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A THEMATIC REVIEW: ETHNOCHEMISTRY IN SECONDARY SCHOOLS

Hidayati[1*)]; Muhammad Damris[1] ; Asrial[1]; M. Haris Effendi Hsb[1]

[1]Department of Science and Mathematics Doctoral Faculty, Faculty of Science and Mathematics Education, Jambi University, Indonesia

[*)] Corresponding author: hidayati.hhidayati@gmail.com

ABSTRACT Chemistry learning is very close to students' daily lives. It is important to involve local wisdom in chemistry learning so that learning is more relevant to students' daily lives (contextual-based learning). The purpose of this study is to offer new insights and practical recommendations to advance the teaching and learning of ethnochemistry in secondary schools. There were 29 articles analyzed thematically in terms of objectives, methods, samples, data collection tools, research results and recommendations. The results showed that ethnochemistry-based learning has a positive impact both in terms of the learning process and contributes as a learning resource so it is important to continue to conduct more in-depth studies related to the application of local wisdom in learning both in terms of qualitative and quantitative research. Further research considers training that can be given to secondary school chemistry teachers on how to integrate cultural knowledge and practices into chemistry teaching and learning.

Keywords: *Ethnochemistry, Thematic Review, Secondary Classroom, Local Knowledge.*

INTRODUCTION

In the learning process, a teacher does not merely deliver the materials included in a textbook. Yet the teacher can provide the learning atmosphere which supports the materials conveyed. The teacher can make connections between the learning and students' cultural identity (Singh & Chibuye, 2016). This is in line with Government Regulation Number 19 of 2005 on National Standard of Education Article 14 Verse (1) mentioned that the curriculum of SMP/MTs/SMPLB or another form of the same level and curriculum of SMA/MA/SMALB or another form of the same level can include local excellence based education. It indicates that the teacher can create interconnection between the topic of learning and students' cultural background, and utilize the cultural wealth the students have. It can be attained by creating the relationships between the students and their family and developing the teaching methods which accept, respect, respond, and make use of the varied cultures (Rahmawati et al., 2017).

(Parmin & Fibriana, 2019) stated that the knowledge hidden behind the local community has a potency to be the learning source of science and an alternative to implement *Back to Nature* concept. In this case, the teacher is expected to be able to integrate local cultural values in science learning process. Ethnoscience deals with the process of transforming pure science to scientific knowledge (Zakiyah & Sudarmin, 2022). Pure science covers any subjects related

to community facts (Rahayu & Sudarmin, 2015). (Atmojo et al., 2021) asserted that ethnoscience learning facilitates the students in learning the facts and phenomena in the society that can be combined with scientific knowledge.

Chemistry is one of science learning parts that plays a vital role in the society life. However, chemistry is still a complicated lesson for the students (Hidayati & Suryani, 2022). This is congruent with (Ugwu et al., 2016) stating that chemistry is the abstract subject for both teacher and students since the instruction is not linked to the students' knowledge and local practices (daily life experiences) which makes the students' learning outcome is low. (Oladejo, 2020) mentioned that the curriculum of chemistry in secondary school must be designed in order the students to be actively involved in the learning process and should implement the practical learning approaches. In addition, local cultural knowledge can be utilized to assist the students to comprehend the difficult concepts in chemistry. (Rahmawati, 2018) stated that in the chemistry classroom, the teacher can create multicultural class by carrying out the instruction which is adaptive to culture and integrate it into the ethics and cultural values. Science values in students' local wisdom is necessary to be implemented in the learning process as ethnic values are the reference of character development which are the closest to the students (Kurniawan et al., 2019).

To achieve science learning objectives, it is crucial to integrate science and culture (ethnochemistry) in the learning process which can later train the students to develop the critical thinking skills (Wahyudiati, 2022a). The integration of ethochemistry into the learning process also allows the students to comprehend the complicated topics, such as the separation and formation of mixture, atomic structure, the periodic table of elements, and chemical bonds (Wahyudiati & Fitriani, 2021). Also, the chemistry learning media such as ethnochemistry based Adobe Flash integrating the local wisdom can enhance students' science literacy. (Heliawati et al., 2022). It confirms that the implementation of ethnochemistry can give positive impact on chemistry learning process.

