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# Indonesian national assessment support: Can RE-STEM Android app improve students' scientific literacy skills?

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**ABSTRACT**

The Indonesian National Assessment set by the government is in line with the Program for International Student Assessment (PISA) assessment which includes students' scientific literacy skills for a 21st century education succeeds. This study determined the increase in students' scientific literacy skills through ethnoscience, science, technology, engineering, mathematics or ethno-STEM learning assisted by RE-STEM App. A quasi-experimental design with the type of one-group pretest-posttest design was used to obtain data from the treatment. There were 102 students involved by purposive sampling technique from a 338 population of grade 8 students in a rural secondary school in Central Java, Indonesia. RE-STEM App involves four themes of Indonesian cultures as learning resources, namely *tarutu*, tin-telephone, *calung*, and bird whistle. This study revealed that students' scientific literacy skills increased by 61.33% in the medium category in general, also in each aspect. Research data indicate that the RE-STEM App has supported teachers to improve students' scientific literacy skills. By applying ethno-STEM through RE-STEM App, teachers can help students to investigate the science concepts in ethnoscience. This strategy proved that ethnoscience aspect can be an important factor in developing students' scientific literacy skills.



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## 1. INTRODUCTION

The Indonesian National Assessment (AN) for mapping the quality of learning activities in all schools in Indonesia entered the implementation stage in mid-2021 [1]. One of the implementations of the AN is the measurement of student minimum competency (AKM), which includes literacy and numeracy skills tests [2]. The Indonesian National Assessment is motivated by the fact that Indonesia's literacy rating in the Program for International Student Assessment (PISA) assessment has not met expectations [2]. According to PISA, the literacy rating of Indonesian students is still low, although in recent years there has been an increase. Indonesian assessment tested higher-order thinking skills which are 21st century skills [3], one of which is scientific literacy skills. Educational stakeholders can find out the profile of the process and results of learning activities in the schools through Indonesian National Assessments. Teachers must be more active in making innovative learning strategies to improve students' literacy skills.

Literacy skills as a work tool are more likely to develop in secondary schools because of their stage who are ready to interact with innovation [4]. Thus, it is urgent to focus on students' literacy skills, especially scientific literacy skills, so that teachers recognize the scientific literacy level of their students and evaluate them in the future. Literacy skills assessment in the minimum competency assessment includes fiction and nonfiction literacy, briefly known as science literacy skills. Indonesian National assessment shows the better development of education that began to pay attention to students' literacy skills. The fact that scientific literacy skills are a national desire shows that our education is moving to a better literacy rank in PISA. It means that teachers must work hard to create innovative pedagogies that have a positive impact on students' achievement and develop their 21st century skills, especially scientific literacy skills [3]. Teachers should further improve innovative strategies to support student literacy activities.

The national assessment certainly encountered many obstacles. Teachers should form new learning strategies [5]. The Indonesian educational authority made a new assessment policy through the national education program. The assessment policy has begun to be recognized by teachers, but many of them have not been able to provide higher-order thinking skills problems according to the indicators of the AN instrument [6]. Thus, teachers need to improve their skills for better literacy assessment. One way to improve teacher skills is to increase learning that supports literacy, as integrating ethnoscience in learning activity. Ethnoscience is one way to help students improve their scientific literacy skills [7]. Considering that Indonesia is a country that is rich in culture, teachers can use it as a source of learning science. Students can be learn to think about the scientific view of each culture or indigenous belief from generation to generation and is still believe today [8]. Another need to support scientific literacy and demand 21st century skills in education is to improve teacher and student training in science, technology, engineering, and mathematics (STEM) fields [9].

STEM education increases students' motivation toward science, involves students' scientific reading, and improve scientific literacy skills [10]. STEM has been at the center of attention in education during the pandemic. STEM helps teachers engage students in discovering social and scientific phenomena. Ethnoscience integrated STEM learning is a breakthrough in improving students' cultural literacy skills. It can also escalate students' scientific literacy skills, critical, creative thinking, and other 21st century skills by understanding science from an unusual context, as understanding science through its own culture. [11]. The development of teaching materials that have integrated STEM and ethnoscience can be a better solution to the lack of knowledge for some teachers. Ethno-STEM Android application called 'RE-STEM App' is structured in such a way to make it easier for students and teachers to carry out science learning. The application of RE-STEM learning that utilizes applications, electronic devices, websites, or the internet (e-learning) can help students improve their scientific literacy skills [12]. E-learning or learning applications are positively affect academic success and student intentions. However, there is a need for developing digital learning competencies [13], [14].

