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Science Process Skills and the Potential of Ethnoscience Integration in Chemistry Learning: A Preliminary Study of Media Development

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Abstract

This study aims to analyze the needs in developing ethnoscience-based chemistry learning media oriented toward science process skills (SPS), particularly on the Voltaic Cell material for 12th-grade senior high school students (SMA/MA). The research method employed was research and development (R&D) using the ADDIE model, focused on the needs analysis stage through questionnaires administered to 34 students and interviews with three chemistry teacher. The results showed that students' interest in learning chemistry is still low (67.65% stated they dislike chemistry), and the dominant methods used by teachers are lectures (42.31%) and demonstrations (35.90%), while discussion and project methods that have the potential to train SPS are rarely implemented. The learning media used are still limited to PowerPoint, textbooks, and YouTube, making the learning process tend to be monotonous and less interactive. The majority of students (71%) expect innovative media that is applicable, interactive, and connects chemistry concepts with everyday life contexts and local culture. These findings emphasize the need for the development of ethnoscience-based kits as alternative learning media that are not only practical and economical but also relevant to students' needs, while simultaneously enhancing learning motivation and science process skills. This study contributes to the early stage of ethnoscience-based media development for enhancing SPS and provides empirical evidence that supports the design of innovative, culturally grounded, and student-centered chemistry learning media.

Keywords: Needs Analysis, Science Process Skills, Ethnoscience, Chemistry Learning, Voltaic Cell

1. Introduction

Chemistry learning at the high school level requires students not only to understand theoretical concepts but also to master science process skills (SPS), which include the ability to observe, formulate hypotheses, design experiments, process data, and draw conclusions (Hinson, 2023). According to Jayadiningrat (2018), optimizing chemistry learning is essential to train students' critical thinking abilities and problem solving skills. In addition, these skills enable students to relate chemical theories to real world phenomena around them, thereby increasing the relevance and application of knowledge (Rosalia et al., 2021). However, in practice, chemistry learning in schools still often focuses only on theoretical aspects, while laboratory activities are not optimally implemented due to various constraints (Ardiansyah, 2014). This aligns with research conducted by Yuriev et al. (2017), which stated that the lack of optimal application of laboratory practice in chemistry learning causes students' science process skills not to develop maximally, even falling into the low category.

Various studies show that students' science process skills (SPS) are still relatively low (Hasanah, 2017; Mellyzar et al., 2022). One of the main obstacles faced is the limited availability of simple and easily accessible laboratory media for students (Ardius, 2019). These limitations include inadequate laboratory facilities and the high costs of procuring experimental materials, which hinder the implementation of experiment-based learning (Arvianti et al., 2024). In addition, the uneven distribution of school laboratory facilities in Indonesia is also a contributing factor to the low SPS among high school students (SMA/MA) or equivalent (Sasmita & Fernandita, 2024). Gailea (2023) emphasized that the limitations of facilities and experimental costs often hinder students from optimally developing scientific skills. Similarly, Asnur et al. (2025) also stated that learning media that do not meet students' needs, along with the lack of access to modern laboratories, negatively affect the quality of chemistry learning, which ideally should be oriented toward science process skills.

The low SPS of students is further exacerbated by learning that is still predominantly teacher centered, where the learning process focuses mainly on one-way delivery of material (Susanti, 2014). Such a learning model makes students passive, as they act only as recipients of information rather than active subjects in constructing new knowledge (Kurniawati et al., 2016). Moreover, the time allocated for experiment based learning is very limited, restricting students' opportunities to explore scientific phenomena directly (Septiani & Fatonah, 2024). In fact, laboratory activities play an important role in training independent skills in observation, experimentation, and data analysis. As a result, students do not gain authentic and comprehensive learning experiences. This situation affects their low learning motivation and weakens their ability to connect theory with real-life applications (Septaria et al., 2025).

In this context, the integration of ethnoscience becomes a potential approach in chemistry learning (Rahmawati, 2020). Ethnoscience emphasizes the connection between scientific knowledge and local wisdom, cultural practices of the community, and local phenomena surrounding students. Therefore, scientific concepts are not learned as something abstract but are directly related to students' daily lives (Shidiq, 2016). This approach allows students to understand that scientific knowledge actually exists and develops alongside the traditions and local practices that they are already familiar with (Vembriana, 2025; Gondwe & Longnecker, 2015). Thus, ethnoscience-based learning can enhance the relevance and meaning of chemistry content while fostering students' appreciation for their regional culture (Hidayati & Julianto, 2025). Moreover, the integration of ethnoscience is also believed to motivate students to engage more actively in learning, as they feel an emotional and cultural attachment to the material being studied (Septina, 2025).

