIEW

### *Culturally Responsive Teaching (CRT)*

CRT is a learning approach that places student culture as an integral part of the knowledge construction process, not just a complement to learning (Gay, 2000).

Culturally responsive learning has been proven to increase learning motivation, student involvement, confidence, and academic achievement because the material learned is linked to the real experiences that students have had (Gay, 2018). Ladson-Billings (1994) emphasized that learning that respects students' cultural identity will be more acceptable and encourages active participation in the learning process. The implementation of CRT in chemistry learning has been empirically tested by Wardani et al. (2023), who integrated an ethnochemistry-based approach within CRT on green chemistry material. The results showed that this approach had a significant effect on improving high school students' cognitive learning outcomes, because students were able to connect chemistry concepts with their cultural practices.

### *Science Literacy*

Science literacy includes the ability to identify problems, interpret scientific evidence, and apply science knowledge in various life contexts (OECD, 2023). Aikenhead and Ogawa (2007) state that true science literacy includes the ability to negotiate between local cultural perspectives and modern science, not just memorizing scientific facts. Thus, the integration of local cultural contexts into science learning has the potential to strengthen students' science literacy achievement in a more meaningful way. This finding is consistent with the study by Syahmani et al. (2024), which developed an e-module based on Culturally Wetland Responsive Teaching (CWRT) and reported an effective improvement in students' science literacy with a positive n-gain value, indicating that an approach responsive to local cultural contexts including wetland environments can measurably strengthen science literacy.

### *Sago as an Ethnoscientific Context on Carbohydrate Matter*

Sago is a local food that contains chemical concepts relevant to carbohydrate matter, such as the structure of amylose and amylopectin, glycosidic bonds, and the process of hydrolysis and gelatinization of starch (Karim et al., 2008). The knowledge of the Papuan people regarding the selection of sago trees that are ready to be harvested and the technique of processing pith into starch is a form of local wisdom that has scientific value and is worthy of being integrated into learning (Asmuruf et al., 2018). When the context of sago is integrated through the CRT approach, students are expected to be able to connect the cultural knowledge they already have with the chemistry concepts learned, so that carbohydrate learning becomes more contextual and meaningful. The integration of local wisdom in chemistry learning is not limited to the sago context. A systematic literature review by Cahyani and Fadly (2024) confirmed that the ethnoscience approach in chemistry learning consistently contributes to improving conceptual understanding, critical thinking skills, and students' scientific attitudes, with project-based and inquiry-based learning models as the most dominant strategies. This provides a theoretical foundation that local cultural contexts including sago have valid pedagogical value for building science literacy.

## METHODS

This study uses a quantitative approach with a one-group pretest-posttest design (Sugiyono, 2022), which is part of a field trial of the development of teaching materials (chemistry e-modules) based on the Culturally Responsive Teaching (CRT) approach in the context of Papuan sago. The focus of this article is on the analysis of improving students' science literacy after learning carbohydrate material using this approach.

### *Population and Sample*

The research population is all students in grade XII SCIENCE SMA Negeri 2 Serui which totals 215 students in the 2025/2026 school year. The research sample was 20 students of class XII MIIA 3 who were selected by purposive sampling technique, taking into account the similarity of the

curriculum (Independent Curriculum), teachers, and the initial level of knowledge of students. The research was carried out at SMA Negeri 2 Serui, Papua, in January-March 2026 through three meetings on carbohydrate materials.

### *Instruments and Procedures*

Students' science literacy was measured using a multiple-choice test of 15 questions arranged based on the two dimensions of PISA science literacy (OECD, 2018), namely the ability to explain phenomena scientifically and the ability to analyze the local socio-cultural context. Each meeting uses five questions that are tested in the form of a pretest (before learning) and a posttest (after learning), with the topic: (1) Papuan Sago - Local Wisdom in a Carbohydrate Perspective; (2) The Structure of Sago Starch and Its Properties; and (3) Sago for the Future - Identification and Innovation. The validity of the question items was tested using Pearson's Product Moment correlation with the help of SPSS, while the reliability of the instrument was tested using the Kuder-Richardson formula of 20 (KR-20) because the instrument was in the form of multiple-choice questions with a dichotomy score (Arikunto, 2013).