RE-STEM is an application that assembled by collecting STEM aspects based on ethnoscience to support science learning. It is hope that through ethnoscience students can carry out science activities according to the scientific method through STEM steps. This application is also support by animated videos and evaluations that can be access directly by teachers and students to facilitate learning on both sides. It is hope that the ethnoscience context can support the aspects of the science context ability, while the science content in this application also supports the students' science content ability. Science process abilities are also support by RE-STEM applications through engineering activities provided complete with animated videos and other applications that provided to support student practice activities. Through several existing activities, it is hope that the students' scientific attitude will naturally emerge. If RE-STEM succeeds in improving students' scientific literacy skills, it hopes that this application can also support the literacy improvement program launched by the government through a national assessment. Therefore, this study determined whether the RE-STEM Application can improve students' scientific literacy skills or not.

## 2. RESEARCH METHOD

The quasi-experimental method with one group pretest-posttest control design employed in this research to test the improvement of students' scientific literacy. This project given in a rural school in Central Java, Indonesia, to the eighth-grade students. The samples taken by purposive sampling of 102 students from 338 student populations in this school. The class activities were focused on the sound wave topic by using Android App, RE-STEM: Science learning App. This application contained ethnoscience (indigenous science) and STEM bases to provide students to learn science-based on their culture. There were four experiments in four themes are included in this App, namely: i) *Tarutu*-themed sound source is a traditional flute made of coconut or banana leaves to determine sound waves and the relationship between *tarutu* length and frequency as shown in Figure 1(a); ii) Sound propagation media with paper cup telephone/tin telephone theme: A traditional telephone toy made of two paper cups or two cans to prove the difference between several sound wave mediums as shown in Figure 1(b); iii) Frequency and resonance with the theme *calung*:

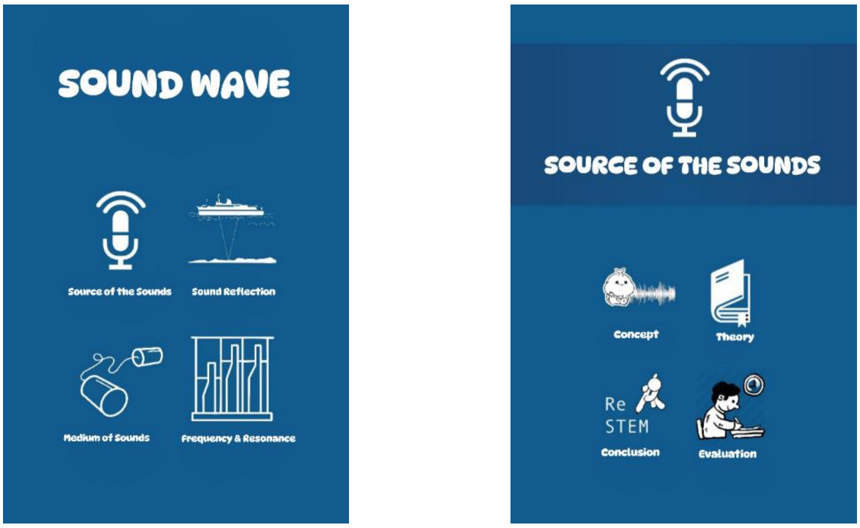
a traditional Indonesian musical instrument made of bamboo to explain the function of the column air to resonance and its relationship to the *calung* frequency as shown in Figure 1(c); iv) Reflection of sound waves with *sempritan manuk* or bird whistles pipe as shown in Figure 1(d). *Sempritan manuk* is a traditional whistle made of bamboo that has a bulkhead that can be pulled and pushed to change the length of the air column inside to show the range of frequency and used as the sound source at reflection kit.

(a) (b) (c) (d)

Figure 1. Indonesian traditional toys and instruments for sound wave themes: (a) *tarutu*, (b) cup telephone, (c) *calung*, (d) *sempritan manuk*

This application provided complete learning steps. First, apperception activities. Second, presentation of material, which included the elaboration of knowledge based on its culture. Third, examples of technology relevant to the theme. Fourth, steps of experimental activities to made students practice, like an engineer equipped with sound meters to support their experimental activities. Fifth, related analysis tables also provided. Ethno-STEM conclusions and evaluations for learning assessment also provided in this application, making it easier for teachers to apply these applications in science learning.