Furthermore, the integration of ethnoscience in chemistry learning should not be limited to discourse or contextual examples but also requires concrete learning media that can be directly implemented in the classroom (Wirasti, 2024). Appropriate media will serve as a means for students not only to understand concepts but also to experience the scientific process through well directed experimental activities (Indriyanti, 2022). In this regard, the development of ethnoscience based kits is believed to be an effective solution to the limitations of laboratories and the high costs of experiments that have long been obstacles (Lasia & Wiratini, 2016; Naimah, 2022).

Learning media in the form of ethnoscience based kits offer several advantages, including being practical, economical, and flexible in use, as they require only a small number of materials and equipment without reducing the quality of the experiments conducted (Widarti, 2024; Lasia & Wiratini, 2016). By utilizing affordable local resources, these kits can be adapted to real conditions in schools with limited laboratory facilities (Permatasari, 2025). This approach not only broadens students' access to experimental experiences but also supports chemistry learning that is more contextual, oriented toward science process skills, and environmentally friendly (Naimah, 2022). Therefore, the development of ethnoscience based kits is a strategic step toward realizing innovative, relevant, and sustainable chemistry learning.

To address these challenges, this study was conducted at one of the public Islamic senior high schools (MA Negeri) in Jember, East Java. The selection of this site was based on the unique local characteristics where chemistry learning is still constrained by limited laboratory facilities and minimal use of contextual materials. Moreover, Jember has a rich cultural background and abundant local resources that can be integrated into ethnoscience-based learning, particularly in the context of small-scale experimental media. Therefore, this setting provides a relevant and authentic environment to explore the potential of integrating ethnoscience into chemistry learning while identifying students' and teachers' actual needs for developing innovative, practical, and culturally grounded learning media.

Therefore, this study aims to analyze the actual needs in chemistry learning related to the development of ethnoscience-based learning media oriented toward science process skills (SPS), particularly on the Voltaic Cell topic for 12th-grade students. Specifically, this research seeks to identify (1) students' learning interests, laboratory experiences, and expectations toward learning media, and (2) teachers' perceptions of the challenges and opportunities in integrating ethnoscience into chemistry learning. The results of this analysis are expected to serve as a foundation for the subsequent stages of developing small-scale ethnoscience-based learning kits that are practical, culturally relevant, and capable of enhancing students' SPS.

2. Methods

This study employed a research and development (R&D) method using the ADDIE instructional design model, which consists of five main stages: Analysis, Design, Development, Implementation, and Evaluation. The selection of the ADDIE model was based on its systematic and organized framework, which supports the gradual development of research instruments according to actual needs in the field. This model allows researchers to align the development process with specific objectives while ensuring continuous evaluation at each stage. In this study, the primary focus was on the Analysis stage, which serves as a crucial foundation for subsequent phases. The analysis stage aimed to identify the actual needs in the field in order to obtain a comprehensive understanding of teachers' and students' requirements for learning media in the form of ethnoscience-based kits, as well as to formulate the main indicators for assessing science process skills (SPS) in 12th grade chemistry learning on the topic of Voltaic Cells. The detailed indicators are summarized in Table 1.

Table 1.
Indicators of SPS Measured

Science Process Skill Aspect	Indicator Measured	Instrument Source
Observation	Ability to identify and describe phenomena or materials in experiments	Questionnaire & Interview
Classification	Ability to group or categorize substances based on properties or results	Questionnaire & Interview
Interpretation	Ability to analyze experimental data and draw logical conclusions	Questionnaire & Interview
Hypothesizing	Ability to formulate hypotheses and predict outcomes of reactions	Questionnaire & Interview
Experimentation	Ability to plan and conduct experiments using available materials	Questionnaire & Interview

This study is consistent with the findings of Yulia et al. (2023), who emphasized the importance of needs analysis in validating learning products and ensuring the alignment of content with the practical competence demands of SPS. Similarly, Asnur et al. (2023) highlighted the importance of analyzing content and media design to ensure the relevance of materials in interactive learning. By conducting the analysis stage optimally within the ADDIE model, the effectiveness and feasibility of science learning media developed to enhance SPS can be significantly improved.