### *Data Analysis Techniques*

The increase in students' science literacy was analyzed using the Normalized Gain (n-Gain) formula from Hake (1999):

$$n\text{-}gain = (Spost - Spre) / (Smax - Spre) \quad (1)$$

with Spost is the average score of the posttest, Spre is the average score of the pretest, and Smax is the ideal maximum score. The categories of increased n-Gain were classified as high ($g>0.70$), moderate ($0.30 \leq g \leq 0.70$), and low ($g<0.30$) (Hake, 1999).

## RESULT AND DISCUSSION

### *Validity and Reliability of Science Literacy Instruments*

Instrument trials were conducted on 26 students outside the research sample to ensure the feasibility of the instrument. The results of the validity test using Pearson's Product Moment correlation showed that all 15 science literacy questions obtained a calculated r value ranging from 0.446 to 0.821, greater than the r table (0.388) at a significance level of 5%, so that all questions were declared valid. The results of the reliability test using the KR-20 formula showed a coefficient of 0.757 (strong category), so that the instrument was declared reliable and suitable for measuring students' science literacy.

These findings are in line with the research of Nurfadillah et al. (2023) which shows that science literacy-based chemistry test instruments compiled based on clear indicators and relevant learning contexts produce a good level of validity and reliability. A summary of the results of the validity and reliability test of the instrument is presented in Table 1.

**Table 1.** Results of the validity and reliability test of science literacy test instruments

| Aspects | Number of Items | Range r calculation | r Table | KR-20 | Remarks |
|---|---|---|---|---|---|
| Science Literacy | 15 | 0.446-0.821 | 0.388 | 0.757 | Valid & Reliable |

### *Improving Students' Science Literacy*

The analysis of the results of students' science literacy skills at three meetings using carbohydrate material learning based on the CRT approach in the context of Papuan sago was obtained from the results of the n-Gain test as presented in Table 2.

**Table 2.** Results of the n-Gain test of students' science literacy ability

| Meetings - Topics | Pretest | Posttest | n-Gain | Categories |
|---|---|---|---|---|
| I - Local Wisdom of Sago | 13 | 65 | 0.60 | Medium |
| II - Structure of Sago Starch | 26 | 75 | 0.66 | Medium |

| | | | | |
|---|---|---|---|---|
| III - Sago of the Future | 40 | 89 | 0.82 | Height |
| Average | 26.3 | 76.3 | 0.69 | Medium |

Based on Table 2, the average pretest score of students increased from 26.3 to 76.3 in the posttest, with an average n-Gain value of 0.69 in the medium category. The most significant increase occurred in the third meeting with the topic "Sago for the Future - Identification and Innovation" (n-Gain 0.82, high category), which indicated that topics that invited students to think creatively about the potential of sago were able to stimulate high-level thinking skills as an important component of science literacy. The comparison of the average pretest and posttest scores at each meeting is shown in Figure 1, while the achievement of the n-Gain category at each meeting is shown in Figure 2.