Though there have been many studies investigating the integration of ethnochemistry into the chemistry learning, the studies on thematic review of ethnochemistry are still limited. Hence, it is crucial to reveal the trend of etnhnochemistry strudies in learning process. The present study aims to provide new insights and practical recommendations to develop ethnochemistry teaching and learning in senior high schools. The objectives of the study are as follows.

1. What are the objectives of the implementation of ethnochemistry based learning?
2. What research methodology did the researchers use?

3. What sampling technique did the researchers apply?
4. What data collection techniques did the researcher use?
5. How the results of ethnochemistry based learning were?

METHOD

This study used thematic review approach systematically combining phenomena in the studies on a particular field by creating theme, providing various sources for the researchers to work the relevant field (Çeliktaş et al., 2021). Based on this description, the thematic review is used to analyze the relevant studies published in 2016 up to 2024.

THE PROCESS OF DATA COLLECTION

The key word used in this study is: "Ethnochemistry", "Cultural chemistry education", "indigenous knowledge in chemistry", and "context-based learning in chemistry". The key word placed was found using search engine such as: "Google Scholar", "Semantic Scholar", "Science Direct", "ERIC", and "BASE (Bielefeld Academic Search Engine). The research articles reviewed are the acticles published in scoups indexed international journal, Copernicus, and national journals indexed by Sinta 4 at the lowest. From the key word found using the search engine, the articles were grouped based on the index, shown in table 1.

Table 1. Articles based on the indexed

Indexed	F
Scopus	19
Sinta	7
Copernicus	3

Based on the search engine, it was found that there are 29 research articles using the key word. Table 2 presented the detail of each articles. In table 2, it can be seen that there are 13 articles on ethnochemistry in 2023. In 2022, there are 5 articles published. There are 3 articles published in 2019. Meanwhile, from 2016 to 2021, the articles on ethnochemistry are scarcely found. In 2020 and 2021, there are 2 articles published. From 2016 to 2018, there is only 1 article. The most current one is published in 2024.

Table 2. The detail of articles

Code	Publication	Index	Writer(s), year	Keywords
A1	Journal	Scopus/Q2	Scholes, et al., 2019	High School/Introductory Chemistry, Laboratory Instruction, Hands-On Learning/Manipulatives, Student-Centered Learning, Minorities in Chemistry, Natural Products, Plant

				Chemistry, Dyes/Pigments
A2	Journal	Scopus/Q2	Zidny & Eilks, 2020	Chemistry education, Sustainability, Indigenous knowledge, Systems thinking
A3	Journal	Scopus/Q2	Nja et al., 2022	Cultural resources, self-concept, achievement, students, enthochemistry
A4	Journal	Scopus/Q2	Rahmawati et al., 2023	CRTT model; chemistry learning; Indonesian culture; cultural sustainability
A5	Proceeding	Scopus/Q3	Rahmawati et al., 2017	-
A6	Journal	Scopus/Q3	Rahmawati, 2018	Cultural ethnics; chemistry teaching and learning; transform;
A7	Journal	Scopus/Q3	Dewi et al., 2019	Chemistry learning, ethnoscience, scientific literacy
A8	Proceeding	Scopus/Q3	Rahmawati et al., 2019	-
A9	Proceeding	Scopus/Q3	Najid et al., 2021	-
A10	Journal	Scopus/Q3	Heliawati et al., 2022	Ethnochemistry; indigenous knowledge; scientific literacy
A11	Journal	Scopus/Q3	Wahyudiati, 2022	Critical thinking skills, ethnochemistry-based learning experience, gender differences, chemistry education students.
A12	Journal	Scopus/Q3	Wiratma & Yuliamiastuti. 2023	Ethnochemistry; Lontar Usada Taru Pramana; task-based learning; scientific explanation
A13	Journal	Scopus/Q3	Achimugu et al., 2023	Cultural heritage; cultural knowledge and practices; integration; secondary school chemistry; teaching and learning.
A14	Journal	Scopus/Q3	Potočnik & Devetak, 2023	Fine art teachers' view; cultural heritage; general elective course; materials of works of art; pre-service chemistry; primary school.