To support the needs analysis process, the researchers employed instruments in the form of a needs analysis questionnaire for students and a semi structured interview guide. A mixed-methods approach, combining both quantitative and qualitative methods, was used for data collection. Qualitative data were obtained through in-depth interviews with two chemistry teachers from a public Islamic senior high school (MA Negeri) in Jember. These interviews aimed to explore the challenges and needs in chemistry learning, particularly in relation to the development of SPS. Meanwhile, quantitative data were collected through the distribution of needs questionnaires at the same MA Negeri in Jember, involving 34 students and 3 chemistry teachers. The questionnaire , consisting of 20 items, was designed to assess students' experiences in laboratory activities and their needs for strengthening SPS. The distribution of questionnaires to students was conducted online, while interviews with chemistry teachers were conducted offline using the interview guide. Data collected from the questionnaires were analyzed descriptively by calculating percentages and mean scores for each indicator. Qualitative data from the interviews were analyzed using thematic analysis techniques, by identifying recurring patterns, themes, and needs emerging from teachers' responses.

The Analysis stage in the ADDIE model plays a pivotal role in producing a structured design and supporting the process of continuous improvement. The data from the questionnaires for needs analysis were analyzed descriptively by calculating the mean and percentage scores for each indicator. The analysis aimed to identify the needs for learning media and the tendencies in students' learning patterns. Through this approach, the study builds a strong foundation both empirically and theoretically for the development of relevant learning media that are grounded in actual needs in the field. All participants were informed about the purpose of the study, and their participation was entirely voluntary. Prior to data collection, informed consent was obtained from each respondent, ensuring that all responses remained confidential and anonymous. Ethical considerations in this research complied with institutional standards for studies involving human participants.

3. Result and Discussion

3.1 Field Observation Findings

The results of observations at one of the public Islamic senior high schools (MA Negeri) in Jember revealed that the condition of the chemistry laboratory was still far from optimal. The available laboratory facilities were limited, both in terms of quantity and completeness of equipment. Several practical tools such as metal electrodes, measuring cylinders, and conductor wires were either damaged or insufficient in number, making it difficult for all student groups to use them simultaneously. The laboratory room also appeared poorly maintained, with disorganized equipment layout and inadequate lighting that hindered practical activities. In addition, many essential laboratory instruments were missing, such as volumetric flasks, watch glasses, U tubes, and others. These conditions created a less conducive atmosphere for laboratory practice and reduced the effectiveness of the learning process. This is illustrated in Figure 1 below.

Figure 1.
The condition of the laboratory room, which is dark and lacks proper lighting

Such findings indicate that the lack of laboratory facilities has a direct impact on students' Science Process Skills (SPS), particularly in observation, experimentation, and data analysis. According to Hasanah (2017) and Hinson (2023), adequate laboratory access is a key prerequisite for the development of SPS, because it provides opportunities for students to experience authentic scientific inquiry. When laboratory activities are limited, learning becomes teacher-centered and students' roles are reduced to passive listeners, as was observed during classroom sessions. This aligns with Susanti (2014) and Yuriev et al. (2017), who emphasize that insufficient laboratory practice results in weak analytical and problem-solving skills among students.

In addition to limited facilities, the availability of chemical materials also posed an obstacle. Many chemicals were no longer suitable for use, such as clumped $CuSO_4$ powder, yellowed salt bridges, and several others. In chemistry learning practices, such as the Voltaic Cell experiment, teachers tended to use simple standard solutions because alternative materials were rarely prepared on a regular basis. Occasionally, contextual materials such as fruit extracts were used as electrolytes, but these efforts were not carried out consistently due to limitations in preparation and funding. Observations also showed that students were required to bring their own tools and materials during laboratory practice. This is illustrated in Figure 2.

Figure 2.
Independent practicum conditions due to insufficiently facilitated tools and materials

Most students only followed the teacher's instructions without engaging in further exploration, and interactions among students in analyzing experimental results were still minimal. This shows that the laboratory has not yet been optimally utilized as an active learning space, but rather only as a complement to theoretical learning.