The sample of RE-STEM App in each part is shown in Figure 2 to Figure 6. The front display menu of the application is shown in Figure 2(a), while the sample of menu for each chapter which contains a menu of concepts, theories, conclusion, and evaluation is shown in Figure 2(b). This application also equipped with concept animations that clarify the concepts in each material, as in the example shown in Figure 3. The theory menu material as shown in Figure 4 starting from science concepts, technology concepts, the engineering section which contains steps for student activities as an engineer, and the mathematics section to invite students to analyze the results of experimental data. The application is also equipped with tutorial videos for simple experiments as presented in Figure 5 and the sound meter for students to calculate frequency, amplitude, and sound intensity as shown in Figure 6.




(a) (b)

Figure 2. Sample of RE-STEM application in (a) front display app and (b) sample of menu of each chapter

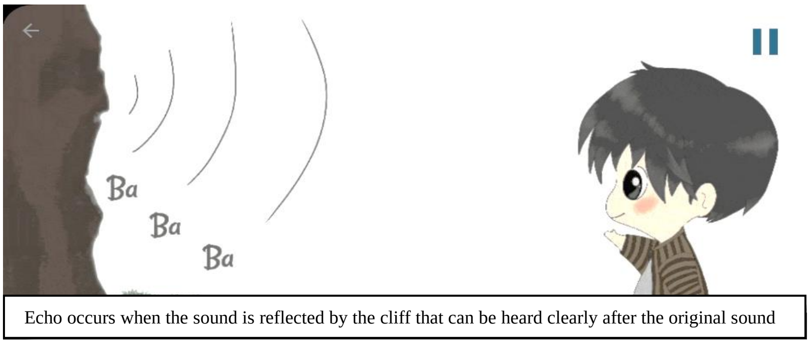



Figure 3. Sample of simple concept animation in reflection of sound chapters

Ethnoscience

**Tarutu,**
*Terompet Khas Banyumasan*

Tarutu adalah terompet khas daerah Banyumas. Terompet tradisional ini terbuat dari daun kelapa atau biasa disebut 'janur'. Sejak kecil, ayah atau ibumu mungkin pernah mengajarimu membuat terompet kecil dari daun pisang atau daun kelapa. Terompet ini diajarkan turun temurun dari nenek moyang kita loh. Oleh para warga Banyumas, terompet ini dinamakan tarutu.

Tarutu, terompet yang dari daun kelapa.

3

Tarutu adalah terompet tradisional yang terbuat dari daun kelapa yang dirangkai menjadi terompet besar. Jenis tarutu ada dua. Pertama, tarutu yang hanya terbuat dari daun kelapa dengan pangkal tarutu yang dibuat pipih. Ke-dua, tarutu yang pada pangkalnya terdapat peluit yang terbuat dari 'damen' atau batang padi yang diberi rongga-rongga kecil pada ujungnya. Peluit kecil tersebut dinamakan 'dromenan'.

Karena dromenan dibuat dari batang padi, maka tarutu hanya bias dibuat ketika panen. Nah, ketika tidak sedang musim panen, kamu juga bisa membuat tarutu sederhana dari daun pisang lho.

re: Ethnoscience Side
Traditional Trumpet from Banyumas
Tarutu is a traditional trumpet from Banyumas. This whistle made from coconut leaves or Banyumas people called it 'janur'. Once childhood, your dad or mom have teach you to make traditional trumpet from banana leaves or coconut leaves, maybe. This trumpet taught from generation to generation by our ancestors. This trumpet called tarutu for Banyumas people.

Tarutu is traditional trumpet from coconut leaves, which strung up to be bigger. Tarutu has two types, tarutu with flat tip and tarutu with 'dromenan' (mini whistle from rice straw with small cavity).