A15	Journal	Scopus/Q3	Anggreni et al., 2023	Etnochemistry; Malay; Microblog; Preserveing culture; TSRD Development
A16	Journal	Scopus/Q3	Wardani et al., 2023	Culturally Responsive Teaching; Ethnochemistry; Green Chemistry; Learning Outcomes
A17	Journal	Scopus/Q3	Asda et al., 2023	Buffer solution; Ethnochemistry; Problem based learning; Science literacy; Students worksheet
A18	Journal	Scopus/Q3	Yuendita & Dina, 2024	Augmented reality (AR); Chemistry learning; Chemical literacy; Madura Culture
A19	Journal	Scopus/Q4	Sutrisno et al., 2020	Ethnochemistry, Chemistry Curriculum, *Sasak* Local Wisdom, Learning Resources
A20	Journal	Copernicus	Singh & Chibuye, 2016	Ethnochemistry, Conventional approach, Attitude
A21	Journal	Copernicus	MUDAU & TAWANDA, 2022	Chemistry metacognition, cultural relevance, ideal chemistry education, indigenous chemistry knowledge, preservice science teachers
A22	Journal	Copernicus	Cecilia et al., 2023	Ethnochemistry, Ethnoscience, Achievement in chemistry, Chemistry students
A23	Journal	Sinta/S2	Wahyudiati & Fitriani, 2021	Ethnochemistry, Sasak Local Wisdom
A24	Journal	Sinta/S2	Wahyudiati, 2022	Ethnochemistry Local Wisdom Teaching Materials
A25	Journal	Sinta/S2	Irawati et al., 2023	Banjarese community, chemistry learning resources, ethnochemistry, exploration, inventory
A26	Journal	Sinta/S2	Wahyudiati* & Qurniati, 2023	Ethnochemistry, local wisdom of Sasak and Java, source of learning chemistry

A27	Journal	Sinta/S2	Astid Putera, 2023	Domino, Elements, Herbalism
A28	Journal	Sinta/S4	Cahyani & Wahyudiati, 2023	Etnochemistry, samawa local wisdom, chemistry learning source
A29	Journal	Sinta/S4	Suanda & Wahyudiati, 2023	Ethnochemistry; *sasak* local wisdom; *ngejot* tradition, chemistry learning resources.

(Ülger & Çepni, 2020) stated that the similarities and differences must be taken into account in thematic review study, not to mention the characteristics of research journal. The characteristics include the objective of the study, research method, sampling technique, data collection technique, result and recommendation. Therefore, the research design is seen as follows:

Figure 1. Research Design Flow

RESULTS AND DISCUSSION

RESULT

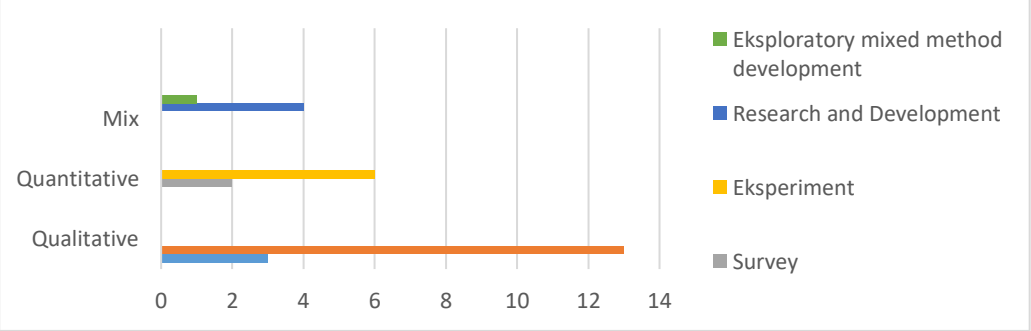
In the light of the findings analyzed in terms of the research characteristics, the main objectives of the studies are as follows.

Table 3. The data of the main objectives of the studies

Theme	Code		F
To develop learning sources that relates cultural practices to chemistry learning. The development of learning sources might be:	Modul	A1	11
	Adobe Flash	A10	
	Microblog of acid - base	A15	
	Student's worksheet	A17	
	Literacy Book	A18	
	Dominoes	A27	
	The local wisdom as teaching material	A24, A25, A26, A28, A29	
To investigare the implementation ethnochemistry based learning	A2, A3, A5, A6, A9, A12, A13, A14, A16, A19, A20, A21, A22, A23		14
To establish students' cultural identity as well as encourage the generation to	A4		1

