Students' perspectives on Batik Cirebon for high school chemistry embedded STEM learning

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Abstract. Batik Cirebon is one of Indonesia's potential local wisdom contexts that can be used in Chemistry high school STEM-based instruction. However, it is necessary to educationally reconstruct the context first so that its scientific content is suitable to be delivered to students. This research was a preliminary study that explored students' perspectives of batik Cirebon context as one of the stages in educational reconstruction. Model of Educational Reconstruction was used as a basis for reconstructing batik Cirebon context. Students’ perspectives were explored through in-depth questionnaire towards 14 respondents about: STEM education; their preconceptions about scientific content of batik and its related chemical concepts; and their interest of implementing batik context in Chemistry embedded-STEM instruction. Analysis of students’ perspectives was carried out based on the hermeneutic-analytic method. The results of this study indicated that students' preconceptions about chemical concepts related to batik context were still far from its correct scientific conceptions. Even so, respondents showed positive attitude towards the possibility of implementing STEM learning in high school chemistry. These findings are important as references in further educational reconstruction research of batik Cirebon context for Chemistry embedded-STEM learning, such as the instructional materials and also its learning strategy and evaluation.

1. Introduction
Following developments in educational trends around the world, Indonesia has been conducting research on STEM for nearly a decade. In those early researches, STEM learning was mostly conducted at the elementary school [1]. Implementing fully integrated STEM is easier to do at primary schools instead of higher levels because its curriculum is thematically integrated. Another reason is that the students are taught by a single teacher. Thus, teachers can freely develop STEM learning designs [2]. It is different when it comes to high school. Apart from the fact that its curriculum is not integrated thematically, each subject is taught by a different teacher. Therefore, implementing fully integrated STEM in high school is more difficult.

Although the main obstacle to implementing STEM learning in high school is the curriculum, restructuring the current curriculum is not the best idea because it is relatively difficult to do [3]. It takes a long time and in-depth analysis to create a curriculum structure that integrates STEM aspects into the trans disciplinary subjects contained in this current curriculum. As this has happened in countries that have already have STEM-based curricula, they took decades to formulate a whole STEM-based curriculum [4].
According to Robert and Chen, the best way to implement STEM in high schools is through embedded-STEM approach [2,5]. In this approach, a daily or real world context is needed as a learning theme. Through these contexts, students’ cognitive domain acquired through problem-solving practices and expert-like activities related to the context [5]. Because the STEM aspects covered in the conventional curriculum are only Science (Chemistry, Biology, and Physics) and Mathematics, these contexts can be embedded in certain topics on one of those subjects. Thus, there is no need for restructuring the curriculum.

Batik Cirebon is a suitable context for STEM learning. It is because it has played a major role in both economic and socio-cultural aspects of the community [6]. Unfortunately, it also has an environmental impact due to its poor waste treatment [6, 7]. This environmental problem can be used as a context for students to practice problem solving. Although there has been a lot of research on the use of batik in learning, research that examines batik to be used in STEM learning has not been carried out. Previous research has put more emphasis on alternative dyes with secondary metabolites, analyzing local plants as natural dyes and innovative skill profile in designing chemical batik motives [8-10]. Meanwhile, there are no related studies examining aspects of batik in STEM learning until now. Therefore, a preliminary study is needed to analyze the possibility of using the batik context in embedded-STEM learning.

Because batik Cirebon is not a mainstream context in the learning curriculum, it is necessary to run educational reconstruction so that it can be appropriately conveyed to students. Scientific content of real-world context is not always exactly suitable to be delivered directly in classroom instruction. The depth of the scientific content may not be appropriate or even not included in the conventional curriculum. Therefore, reconstruction process was crucial to be conducted. In this study, analysis study of students' perspectives on STEM education and the relationship between batik Cirebon context and high school chemical concepts was carried out. The purpose of this study was to find out the ability of students to relate the scientific content of batik with chemical concepts they have learned in school. This is a crucial step in the process of reconstructing batik context for learning activity. In addition, students' perspectives on the possibility of implementing STEM learning using batik as a context in chemistry lessons were also analyzed as well as students’ interest in the learning model. The results of this study are important for further studies in developing design and evaluation of STEM learning in high school chemistry.