Because of dromenan made from rice straw, so, tarutu only exist during the rice harvest. So, when it's not harvest season, we can still make it from banana leaf! (Translated)

Figure 4. RE-STEM theory of wave sub-chapters

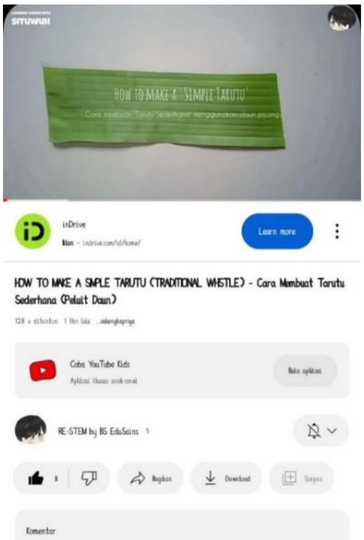


Figure 5. Video tutorial for simple experiments (How to make a simple *tarutu*)

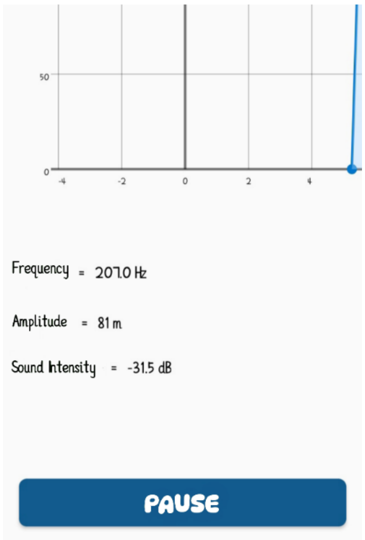



Figure 6. The sound meter for students to calculate frequency, amplitude, and sound intensity

Every student applies the RE-STEM app as their learning media to guide themselves when doing every simple experiment. The description of cultural science, science, and technology content provided in the explanation story texts. Engineering content that served in the form of simple experiments with work instructions in the text and videos. To obtain data on science literacy improvement, students tested with 20 scientific literacy essay questions (based on aspect of science context, science content, science process, and science attitudes) before and after treatment. The question divided into four post-test sessions after the activity, where they would answer five questions related to the activities they have done. The five questions always cover four aspects of scientific literacy, so that each activity evaluated for its scientific literacy skills. These aspects of scientific literacy skills in this case based on PISA (the context of science, science content, science processes, and science attitudes). The literate students explained clearly based on theory, but they could explain with their own arguments.

> "*The smaller hole of tarutu, the more vibrations it produces. If the base hole of tarutu is flattened, it will make the incoming air produce a faster vibration, so the sound produces will be louder than the tarutu whose base is not flattened*." (Literate students' answers)

The students with low scientific literacy skills could not answer with clear argument. They just explain without explaining reason or giving argument with the theory.

> "*Because if the hole in the trumpet is small it produces sound*." (Non-literate students' answers)

Normalized Gain (N-Gain) test data according to the Hake factor [15] was used to analyze the increased of scientific literacy skills.

$$\langle g \rangle = \frac{\langle post \rangle - \langle pre \rangle}{100 - \langle pre \rangle}$$

## 3. RESULTS AND DISCUSSION

### 3.1. Results

The data obtained from the treatments show that there is a significant improvement in students' scientific literacy by the N-Gain test. This improvement explained by the differences between pretest and post-test achievement as presented in Table 1. The student achievement in the experiment class increased significantly. The average increase in students' scientific literacy ability of 0.65 points, in the range of 0.3<N-Gain<0.7 included in the moderate category. This result showed that RE-STEM App could improve students' scientific literacy skills. The N-Gain of students' scientific literacy in every aspect also measured. Improvement in these aspects shown in Table 2.

The N-Gain of students' scientific literacy skills in each aspect increased significantly in the moderate category. The lowest N-Gain is the attitude toward the science aspect, with the lowest average score of the post-test. However, the N-Gain of attitude toward science aspects is still in the moderate range, and the average post-test score is good. The highest N-Gain score is the scientific process skills aspect with a score of 68.62%, almost reaching a high improvement category. This result showed that RE-STEM App could improve students' scientific literacy skills not only in general skills, but also in each aspect.

Table 1. N-Gain test of students' scientific literacy skills

| Pre-test | Post-test | N-Gain (%) | Category |
|---|---|---|---|
| 27.12 | 71.79 | 61.33 | Moderate |

Table 2. N-Gain test of scientific literacy aspects

| Scientific literacy aspects | Pre | Post | N-gain (%) | Category |
|---|---|---|---|---|
| Science context | 26.06 | 74.84 | 65.97 | Moderate |
| Science content knowledge | 21.27 | 65.05 | 55.60 | Moderate |
| Scientific process | 28.87 | 73.68 | 62.99 | Moderate |
| Attitude toward science | 33.82 | 73.28 | 59.63 | Moderate |

### 3.2. Discussion

The result showed that the learning activities with RE-STEM App have great potential in developing scientific literacy skills, especially in the 'sound wave' topic learning. The improvement of scientific literacy was in favor of the application in the experiment class employed. Ethno-STEM activities in science learning are effective methods for improving their scientific literacy skills by up to 65%. This result is acquiescent with STEM learning studies in digital application, e-learning, or blended learning in enhancing student scientific literacy skills [16]. Scientific literacy is a step of finding information of curiosity, decision making, elaboration [17], and understanding of general knowledge and its methods to solve a specific content [18].