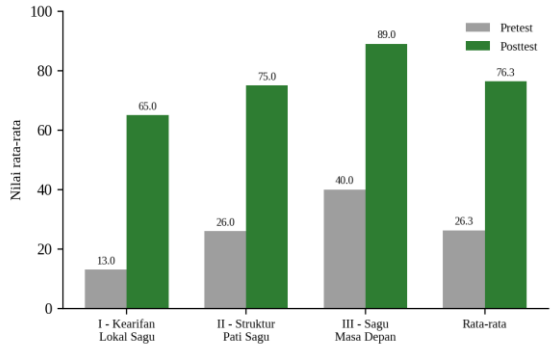



**Figure 1.** The average pretest and posttest scores of science literacy ability in each meeting

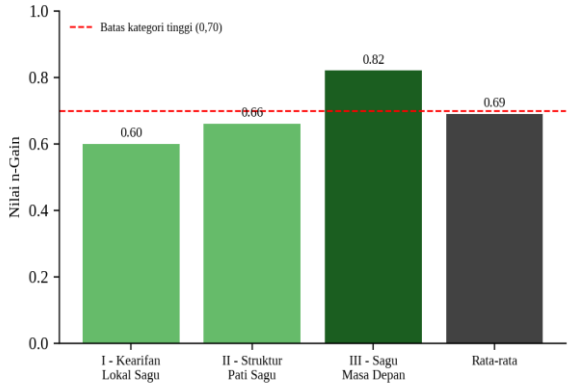



**Figure 2.** Diagram of n-Gain of science literacy skills per meeting

Consistent improvement from the first to the third meeting showed that carbohydrate learning based on the CRT approach in the context of Papuan sago contributed positively to students' science literacy skills. These findings are consistent with research that shows that ethnoscience-based chemistry learning is able to improve students' science literacy because the local cultural context provides a strong foundation to understand science concepts contextually (Sudarmin, 2014). The CRT approach that respects the cultural background of Papuan students and integrates them into chemistry learning has been proven to create a learning environment conducive to the development of science literacy, in line with the view of Aikenhead and Ogawa (2007) that science literacy includes the ability to negotiate between local cultural perspectives and modern science.

However, the achievement of n-Gain in science literacy as a whole is still in the medium category (0.69) and has not reached the high category (≥ 0.70). There are several factors that can explain this condition. First, the learning duration limited to three meetings is not enough to build the entire dimension of science literacy in depth, especially the process dimension that requires the ability to design scientific investigations. Second, carbohydrate concepts such as the structure of amylose, amylopectin and glycosidic bonds require repetitive molecular visualizations that are difficult to achieve optimally in just three learning sessions. Third, students are not familiar with the format of science literacy-based questions that require data interpretation and evidence-based decision-making, which is different from the common memorization questions. Fourth, low pretest scores (average of 26.3) indicate that students' initial science literacy ability is far below standard, so upgrading to the high category requires a longer duration of intervention.

These findings suggest that the application of the CRT approach in the context of Papuan sago ethnoscience needs to be implemented in a longer learning framework, complemented by guided inquiry activities, and integrated with continuous formative assessments so that the

improvement of students' science literacy can reach the high category.

## CONCLUSION

The Culturally Responsive Teaching (CRT) approach contextualized with the local wisdom of Papuan sago has proven to be effective in improving the science literacy of grade XII students of SMA Negeri 2 Serui in carbohydrate materials, with an average n-Gain value of 0.69 in the medium category and the highest achievement (0.82, high category) in topics that require high-level thinking skills. These findings suggest that the integration of local cultures into chemistry learning is able to bridge traditional knowledge with formal science concepts. Implicitly, chemistry teachers in areas with local cultural richness can adopt the CRT approach as a strategy to improve students' science literacy, by extending the duration of interventions and adding guided inquiry activities to achieve more optimal improvements.

## ACKNOWLEDGEMENT

The author would like to thank SMA Negeri 2 Serui for the support and permission given during the implementation of this research.

## REFERENCE

Aikenhead, G. S., & Ogawa, M. (2007). Indigenous knowledge and science revisited. Cultural Studies of Science Education, 2(3), 539-620. https://doi.org/10.1007/s11422-007-9067-8

Arikunto, S. (2013). Research procedure: A practical approach. Rineka Cipta.

Asmuruf, O., Wanma, J. F., & Rumatora, A. J. (2018). The local wisdom of the Ayamaru people in the use and cultivation of sago. Journal of Agriculture of Papua, 7(2), 85-96. https://doi.org/10.46703/jurnalpapuasia.Vol4.Iss2.100

Bintoro, M. H., Supriadi, D., & Ardiana, R. (Eds.). (2018). Sago: An alternative carbohydrate source for food security. IPB Press.