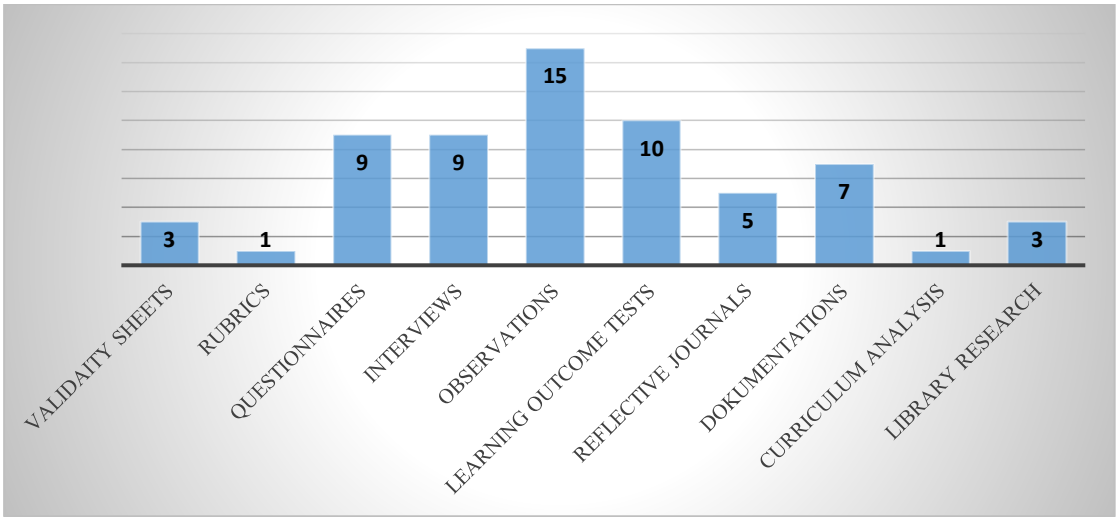
preserve the cultural inheritance along with learning the chemistry concepts			
To discuss 21st century skills that can be examined through the ethnoscience approach in chemistry learning.	Science literacy	A7	3
	Critical thinking	A8, A11	

As shown in Table 3, it was found that there are four themes of research objectives and different codes. There are two themes of the main objectives of the study, that is, there are 11 research articles aim to find out the effect of the developed learning sources that interconnect cultural practices to chemistry learning. There are 14 research articles discussing how ethnochemistry based learning is implemented. The research method can be revealed from the main objectives of the studies. Graph 1 demonstrates three types of research methods used.



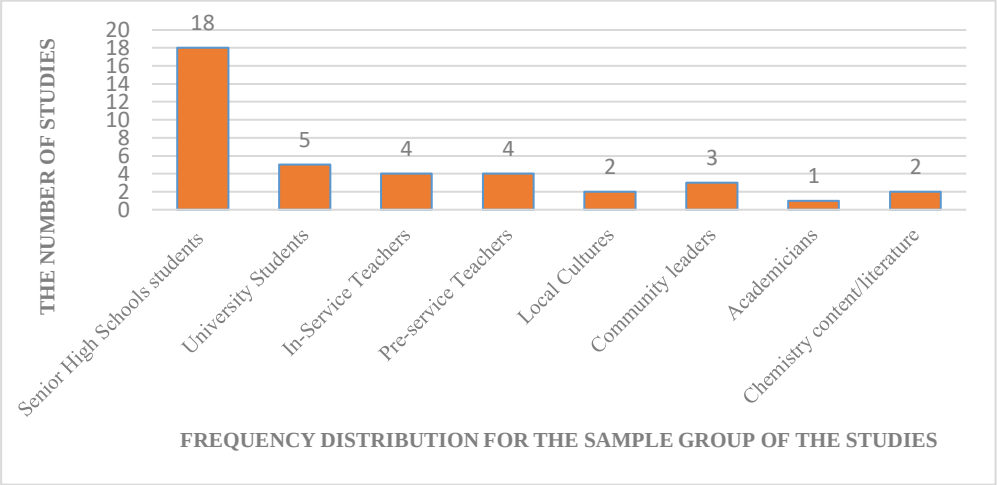
Graph 1. The focus of research methods

It can be seen in Graph 1 that there are three types of research methods including qualitative approach with study case and ethnography, quantitative approach with survey and experimental design, and mixed method with research and development design. The next research focus which is research collection techniques can be seen in Graph 2.



Graph 2. Research Collection Techniques.