For example, based on the results of observations in this study, students have given an apperception in the form of an introduction to the culture of their place of residence. Then, students have given a prompting question, ‘How can sound be created from this simple *tarutu*?’ Literate students find out information from the reading sources in the application. They present arguments based on the information they have obtained. Some of them directly provide argumentation without reading good answers. Students who answered well (as the teacher expected) indicated that these students already had good initial scientific knowledge. They could process the information they had previously obtained without searching for new pieces of information. Some of the other students answered randomly without exploring the information first.

The ethnoscience can encourage students to be curious and willing to give an idea even though it was not entirely true. This issue is one of the exciting issues in this research. The integration of local wisdom in long-term education affects their awareness of solving scientific problems, providing ideas, or increasing their scientific and technological knowledge [7]. Teachers can exploit the cultural issues, to invite students to find the answer according to scientific facts. Activities directly related to the local environment are the key to finding the meaning of science and developing students to provide scientific solutions and arguments [19]. Cultural science activities in STEM learning encourage students’ scientific literacy skills [7]. This statement is supported by some ethno-STEM research which this learning model and strategy show the enhancement of scientific literacy skills [20].

Indigenous students can identify scientific issues and explain scientific phenomena better than non-indigenous students [21]. Although only small number of students are familiar with the culture that is the theme of the student experiment, their curiosity increases as they discover new things. Most students feel unfamiliar with the culture introduced by teachers such as *tarutu*, but they are familiar with the local wisdom materials used so that it is easier for them to practice. The curiosity of students showing good self-confidence and motivation is what will further encourage their scientific achievements [22]. The learning that is carried out by integrating the culture in the local area creates a learning atmosphere that can increase students’ insight and motivation toward science [23]. Through their cultural content, they are increasingly confident in their scientific abilities, thus helping to improve their scientific literacy [7]. Students’ scientific literacy skills are represented by their perception of their ability because self-beliefs play on one’s competencies [9]. Based on the test results of increasing scientific literacy skills, it clearly shows the effect of using RE-STEM applications on students’ scientific literacy skills. It was hope that this application can support the literacy improvement program has launched by the government through the national assessment. Moreover, the content of ethnoscience which a source of learning in this application supports literacy strengthening. Not only ethnoscience, the STEM pathway used also trains students to be more scientifically literate.

### 3.3. Science context

Science context is an understanding of science and technology through global, local, or personal issues [24]. As explained, ethnoscience is indigenous knowledge owned by the community from a scientific point of view. Ethnoscience is a way of understanding science through the context of the local culture. If students can understand the context of science from their culture, then they can apply science well. RE-STEM App can deliver students’ scientific understanding of their cultural knowledge and increase their context science aspect of scientific literacy by 65.97% in the moderate N-Gain category. Students can understand science by thoroughly understanding culture and their daily activities. Environmental experiments using nature materials help to make scientific language foreign more real. Indigenous content in this App focused on linking science to understanding sociocultural knowledge. This content can support teachers to distinguish students’ experience and their learning needs [25]. Indigenous students are capable to show off their critical arguments and concerning their experiences to the relevant thematic science content [26].

### 3.4. Science content knowledge

Science content knowledge is an understanding of concepts, theories, laws, or phenomena based on scientific knowledge [24]. A science-literate person is someone who has a piece of scientific knowledge and understands it in keeping the principle of science by achieving scientific information from any tools [27]. The understanding of science principles by achieving scientific information is the body of scientific knowledge or science content knowledge. Through RE-STEM App, students’ scientific content knowledge has improved by 55.60% in the moderate N-Gain category. This improvement shows that students can achieve some information about science, especially sound wave material from any tools, including RE-STEM App. Science principle through ethnoscience explained in this App in some STEM steps. Furthermore, ethno-STEM learning support teacher to enhance students’ conceptual understanding of science [28]. Some students can clearly describe sound concepts in *tarutu* and add more detail explanatory ideas made by themselves. Indigenous knowledge given to students raises students’ scientific motivation so that they are confident in expressing ideas and questions about the material they are studying.