2. Methods
This study used qualitative approach with Model of Education Reconstruction (MER) as a basis for reconstructing the batik context. As a complete process, MER identifies and interprets the aspects of: 1) clarification of scientific content of certain context, 2) learners’ perspectives and 3) its learning environment including design, analysis and evaluation, to reconstruct innovative or relatively new contexts that are excluded from conventional curriculum [11]. This study specifically focused on the second aspects, i.e. students’ perspectives on batik as learning contexts, especially their preconceptions towards scientific content of batik and its relation to chemical concepts they have learned as well as their perspectives on the possibility of implementing STEM learning using batik as a context in chemistry lessons. Exploration of students' perspectives was carried out through online in-depth semi-structured questionnaire with open-ended questions towards 14 high school students, due to the covid-19 pandemic situation. Semi-structured questionnaire with open-ended questions is commonly used to explore respondents' perspectives on their knowledge of certain concept [12].

In this study, credibility and dependability were achieved by member check/peer examination through expert judgment. These processes were carried out as the analogy of validity and reliability tests in quantitative research. Both credibility and dependability have similarity, where in the processes, colleagues help identify uncovered category/negative cases from the research questions [13]. In the member check/peer examination of this study, there were several improvements in terms of language, layout and content. The questionnaire was developed consisted of 16 questions divided into 3 parts, e.g.: 1) Part 1 about STEM education (4 questions), 2) Part 2 about batik Cirebon and
related chemical concepts (5 questions), and 3) Part 3 about student perspectives if *batik Cirebon* is implemented in STEM based-chemistry subjects (7 questions).

The data of this study were analyzed using the hermeneutic method as described by Katmann in a scientific clarification of a certain context [14]. This analysis include: 1) which are the scientific theories and concepts on high school chemistry associated with *batik* manufacturing based-on their perspective, 2) where are their limitations in explaining *batik* manufacturing process, 3) which social and ethical implications are associated with the context and 4) which applicative field are affected from those contexts.

### 3. Result and Discussion

#### 3.1. Students' preconception on scientific content of batik

In this study, investigation of students' preconception on scientific content related to *batik Cirebon* was run based on the result of previous study that has been conducted by the researcher about the clarification and analysis of the significance of scientific content from the *batik* context. Based on previous research, it is known that there are several chemical concepts related to *batik* Cirebon, e.g. aromatic derivatives and polymer; electromagnetic radiation; chemical bonds; redox and stoichiometry. These chemical concepts relate to several aspects of *batik*, e.g. the main components of *batik* (fabric, wax and dye) and the manufacturing process. The relationship between *batik* context and the chemical concept can be seen in figure 1.

![Figure 1. Linking scheme between scientific content of batik with high school chemical concepts](image)

Chemical concept that explains *batik* cloth is polymer. *Batik Cirebon* craftsmen usually use several types of fabrics, some of which are natural polymers, but others are synthetic polymers. The
differences in the structure of the polymers affect the quality and durability of the *batik* produced. Chemical concepts that described the wax used in *batik* manufacturing are lipid and alcohol. Wax is a chemical compound that is composed of fatty acid ester and long-chain alcohol [15]. The hydrophobic nature of the wax can prevent the contact of the dye with the *batik* cloth during the colouring process so that various colours are obtained on the *batik* motives that have been drawn. Regarding *batik* dyes, the concept of intermolecular force and chemical bonding explains how the dye molecules can stick to the fibre molecules. A dye can emit a certain colour through the mechanism of electromagnetic radiation on its molecules. Furthermore, there are several chemical processes that occur in the *batik*-manufacturing process, namely redox reactions (occurs when using indigosol dyes) and acid-base reactions (occurs when using naphthol dyes). Indigosol and naphthol are most commonly used by *batik* *Cirebon* craftsmen. They are both derivatives of aromatic and chromophore compounds, which have conjugated double bonds.

Students' preconceptions about chemical concepts related to fabrics, waxes, dyes, and *batik* manufacturing process were explored through questionnaire, especially in Part 2 of the questionnaire. Figure 2 below showed the percentage of respondents' correct answers related to chemical concepts from the scientific content of *batik*. There were none of the respondents answered correctly on the question of fabrics and principle of colouring process, while there was only one respondent answered correctly on the question of chemical structure of dye.