Based on data analysis in Graph 2, the studies used validity sheet and library research (F = 3), rubric and curriculum analysis (F = 1), questionnaire and interview (F = 9), learning outcome test (F = 10), observation (F = 15), reflective journal (F = 5) and documentation (F= 7). The focus of research sampling can be seen in graph 3.



Graph 3. The data of research sampling

In graph 3, it is found that there are eight types of research sampling such as 18 studies involved secondary schools students, 5 university students, 4 participants for in service teachers and pre service teachers, 2 local wisdom, 3 public figures and 1 for academic and content/chemistry literature. As demonstrated that most of studies involved Senior High Schools students (F = 18), university students (F = 5) as well as in service teachers and pre service teachers (F = 4). Moreover, the focus of research findings is shown in Table 4.

Tabel 4. The data of research findings

Findings	Code		F
Give the positive impact on chemistry learning	Students' understanding on sustainable issues	A2	17
	Self-concept of academic and understanding on chemistry concepts	A3	
	Critical reflective thinking skills and students' autonomy	A6	
	Science literacy competences	A7, A10	
	Learning outcome and critical thinking	A8, A16	
	Students' scientific attitude	A9	
	Critical thinking skills and learning experiences	A11	
	Students' scientific explanatory competence	A12	
	Students' attitude	A20	
	Enhancing students' comprehension and learning achievement	A21, A22, A5	

	Educating and empowering students as Indonesian culture conservationist	A4	
	Promoting the prospective teachers' interest and comprehension	A14	
	Serving as nature laboratory and learning media to create meaningful learning atmosphere	A19	
Give descriptive information	Explaining the strategies and challenges in the implementation of ethnochemistry	A13	1
Provide the contribution for learning sources	Module	A1	11
	Microblog of acid – base	A15	
	Student worksheet of problem based learning based buffer solution	A17	
	Chemistry literacy book which uses Augmented Reality (AR) technology	A18	
	Elemental Chemistry in Dominoes as learning	A27	
	Local wisdom	A23, A24, A25, A26, A28, A29	

Table 4 demonstrates that research findings on ethnochemistry gave positive effect. Ethnochemistry contributed to chemistry learning process in the form of local wisdom and learning media.

Table 5. The data of research rescommendations

Recommendations	Code	F
Recommendation for learning process in the classroom	Investigating the further effectivess of CRTT model by empowering the students on cultural preservation using other ethnochemistry topics in the scope of Indonesian culture	1
	Teachers can utilize the available cultural resources efficiently and effectively to teach chemistry.	2
	Conducting a review to include ethnochemistry based learning into the curriculum	2
	The government carries out the training for chemistry teachers at the the secondary schools on how to integrate science and cultural practices into chemistry instructions through seminar, conference and workshop.	4
	It is necessary to involve the indigenous people and local technicians when conducting the training for the chemistry teachers in integrating cultural practices into the classroom.	1
	The researchers on chemistry collaborate with other stakeholders to create the list of chemistry concepts related to local practices and disseminate it in the form of magazines to schools.	1
	Provide the society with an understanding about potential of integrating cultural practices into chemistry learning.	1
	Involve the industry to promote the integrating of cultural practices by supporting chemistry teachers and students.	1
	Conducting the documentation on any studies of	1

	ethnochemistry practices.	
	Observe any integration of ethnochemistry into chemistry learning properly.	1
	Conducting deep analysis on sasak local wisdom or other regions that relate to others chemistry content so the studies on ethnochemistry are wider as learning sources.	1
	Explore the chemistry concept on the preservation of cultural heritage through the process of transferring knowledge on the use of traditional and modern medical plants.	1
Recommendation for learning process in the classroom	Urge the new innovations by utilizing natural ingredients in Indonesia for health and other fields.	1
	Conduct the correlational and comparative studies to find out the effectiveness of the implementation of sasak local wisdom based learning sources.	1
	Increase the relevance of chemistry learning by identifying how the society perspective and view point in various countries.	1
	In the development of chemistry curriculum in the faculty teacher training, the pre service teachers' multicultural can be utilized to compose the chemistry subjects in the university	1

DISCUSSION

The objective of the present study is to analyze previous relevant studies related to ethnochemistry reviewed from the objective, method, data collection technique, sampling technique and research findings. The articles were analyzed using search engine by the key word "Ethnochemistry", "Cultural chemistry education", "indigenous knowledge in chemistry", and "context-based learning in chemistry". The articles are those which are indexed by scopus, sinta and Copernicus. From the results of research articles search, there are 29 articles published from 2016 to 2024. Even though, there might be articles on local wisdom in chemistry learning published before 2016, the articles reviewed based on some criteria.