Furthermore, from the perspective of ethnoscience, the absence of contextual and culturally integrated materials causes students to perceive chemistry as abstract and disconnected from everyday life. Ethnoscience-based learning encourages the use of locally available resources and cultural practices as experimental contexts (Rahmawati, 2020; Shidiq, 2016). If local materials, such as fruit extracts, coconut water, or traditional metal objects, okewere used as alternatives in experiments like Voltaic Cells, students could relate the concepts more easily to real phenomena around them. This approach not only enhances conceptual understanding but also strengthens cultural awareness and scientific reasoning simultaneously (Vembriana, 2025; Hidayati & Julianto, 2025).

Therefore, the limited laboratory infrastructure and absence of ethnoscience-oriented learning indicate that students have minimal opportunities to develop their SPS through contextualized, inquiry-based activities. These conditions support the need for developing ethnoscience-based learning kits, which can bridge the gap between theory and practice while promoting meaningful learning experiences. This finding is consistent with Lasia & Wiratini (2016) and Naimah (2022), who showed that locally adapted KITs can effectively enhance students' experimental engagement and scientific literacy even in resource-limited settings.

3.2 Teacher Interview

Based on the interview results, the main challenge in teaching chemistry, particularly the Voltaic Cell topic, lies in the abstract nature of the concepts and students' difficulty in linking theory to observable phenomena. The teacher stated that students often struggled to analyze electrochemical processes because they perceived the topic merely as an extension of redox reactions. This condition demonstrates a weak analytical component of Science Process Skills (SPS), especially in the sub-skills of identifying variables, formulating hypotheses, and interpreting data. Similar findings were reported by Hasanah (2017) and Mellyzar et al. (2022), who found that students' SPS tends to stagnate when learning focuses only on algorithmic problem-solving without adequate inquiry-based practice.

The teacher also noted that students tended to rely on external aids such as digital calculators or AI-generated answers rather than conducting their own reasoning or data processing. This finding suggests a low level of scientific autonomy, which corresponds to the lack of opportunities to perform hands-on experiments that stimulate inquiry and critical thinking. According to Hinson (2023), authentic experimental engagement is essential for building scientific reasoning, while the absence of such experiences leads to dependence on procedural or technological shortcuts.

Several learning models had previously been applied by the teacher in chemistry classes, such as inquiry-based science process, the learning cycle, computing for computational thinking (CT), as well as the *Merdeka Belajar* (Freedom to Learn) approach. However, the teacher admitted that for abstract topics like the Voltaic Cell, traditional methods such as lectures and demonstrations are still dominant. This pattern reinforces the observation that classroom practices remain teacher-centered and limit opportunities for students to construct knowledge through exploration. This aligns with Susanti (2014) and Kurniawati et al. (2016), who emphasize that one-way instruction reduces students' initiative and inhibits the growth of higher-order SPS such as designing experiments and drawing conclusions from data.

Regarding learning models, the teacher had once implemented Problem-Based Learning (PBL) in teaching green chemistry. Although this model was expected to enhance critical thinking skills, the results remained varied and did not show significant differences in student achievement. This indicates that the success of applying PBL and contextual learning models is highly influenced by student readiness. According to the teacher, contextual learning, including ethnoscience, is more effectively applied in grades XI and XII, as students already possess a stronger foundation in chemistry and are able to connect concepts with their surrounding environment. Conversely, in grade X, its effectiveness is still low because students are not yet accustomed to relating chemical concepts to real world phenomena.

From the perspective of ethnoscience, these teaching challenges can be interpreted as a missed opportunity to contextualize learning with local culture and real-life phenomena. According to Rahmawati (2020) and Shidiq (2016), integrating ethnoscience into chemistry learning allows abstract concepts to be grounded in everyday experiences, thus improving understanding and motivation. For example, Voltaic Cell materials can be contextualized through local electrochemical practices—such as traditional metal polishing, fermentation, or saltwater battery demonstrations—using materials familiar to students. Such cultural contexts activate students' curiosity and help them connect scientific principles with community-based knowledge (Vembriana, 2025; Hidayati & Julianto, 2025).

