

A Systematic Literature Review : Content and Pedagogy That Developed in Chemistry Teaching and Learning Materials at Secondary School

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Abstract

To improve the efficacy of chemistry teaching and learning in secondary schools, the development of relevant and contextual teaching material is essential. The development of teaching and learning materials is one of the considerable research carried out, especially in the development of chemistry teaching and learning materials for secondary school which is conducted to support an improvement in learning process. This study aims to analyzed contexts of content and pedagogy in the development of chemistry teaching and learning materials. The research method used was a systematic literature review. Employing a systematic literature review method, this study analyzed 51 articles selected from 2015 to 2021 based on keyword "development of chemistry teaching and learning materials in secondary school". The findings show that context of content and pedagogy that had been used in developing chemistry teaching and learning materials is varied. However, there are certain content in chemistry that oft to developed such as acid-base, chemical equilibrium and colloid, meanwhile context of pedagogy that oft to used in developing chemistry teaching and learning materials are Information and Communication Technology (ICT) and Problem based learning (PBL). Under this literature review results, The researcher recommend the continuity the development on chemistry teaching and learning materials not only in content acid-base or chemical equilibrium but also in others that integrated the development to pedagogy approaches supporting 21st century skills (Critical Thinking, Communication, Collaboration and Creativity).

Keywords: *chemistry teaching and learning materials, Development of teaching and learning materials, secondary school*

Introduction

Chemistry is the absolute science that investigates what, why, and how natural occurrences are related to matter's composition, structure, and properties, as well as changes, dynamics, and energy (Sholihah, Dj., & Efendi, 2018). Chemistry materials have scientific and abstract characters that is widely applied in everyday life, so in the process of teaching and learning chemistry materials must be delivered in the right way that able to help students understand concepts and attract student's interest to learn (Helsy, 2017). Furthermore, chemistry material delivery should engaging and exploring the relationship between chemistry and its use in everyday life. (Nasution, 2020)

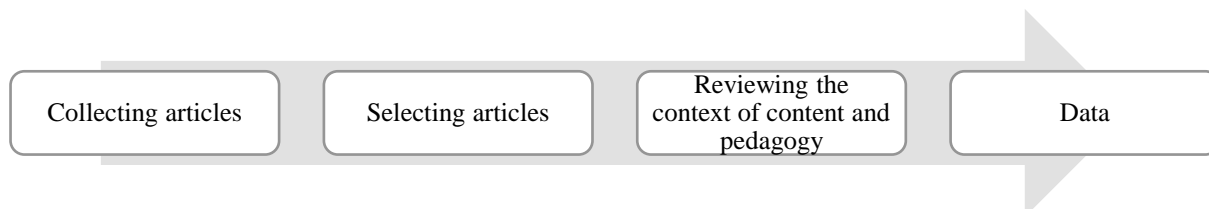
Chemistry learning is influenced by a variety of things. The instructional materials are one of them (Redhana, 2021). Researchers' attention is currently focused on the production of chemistry teaching materials for secondary schools, which is being intensively pursued. The development of teaching materials seeks to meet the needs of students and teachers in reaching the objectives of studying chemistry (Syamsuri, Anwar, & Sumarna, 2017). The development of chemistry teaching materials is also adjusted to the prevailing curriculum conditions (Hasanah & Anwar, 2018). Along with O.Lestari and S.Anwar study on the production of SETS-based

chemistry teaching and learning materials in 2020, which seeks to assist students meet their learning objectives while simultaneously improving their scientific literacy (Lestari & Anwar, 2020). The usage of designed teaching and learning materials improves student learning results in chemistry as well (Listriani, 2017). In general, the development of teaching materials is linked to the development of the teaching materials context, which includes both the content (material) and pedagogical contexts. The content context refers to the scientific knowledge, which includes facts, concepts, principles, laws, and theories, while the pedagogical context refers to the methods that can be used to help students learn and solve issues in science (Purwianingsih, 2010).

This research is a literature review study that aims to describe the trend of developing chemistry teaching and learning materials in Indonesia from 2015-2021. The discussion focuses on the development of chemistry teaching and learning materials that have been carried out in terms of content context and pedagogical context. The research question is what content context and pedagogy context that had been developed as chemistry teaching and learning materials for secondary school during that time. Through the research trends obtained, it is expected that it can be a reference for researcher to develop chemistry teaching and learning materials in the future studies. This research examines and collects relevant articles on the subject before classifying it.

Method

To find out the content and pedagogical context that has been developed in chemistry teaching and learning materials for secondary school we conducted a Systematic literature review (SLR). SLR that we used is a systematic and specific method to collect, select and analyze articles relevant to the research question (Snyder, 2019).