During online and offline activities, students asked more questions and gave their opinion about the science concepts in cultural themes that were implemented in learning, such as how the sound can be heard loudly on *calung* bamboo sticks. In the middle of the activity, students found one of the bamboo sticks which was broken and did not produce a loud sound when hit. Such an unexpected situation needs used by the teacher to ask students why the broken *calung* bamboo stems cannot produce a loud sound. Unexpectedly, students competed to answer the teacher's questions more enthusiastically than in the previous learning activities. Students need teacher assistance during the learning process which is important for students' motivation and beneficial for students' permanent scientific literacy skills [29]. Although the scientific literacy skills have improved by 66%, we cannot ignore some students who have difficulty understanding science concepts in ethno-STEM reasoning. Students who have a limited vocabulary of science do not have a good ability for understanding science papers at school [27]. Based on student answers, some students were able to re-describe the theory on the short material menu in the application without adding ideas and some students cannot explain the scientific theory well. They are not proper at understanding text and difficult to collect the main ideas and are limited in arranging relevant text from their science books [27].

### 3.5. Science process

RE-STEM application supports students in conducting simple experiments trains the scientific process to students that are adapted for students learning to become engineers or scientists. The result of this study shows that student scientific process skill has improved by 62.99% in the moderate category. Students' scientific process has a higher improvement that almost reaches a high category (70% or above). This result supports several studies, that STEM learning help teacher improve students' scientific process skill [30] and the content of STEM connected students' attainment of the science process and their academic achievement [31]. Ethno-STEM learning helps students learn science with the right scientific process so that it helps improve their scientific knowledge [32]. By improving their indigenous knowledge in the ethno-STEM program, students know their science competencies to do more science experience and recognized their motivation to do science learning [28].

Each given theme invites students to make simple works such as a *tarutu* traditional game (a whistle made of banana leaves) with variations in pipe length to understand the different frequencies in different *tarutu* air columns. This activity not only invites students to learn about the culture that has been eroded by modern times but also hones students' literacy skills in applying their knowledge to the stage of scientific practice. Students indirectly invited to think about how *tarutu* can sound, why the length of the pipe can affect the frequency of the sound produced, and why the sound can sound loud only if the base of the *tarutu* flattened. The scientific process that triggers students exemplified by knowing what *tarutu* was their initial knowledge and how the knowledge they can understand from this traditional music game. At this stage, students have made initial observations to build problem formulation knowledge that they store in their thoughts. The scientific questions they get are what encourage students to dig deeper into scientific information. The information that they get then used to prove the results of their thoughts through small experiments provided in the application through the theme of activities according to the material they are studying. In the *tarutu* theme, students are invited to understand the concept of sound sources and how sound can propagate. The simple sound meter application that inserted in RE-STEM App also helps students understand how the device works in capturing the frequency and intensity of sound in real-time.

### 3.6. Students' attitude toward science

RE-STEM App supports students' attitude toward science in the moderate category by 59.63% N-gain achievement. This result shows that ethnoscience supports STEM in fostering interest in science [33]. This study also corroborates Fasasi and Olagunju that ethnoscience-based learning had a significantly positive correlation in attitude toward with science [34]. Ethno-STEM improves their indigenous science confidence and self-efficacy in learning science by using their daily lives [28]. Indigenous students have identities as learners, users, and extend and the body of science and STEM. Culture is relevant to students' science experiences and supports their capacity to cross-culturally connect with their understanding of science. By providing culturally relevant teaching, which redirects complex knowledge, their learning experience opportunities are more likely to demonstrate scientific achievement, interest, and cross-cultural differences between their cultural knowledge and their scientific knowledge. Cross-cultural pedagogy helps students link science and sociocultural knowledge [26].

## 4. CONCLUSION

Generally, scientific literacy skills can improve by implementing ethno-STEM through RE-STEM App. The scientific learning methods (in app supported) also help teachers enhance students' scientific literacy in each aspect. Ethnoscience-learning integration embodied in several learning themes and related to traditional Indonesian culture is one of the significant factors in developing students' scientific literacy skills.

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