From the analysis process of articles, the researchers have specified some characteristics in selecting the articles. The first characteristic is the research objective. There are four themes of research objective such as to develop the learning sources that relate cultural practices to chemistry learning. The development of learning sources includes learning module (Scholes, 2019), Adobe Flash (Heliawati et al., 2022), Microblog of acid - base (Anggreni et al., 2023), *buffer solution* student worksheet (Asda et al., 2023), Literacy book (Yuendita & Dina, 2024), Dominoes (Astid Putera, 2023) dan local wisdom as teaching materials, for example Java and Sasak local wisdom (Wahyudiati* & Qurniati, 2023; Wahyudiati, 2022a), Banjar local wisdom (Irawati et al., 2023), Samawa local wisdom (Cahyani & Wahyudiati, 2023), Sasak locak wisdom through ngejot tradition (Suanda & Wahyudiati, 2023).

The next theme is to investigate the implementation of ethnochemistry based learning. There are 14 articles including: to find out the effect of ethnochemistry practice on students' attitude (Achimugu et al., 2023; Cecilia et al., 2023; MUDAU & TAWANDA, 2022; Najid et al., 2021; Nja et al., 2022;

Potočnik & Devetak, 2023; Rahmawati, 2018; Rahmawati et al., 2017; Singh & Chibuye, 2016; Sutrisno et al., 2020; Wahyudiati & Fitriani, 2021; Wardani et al., 2023; Wiratma & Yuliamiastuti, 2023; Zidny & Eilks, 2020), the implementation of ethnochemistry in learning which is responsive to culture (Rahmawati et al., 2017), the implementation of cultural ethics and values through CRT (Culturally Responsive Teaching) (Rahmawati, 2018), to find out the potency of Sasak local wisdom as learning source in Chemistry subject and to appreciare the relevance degree of Sasak local wisdom on chemistry material (Wahyudiati & Fitriani, 2021), the investigation of students' perception and experience through learning that integrates local science perspectives and western science based on socio-scientific issues that are sustainable oriented (Zidny & Eilks, 2020), to reveal the cultural resources, self-concept and learning outcomes of chemistry students in Senior Secondary Schools in Nigeria (Nja et al., 2022), developing students' attitudes through the application of CRTT (Culturally Responsive Transformative Teaching) on the topic of colloids (Najid et al., 2021), evaluate the impact of task-based learning, which utilizes the ethnochemical potential of vines found in Lontar Usada Taru Pramana, on students' scientific explanation abilities (Wiratma & Yuliamiastuti, 2023), evaluate methods that can increase the implementation of cultural practices into secondary school chemistry teaching. (Achimugu et al., 2023), find out the opinions of pre-service chemistry teachers, elementary school teachers, and fine arts teachers on how to increase curiosity about cultural heritage and chemistry education through teaching aids from a chemistry perspective (Potočnik & Devetak, 2023), determine whether the use of a responsive ethnochemistry-based teaching style can improve students' cognitive learning outcomes when studying green chemistry in secondary schools (Wardani et al., 2023), discussing Ethnochemistry in the local wisdom of the Sasak tribe, West Nusa Tenggara, Indonesia which is found in the Merarik (wedding) tradition (Sutrisno et al., 2020), The influence of local chemical knowledge on chemical metacognition based on the views of pre-service science teachers (MUDAU & TAWANDA, 2022), and examine how students' achievement in chemistry is influenced by an ethnochemistry-based learning package (Cecilia et al., 2023). The third theme of the main research objective is to build students' cultural identity and encourage generations to maintain their cultural heritage while simultaneously studying chemical concepts (Rahmawati et al., 2023). The fourth theme aims to discuss 21st century abilities that can be investigated through an ethnoscience approach in chemistry learning, such as critical thinking skills. (Rahmawati et al., 2019; Wahyudiati, 2022b) and students' scientific literacy abilities (Dewi et al., 2019).