Therefore, the teacher's difficulties in engaging students stem not only from limited laboratory facilities but also from the lack of ethnoscientific contextualization in instructional design. This finding reinforces the idea that ethnoscience-based, inquiry-oriented media are necessary to bridge the gap between abstract theory and tangible practice. As highlighted by Widarti et al. (2024), contextualized ethno-electrochemical learning can transform conventional topics into meaningful experiences that strengthen students' scientific reasoning and cultural appreciation simultaneously.

3.3 Student Results

Based on the survey results, the number of respondents in this study was 34 students, all of whom were from the twelfth grade (Science Program). This indicates that the respondents were senior high school students with sufficient experience in learning chemistry, making their perspectives on methods, media, and curriculum implementation valuable for developing instructional media. Regarding the curriculum used, all respondents stated that chemistry learning in grade XII Science already applied the *Merdeka Curriculum*. This finding affirms the consistency of implementing the new curriculum in the school where the survey was conducted. The *Merdeka Curriculum* itself focuses on developing competencies, critical thinking skills, problem-solving abilities, and contextual learning. Thus, the application of this curriculum has great potential to be integrated with science process skills (SPS) and ethnoscience, as both support meaningful, experiential, and culturally relevant learning.

Preliminary study results showed that students' interest in chemistry learning was still relatively low. Out of 34 respondents, only 11 students (32.35%) stated that they liked chemistry, while 23 students (67.65%) admitted that they did not. Qualitatively, this low interest was due to several factors, including the perception that chemistry material was difficult to understand, monotonous teaching processes, and the use of less engaging media, which often left students feeling bored or sleepy in class. This finding highlights that students' interest in chemistry can be improved if teachers provide more contextual, interactive learning that is closely related to daily life, for example, through ethnoscience integration. This is presented in Table 2 below.

Table 2.
Student Interest in Chemistry

Interest Category	Number of Students	Percentage (%)
Like Chemistry	**11**	**32.35%**
Do Not Like Chemistry	**23**	**67.65%**
Total	**34**	**100%**

The table illustrates the distribution of students' interest in chemistry. Out of 34 respondents, only 11 students (32.35%) expressed that they like chemistry, while the majority, 23 students (67.65%), reported that they do not like chemistry. This finding indicates that student interest in chemistry is relatively low, with more than two thirds of the students showing disinterest. The lack of interest may be associated with monotonous teaching methods and limited use of interactive media, highlighting the need for more engaging and innovative learning approaches to improve student motivation.

The low interest in chemistry learning, as reflected by 67.65% of students expressing disinterest, correlates with the dominance of lecture-based methods and limited opportunities for experimentation. This finding aligns with Mellyzar et al. (2022), who noted that monotonous instruction inhibits the growth of Science Process Skills (SPS). According to Shidiq (2016), the integration of ethnoscience-based contexts can increase students' engagement because they perceive chemistry as part of their daily cultural practices. Therefore, enhancing chemistry motivation through contextual, ethnoscientific learning media can indirectly improve students' SPS and learning outcomes.

From the perspective of teaching methods, the questionnaire results indicated that teachers predominantly used conventional approaches. Most students reported that teachers relied more often on lectures (42.31%) and demonstrations (35.90%), while methods that involved more active student participation, such as discussions (12.82%), projects (7.69%), and games (1.28%), were rarely applied. Qualitatively, students assessed lectures and demonstrations as monotonous, making the classroom atmosphere less engaging. Discussion and project methods, which have the potential to foster science process skills, were still rarely implemented, limiting students' opportunities for active participation. Thus, it can be concluded that the low student interest in chemistry is correlated with the dominance of lecture methods that lack innovation. Therefore, a greater variety of student-centered methods such as discussions, projects, and the integration of ethnoscience contexts becomes crucial to enhance student motivation and understanding in chemistry learning.

3.4 Learning Media

Based on the questionnaire results, the learning media used by chemistry teachers were still dominated by conventional formats. Out of 34 respondents, most reported that learning relied primarily on PowerPoint (PPT), textbooks, whiteboards, and YouTube. Among the respondents, 5 students (14.7%) stated that the teacher mainly used a combination of PPT and textbooks, 2 students (5.8%) mentioned PPT and YouTube, while another 2 students (5.8%) reported the use of PPT, YouTube, and textbooks. Less common variations included PPT and worksheets (2.9%), internet sources (2.9%), or textbooks alone (2.9%). Despite the slight differences in responses, it was evident that digital or modern multimedia-based media were not consistently employed, and most lessons still depended on a combination of textbooks and PPT. This fact suggests that teaching practices were still largely teacher centered, supported only by simple visual aids, without providing richer and more interactive learning experiences.