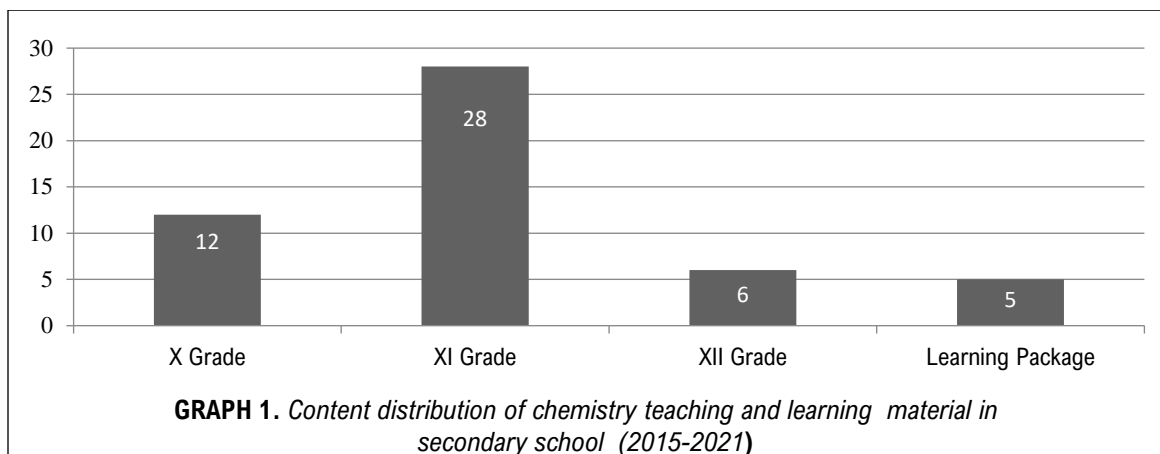
Picture 1. Stages in data collection

The parameters were content context (i.e fact, concept, principle, law and theory) such as chemistry materials for secondary school under 2013 curriculum (K 13) and pedagogical context (i.e methods) that help student to understand chemistry materials. The relevant articles obtained from 2015-2021 were 51 articles by means uses keywords “development of chemistry teaching and learning materials”. The researcher searched international and national well known databases (Google scholar, research gate, semantic scholar, CrossRef and e-sources). Analysis methods that used is thematic analysis related to the content and pedagogy in the development research.

Results

Content in Chemistry Teaching and Learning Materials that had been developed at Secondary School

A total of 51 articles were examined to determine the content on chemistry. 12 teaching materials are topics in X grade, 28 teaching materials are topics in XI grade, 5 teaching materials are topics in XII grade, and 5 teaching materials are learning packages containing of several topics. Graph 1 shows the distribution data.



Curriculum 2013 (K13) classified chemistry for secondary school in every grade is like this : X grade (introduction to chemistry, atomic structure, chemical bond, Electrolyte and non electrolyte solution, Oxidation and Reduction, Laws of Chemistry and stoichiometry; XI grade (Hydrocarbons and petroleum, Thermochemistry, Reaction Rate, Equilibrium, Acid-base, Salt Hydrolysis, Buffer Solution, and Colloid); XII grade (Colligative Properties, Oxidation Reduction Reaction, Voltaic Cells, Stoichiometry, Chemical Element, Hydrocarbon and Macromolecules). This classification is used to be references to choose topic of chemistry for researcher to develop teaching and learning materials. Although there are also several researchers who have developed teaching and learning materials consisting of several chemistry topics as known as learning package. The following table summarize the detail context of content in every grade and its frequency.

TABLE 1 Data on content and their frequency identified in articles on the development on chemistry teaching and learning materials at secondary school.

Grade	Content	freq
X	introduction to chemistry	0
	atomic structure	0
	Chemical Bond	2
	Electrolyte and non electrolyte solution	3
	Oxidation and Reduction	3
	Laws of Chemistry	3
	stoichiometry	1
XI	Hydrocarbons and petroleum	3
	Thermochemistry	3
	Reaction Rate	3
	Chemical Equilibrium	5
	Acid-base	5
	Salt Hydrolysis	3
	Buffer Solution	1
XII	Colloid	5
	Colligative Properties	0
	Oxidation Reduction Reaction	1
	Voltaic Cells	1

Stoichiometry	0
Chemical Element	0
Hydrocarbon	4
Mcaromolecules	0
Learning packages	5
total	51

Pedagogical Context on Chemistry Teaching and Learning Materials at Secondary School

The development on chemistry teaching and learning materials is accompanied by the use of a pedagogical context that is tailored to the desired outcomes. Various approaches were used in these 51 articles' pedagogical context. The following table summarizes the context of pedagogy:

TABLE 2. Data on pedagogical contexts and their frequency identified in articles on the development on chemistry teaching and learning materials at secondary school.