Based on the analysis of data collection methods and tools, it shows that the literature tends to lead to qualitative research with an ethnographic research model. The fact that the studies reviewed are qualitative based illustrates the need for a more in-depth analysis of a research problem of a social nature. As explained by (Tenny et al., 2022) Qualitative research is a type of research that explores and provides deeper insight into real world problems, which in this research is used to answer how and why, not how much. Apart from that, in the literature analysis it was found that the majority of the research samples were high school students, college students as well as teachers and pre-service teachers. This is indicated in several studies to find out how effective the use of ethnochemistry is in the learning process both in

high schools and in universities. The next analysis is regarding the research results. From the results of literature analysis, the majority of studies provide research results that have a positive impact on the chemistry learning process. Like Zidny et al.,(Zidny & Eilks, 2020) apply a learning approach that integrates local science and western science perspectives with a socio-scientific basis and is oriented towards actual and controversial sustainable issues. One of the topics used is related to the use of pesticides. The research results show that students gave a positive response to this topic. This is because students consider the topic of pesticide use to be a topic that interests them in learning and is relevant to their learning experience. Moreover, the research results also found that learning with the help of various points of view has great benefits. A learning process like this can broaden students' horizons and this shows that chemistry needs to be studied as part of an interconnected system, if we want to find answers to sustainability issues at the global level.

Nja et al., (Nja et al., 2022) provided the results of their research regarding the positive influence of the application of cultural practices and surrounding resources on academic achievement and students' self-concept in chemistry subjects. This is because linking cultural practices and resources or content related to what teachers teach in class can reduce the abstract nature of chemistry learning material. Here, cultural practices and surrounding resources play a role as tools to help students understand chemical concepts.

Rahmawati et al., (Rahmawati et al., 2023) conducted research using the CRTT (The culturally responsive transformative teaching) model in four schools in four provinces in Indonesia. The research carried out was interpretive mini ethnographic research. The results of their research show that the CRTT model applied in ethnochemical learning and applied in the Indonesian cultural context has the ability to invite middle school students to explore the relationship between the chemistry curriculum, cultural practices around students and examples of chemistry that are relevant in everyday life. Through the application of the CRTT model, there is a meaningful increase in chemistry learning. This is because the CRTT model combines cultural learning with an inquiry-based, student-driven approach and a collaborative-based approach. The implementation of the CRTT model was also carried out by (Najid et al., 2021) which aims to develop students' attitudes through the application of the CRTT model to the topic of colloids. The results of their research showed that students became motivated to be involved in the chemistry learning process through Banten cultural practices. Students can understand chemical concepts through a process of meaningful learning experiences. The CRTT model also provides opportunities for students to develop scientific attitudes in the classroom. Singh (Singh & Chibuye, 2016) found a positive impact on improving the attitudes of secondary school students by incorporating ethnochemical practices in the chemistry learning process. Besides, (Wiratma & Yuliamiastuti, 2023) explained that there was an improvement on students' scientific explanation skills using task based learning by utilizing ethnochemistry of vines in Lontar Usada Taru Pramana. Lontar usada taru pramana is one of the local wisdom in the form of a reference book for traditional Balinese medicine written on palm leaves and contains information about plants that can be used as medicine. Lontar Usada Taru

Pramana learning integrated into the steps of assignment activities such as making lists, sharing and problem solving can make the learning process more meaningful and have a positive impact on the preservation of the cultural wisdom of the Balinese people.

In the process of analyzing the research results, it was not only found how the impact was given from the application of ethnochemical learning. Further, (Achimugu et al., 2023) explain the results of her research on key strategies and challenges in integrating cultural practices in teaching and learning chemistry in secondary schools. The results of the study showed that the strategies to enhance the integration of cultural practices into chemistry teaching and learning include: 1) Incorporate cultural content and practices relevant to chemistry concepts into the secondary school chemistry curriculum; 2) Provide adequate training and professional development for chemistry teachers so that they can effectively integrate cultural practices in learning; 3) Develop teaching materials and learning resources that utilize local wisdom and cultural practices in explaining chemical concepts; 4) Encourage collaboration between chemistry teachers and local community and cultural leaders to identify cultural practices that can be integrated into learning. In addition, there were also factors that hindered the integration of cultural practices, such as: 1) Chemistry curriculum has not explicitly accommodated and integrated local culture practices; 2) The lack of education resources, textbooks, and learning media that include local wisdom; 3) Chemistry teachers have not had adequate understanding and skills in integrating cultural practices into learning; 4) Limited collaboration between schools, communities and local cultural stakeholders. The application of ethnochemistry in the learning process has an impact on learners' 21st century skills such as: argumentative and critical thinking skills (Rahmawati, 2018), students' science literacy skills (Dewi et al., 2019; Heliawati et al., 2022), and improve learning outcomes and critical thinking (Rahmawati et al., 2019; Wardani et al., 2023).