Cahyani, V. P., & Fadly, D. (2024). Local wisdom in chemistry learning: A literature review on the ethnoscience approach. *Jurnal Studi Guru dan Pembelajaran, 7*(3), 1262–1274. https://doi.org/10.30605/jsgp.7.3.2024.4801

Gay, G. (2000). Culturally responsive teaching: Theory, research, and practice. Teachers College Press.

Gay, G. (2018). Culturally responsive teaching: Theory, research, and practice (3rd ed.). Teachers College Press.

Hake, R. R. (1999). Analyzing change/gain scores. American Educational Research Association. https://web.physics.indiana.edu/sdi/AnalyzingChangeGain.pdf

Jumriati, & Allo, E. L. (2024). The development of ethnoscience in chemistry learning in the Independent Curriculum: A literature review. ChemEdu: Scientific Journal of Chemical Education, 5(1), 150-162. https://doi.org/10.35580/chemedu.v5i1.62393

Karim, A. A., Tie, A. P. L., Manan, D. M. A., & Zaidul, I. S. M. (2008). Starch from sago (Metroxylon sagu) palm tree-properties, prospects, and challenges as a new industrial source for food and other uses. Comprehensive Reviews in Food Science and Food Safety, 7(3), 215-228. https://doi.org/10.1111/j.1541-4337.2008.00042.x

Ministry of Education and Culture. (2024). Indonesian Education Report Card 2024: Results of national assessment.

Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia. https://raporpendidikan.kemdikbud.go.id

Ladson-Billings, G. (1994). The dreamkeepers: Successful teachers of African American children. Jossey-Bass.

Nurfadillah, T., Elvia, R., & Elvinawati. (2023). Development of science literacy-based chemistry test instruments to measure students' science literacy. ALOTROP: Journal of Education and Chemical Sciences, 7(1), 44-56. https://doi.org/10.33369/alo.v7i1.28253

OECD. (2018). PISA 2018 assessment and analytical framework. OECD Publishing. https://doi.org/10.1787/b25efab8-en

OECD. (2023). PISA 2022 results (Volume I): The state of learning and equity in education. OECD Publishing. https://doi.org/10.1787/53f23881-en

Rozi, F., Suyanti, RD, & Ansya, YAU (2025). Culturally Responsive Teaching as a Strategy to Improve Students' Science Literacy in Higher Education. *Journal of Science Education Research*, 11 (6), 58-67.

Siregar, T., Karubaba, M., Siallagan, J., & Inggamer, M. M. (2022). Development of chemical e-modules based on Papua local wisdom on reduction and oxidation reaction materials to increase student learning outcomes. Journal of Indonesian Education, 10(3), 118-128. https://doi.org/10.31957/jipi.v10i3.2409

Salsabila Allissa Fitri, H., & Wiyarsi, A. (2025). Students' chemical literacy improvement in culturally responsive teaching oriented toward green chemistry for stoichiometry topic. *EPJ Web of Conferences, 344*, 1–7. https://doi.org/10.1051/epjconf/202534400000

Syahmani, S., Iriani, R., Kusasi, M., Prasetyo, Y. D., Norhasanah, H., & Rahman, N. F. A. (2024). Culturally Wetland Responsive Teaching to improve science literacy and Wasaka character.. *Journal of Innovation in Educational and Cultural Research, 5*(2), 196–206. https://doi.org/10.46843/jiecr.v5i2.1075

Sudarmin. (2014). Ethnoscience character education and local wisdom (Concept and application in science research and learning). Faculty of Mathematics and Natural Sciences, Semarang State University.

Sugiyono. (2022). Quantitative, qualitative, and R&D research methods (Revised edition). Alphabet.

Wardani, LK, Mulyani, B., Ariani, SRD, Yamtinah, S., Masykuri, M., Ulfa, M., & Shidiq, AS (2023). The effect of a culturally responsive ethnochemistry-based teaching approach to improving cognitive learning outcomes in green chemistry material in senior high schools. *Journal of Science Education Research*, 9 (12), 11029-11037.