No	Context of Pedagogy	freq
1	Green chemistry	2
2	PBL	5
3	Oriented critical thinking	1
4	Guided inquiry	5
5	3 level of representations	2
6	STEM-PBL	1
7	Intergrated islam-science	1
8	Character building	1
9	Integrated spiritual value	2
10	ICT	8
11	Scientific inquiry-PBL	1
12	Environment discovery learning	1
13	STEM	1
14	ICT – Green chemistry	1
15	PJBL-ICT	1
16	Chemo-entreprenurship	2
17	HOTS	1
18	Investigation	1
19	Contextual	4
20	STEM-PJBL	1
21	SET	2
22	Contextual- islamic	1
23	ICT-3 level of representations	1
24	SETS	1
25	Knowledge building environment	1
26	PJBL	1
27	Interactive-environment based	1
28	Interactive-PBL	1
	total	51

Discussion

Content in Chemistry Teaching and Learning Materials

Based on graph 1 the development of chemistry teaching materials carried out in c X grade ($n:12$), XI grade ($n:28$) and the development of chemistry teaching materials was carried out the least in class XII ($n:6$). Development can have a positive impact on the chemical learning process, development of teaching materials should be evenly distributed in every grade. Equilibrium, acid-base and colloid material are the most developed topics in XI grade. The acid-base materials were chosen based on the available instructional resources, which were less relevant to life and lacked presentment (Silalahi, 2016). Chemical equilibrium material was obtained by majority of teaching resources, such as handbooks owned by teachers and students, are still the same. Handbooks held by teachers and students from a variety of publishers typically contain largely explanations of content or concepts, example questions, and practice questions or assignments that students must complete, leaving little room for students to explore more knowledge (Saraswati, Linda, & Herdini, 2019). As a result, there is a lot of work being done on developing chemistry teaching and learning materials on chemical equilibrium. Colloid as one of the topics that close to penomenon in daily life and can contribute to laboratorium activities (Siahaan, 2020). Laboratorium activities in colloid materials help students to improve the ability of applying chemistry in daily life, thats why colloid come as the most developed topic in teaching and learning materials (Rizqiana, 2017). These are the trend of topics that oft to developed. Meanwhile, topics that are not found in the development of teaching and learning materials are introduction to chemistry & atomic structure in X grade; Colligative Properties, Stoichiometry, Chemical Elements, and Macromolecules in XII grade.

Five of the 51 articles relate to the the development of teaching and learning materials in form Learning package. Three of them are learning package consisting chemistry topics : Hydrocarbons and petroleum, thermochemical, reaction rates and chemical equilibrium. These topics are taught in odd semseter of XI Grade so they are suitable as a alearning package (Fitriani, 2016). Apart from that, the choice of chemistry topics in odd semseter of XI grade is because the materials taught is closely related to chemistry and its application in life (Arfin, 2018). The two other learning package that developed consists of acid-base & colloids and Oxidation Reduction Reaction & compound nomenclature with the same reson of choosing is beacuse the relatavle of the topics to daily life.

Pedagogical Context in Chemistry Teaching and Learning Materials

Table 2 shows the pedagogical context used and their frequencies. Based on these data, the 4 most frequently used are PBL 5 articles, Inquiry 5 articles, ICT 8 articles and contextual 4 articles. The context of PBL pedagogy is problem-based learning. Through research that has been done, PBL can build students' higer order thinking skills (Ramdoniati, 2018). Where high-order thinking skills are needed in facing the challenges of the 21st century. 5 articles that used guided inquiry, the guided inquiry method is an inquiry approach in which the teacher directs a discussion and asks introductory questions to steer students through tasks. The teacher is involved in identifying the problem and the stages of its resolution. Students learn to be more oriented toward guidance and instruction from the teacher with this technique, allowing them to understand the lesson's concepts (Sudigdo, 2020). Learning through the guided inquiry approach is supposed to teach students not just how to recognize science's products (chemistry), but also how to discover science and, eventually, nurture a scientific attitude (Siahaan, 2020). Contecxt of ICT used in 8 articles. The context of ICT pedagogy has been widely developed because through technology rocks the teacher can visualize abstract content

contained in chemistry learning such as bonding material, chemical reactions and others (Fitriyah, 2021). Through learning with the help of ICT can also increase student motivation (Purba & Fitri, 2021). Pedagogical context of Contextual approach is found in 4 articles on chemistry teaching and learning materials development. The idea of using contextual is because students become bored and believe that chemical material is not necessary to learn when learning processes are not connected (Ariyani, 2019).

Conclusion

The literature review concludes that context of content and pedagogy that used in developing chemistry teaching and learning materials in 2015-2021 play a big role. Content that off to developed is in XI grade with topic acid-base, chemical equilibrium, and colloid, meanwhile top four context of pedagogy that off to used in developing chemistry teaching and learning materials are ICT, PBL, Guided inquiry and Contextual. These findings have implication for the other development of chemistry teaching and learning materials. In addition the researcher recommend the continuity of context development on chemistry teaching and learning materials in every grade that can construct 21st century skills (Critical Thinking, Communication, Collaboration and Creativity) in secondary school.

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