Moreover, the results of literature analysis demonstrated that there are 11 articles investigating the ethnochemistry learning that gave contribution as learning sources. (Scholes, 2019) explained the results of research related to the application of teaching modules that serve to bridge the understanding gap for indigenous students. This was done because it was found that there are different factors between formal science education and traditional indigenous education, especially for remote indigenous communities. The module used is one that involves the topic of the use of pesticide. He topic was chosen because it was interesting and in accordance with the students' learning experience. From the application of the module, it shows that the module can be well received by students and help students think about traditional activities in a scientific way and develop the participation of both indigenous and non-indigenous students in chemistry subjects at both secondary and higher education levels.

From the results of this study, it can be seen that in the process of learning chemistry involving local wisdom can have a positive impact both in terms of learning and in maintaining local cultural identity. Several studies provide recommendations regarding ethnochemical research. The recommendations given are expected to be able to provide benefits in the chemistry learning process and provide solutions to problems faced in the world of education. As (Zidny & Eilks, 2020) from the

results of his research provides recommendations for further research to be able to identify potential topics related to sustainable issues. This research is expected to identify the exact relationship between socio-scientific issues and the chemistry material studied. In addition, further research could identify how the worldview of science in indigenous communities and other countries can add to our knowledge of sustainable chemistry learning linkages. It is hoped that these studies will provide us with insights into the long-term effects of routinely implementing the learning unit process. Another study (Nja et al., 2022) explained that the CRTT model provides benefits so that chemistry learning can move from abstract to more concrete, meaningful, and related to local culture by combining ethnochemical texts and related subject matter. So the researcher provides recommendations to future studies to be able to conduct more research involving other cultural contexts by applying the CRTT model in ethnochemical learning.

(Singh & Chibuye, 2016) suggested several things that should be considered in learning ethnochemistry such as: 1) There should be attention and encouragement to document all ethnochemical practices; 2) Attention is needed to apply appropriate ethnochemical knowledge in chemistry lessons; 3) Organize workshops and seminars aimed at introducing and sensitizing chemistry teachers to the integration of ethnochemical knowledge in teaching chemistry concepts to students; 4) Integrate appropriate ethnochemical knowledge through Teacher Training Institutions. It is intended that after the teacher participates in training activities the teacher gets provisions on how to teach certain chemical concepts effectively. Another suggestion was given by (Wiratma & Yuliamiastuti, 2023) that it is hoped that future chemistry learning curriculum policies can consider the application of task-based Lontar Usada Taru Pramana learning. In addition, the researchers recommend exploring the concept of chemistry to preserve cultural heritage by sharing information about the use of traditional and modern medicinal plants and research advances.

The strategies and obstacles faced in integrating ethnochemistry in the learning process conducted by (Achimugu et al., 2023) provide several recommendations to improve the teaching and learning of chemistry at the secondary school level, including: 1) The need for chemistry curriculum revision to strategically integrate relevant cultural practices; 2) The need for training programs and professional development of chemistry teachers in integrating local wisdom; 3) Develop chemistry teaching materials and learning resources that are rich in local cultural content; 3) Collaborate between schools, communities, and local cultural stakeholders regarding the integration of cultural practices into chemistry teaching and learning.

CONCLUSION

The results show that most of the literature provides research results that have a positive impact on the learning process. This means that ethnochemical-based learning can make chemistry learning more enjoyable and relevant to students' daily lives (contextual-based learning). From the description of recommendations from several studies, it can be concluded that there is a revision of the chemistry

curriculum to strategically integrate relevant cultural practices and the need for government agencies to provide training for secondary school chemistry teachers on how to integrate cultural knowledge and practices into chemistry teaching and learning through seminars, conferences and workshops. It is aimed that teachers gain knowledge on how to integrate ethnochemistry in the learning process effectively.

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