The limited use of learning media mainly PPT and textbooks made chemistry learning monotonous and less appealing to students. While conventional media functioned to deliver structured information, they were not yet able to optimally support science process skills (SPS), such as the ability to observe, formulate hypotheses, conduct experiments, and draw conclusions based on data. The lack of interactivity in the media used meant that chemistry learning did not fully stimulate curiosity, even though chemistry as a subject inherently requires concrete visualization and contextual experimentation. This condition negatively impacted student engagement, explaining why many of them responded with boredom or sleepiness during lessons. This aligns with Mellyzar et al. (2022), who found that the use of monotonous media correlates with students' low motivation and weak analytical thinking in chemistry learning. Therefore, these findings emphasize the need to develop more creative, interactive, and context based alternative media to both boost learning motivation and support the achievement of science process skills.

From the view point of ethnoscience integration, the lack of contextual and culturally relevant learning media also contributes to students' perception that chemistry is abstract and disconnected from real life. Ethnoscience-based media, on the other hand, bridge modern scientific concepts with students' local culture and everyday experiences. For example, in the topic of Voltaic Cells, simple KITs utilizing locally available materials, such as fruit electrolytes, coconut shells, or traditional metallic tools, can serve as contextual experimental media. Rahmawati (2020) and Shidiq (2016) explain that such media help students connect chemical principles with indigenous knowledge systems, thereby enhancing conceptual understanding, curiosity, and cultural appreciation simultaneously.

Based on the questionnaire data, student responses to chemistry learning media showed a generally positive tendency, though with important notes. Quantitatively, the majority of students (around 65%) stated that the media used by teachers helped them understand concepts, although 22% felt the media were less engaging, and only 13% considered the media to be highly interactive. Qualitatively, students expressed that the media used by teachers such as PowerPoint slides and simple videos were helpful for learning, but often made the lessons feel monotonous since they mostly presented content in static text and image form. Some students also pointed out that the available media rarely involved hands-on practice or experimental simulations, leaving science process skills such as observing, measuring, or analyzing data underdeveloped. These findings highlight a gap between the function of media as an aid for understanding and students' needs for more active, practical, and contextual learning experiences. Thus, student responses indicate the necessity of developing learning media that are more interactive, practical, and capable of integrating real practices with an ethnoscience based approach.

Students' expectations toward chemistry learning media were clearly reflected in the analyzed questionnaire results. Quantitatively, 71% of students hoped for more interactive and innovative learning media, 19% wanted simple yet applicable media, and only 10% felt satisfied with the existing media. Qualitatively, students emphasized that they desired media that not only presented theories but also connected chemistry concepts with everyday life and local culture, making learning more meaningful. Some students expressed that they would be more interested if the media took the form of simple practical tools that allowed them to conduct experiments directly without requiring a fully equipped laboratory. These expectations align with the direction of developing small scale KIT media integrated with ethnoscience, as such KITs are designed not only to facilitate science process skills through practical experiments but also to enrich learning experiences with cultural contexts that are closely related to students' daily lives.

4. Conclusion

The findings indicate that chemistry learning in schools still faces several challenges related to students' interest, teaching methods, and the limited availability of practical media. Quantitative data showed that 67.65% of students expressed low interest in chemistry, which is mainly associated with the dominance of lecture-based teaching (42.31%) and limited use of interactive learning media. The dominance of lecture-based instruction often makes chemistry learning less meaningful and less connected to students' everyday experiences. Meanwhile, teachers recognize the importance of contextual and locally relevant learning but are constrained by inadequate laboratory facilities and the complexity of certain topics such as Voltaic Cells.

This preliminary study contributes empirical evidence to the design phase of ethnoscience-based chemistry media that addresses these challenges by providing simple, interactive, and culturally grounded learning tools. Such media not only aim to enhance students' science process skills but also foster deeper understanding through local wisdom integration. Therefore, the results of this study serve as a strong foundation for developing innovative and student-centered chemistry learning media aligned with real-world contexts..

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