![Figure 2. Diagram of respondent’s answer to the questionnaire](image)

Regarding the chemical concepts related to fabrics, the question of the questionnaire was: *what chemical concepts discuss natural fibres and synthetic fibres?* The correct answer should be polymers. However, none of the respondents answered correctly. The closest answer was from respondent C, who answered wool and polyester (which are examples of polymers). However, he could not identify the specific and correct chemical concept. In fact, in high school chemistry textbooks published by the Ministry of National Education, concept of polymer is clearly stated [16, 17]. Even fibres are explicitly listed as examples of polymers in some of those books. Thus, it was the intrinsic factor that causing respondent having the difficulty in linking the polymer concept with fabrics context.

Questions about colouring aspects of *batik* were divided into two parts: the principle of dyeing and the chemical structure of dyes. First question about colouring aspects of *batik* is: *what chemical concept discusses the process of colour formation in batik cloth?* From this question, none of the respondents answered correctly. The correct answer for the principle of dyeing should be electromagnetic radiation. Referring to common general chemistry textbooks, conceptually, electromagnetic radiation is included in the topic of atomic structure [18-20]. However, in the current curriculum, this concept does not explicitly appear in the *Standar Isi* (standard of subject content) for high school chemistry subject. Through research on several high school chemistry books, it was revealed that the concept is not included in most of these books [21, 22]. There is only one book that contains a discussion of electromagnetic radiation [23]. Therefore, it is likely that this concept is not taught to students. This may be the reason why there were no respondent answered correctly for these questions. Although if the concept is assumed taught by the teacher, maybe the low level of students'
connected-conception to the topic of atomic structure is another reason why respondents were unable to connect the batik colouring process with the concept of electromagnetic radiation [24].

Regarding the chemical structure of dyes, they asked similar functional groups in the two most commonly used batik dyes, i.e. naphthol and indigosol, and in what group of compounds this functional group belongs to. The correct answers to the questions are phenyl and benzene derivative compound. From this question, there was one respondent who answered correctly the set of the questions. Other respondents cannot answer correctly because they are not familiar with those compounds mentioned in the question. Through analysis on several high schools chemistry books, it was found that these compounds were never discussed in the aromatics chapter. Therefore, there is a possibility that they are fixated on the examples of compounds listed in the textbook and cannot apply the general concept to other compounds. This means that students' cognitive abilities are still below the C-3 (application) level according to Bloom’s taxonomy so that it can be interpreted that their cognitive abilities are in the range of lower order thinking skills [25].

Based on the three aspects explored above, there are several conclusions related to students' preconceptions on chemical concepts related to the batik context: 1) almost all of the students' preconceptions do not match the correct scientific content; 2) those incorrect preconceptions come from intrinsic (low level of students' connected-conception, lower order thinking skills) and extrinsic (chemical concepts that are not included in curriculum structure) aspects. Several studies on students' perspectives-based restructured learning design that are successful in correcting students' preconceptions include using modelling and modelling skills (MMS), science heuristic writing (SWH) as well as supporting media and animation to address students' inappropriate conceptions [26, 27]. These approaches can be considered in designing embedded-STEM learning using batik context.

3.2. Student interest in STEM learning in the context of batik

In this subsection, students' perspectives that were explored are those related to their knowledge of STEM education, their interest on it, and their opinions on the possibility of implementing batik context in high school chemistry STEM learning, which can be found in Part 1 and 3 of the questionnaires. As performed by Katmann in scientific clarification of learning context, analysis of the data of this study also used the hermeneutic method [14]. This analysis was carried out to find out the social implications of using batik context in high school chemistry STEM learning and how this context affects the implicated field, in addition to uncovering their preconception towards scientific content associated with batik and their limitations in explaining it.

Based on the answers given by respondents, most of them did not really know what STEM education is initially. Their knowledge is limited to what STEM stands for. After being given an insight into what STEM education is, they were asked to give their opinion about the strengths and weaknesses of STEM education. Regarding the advantages of STEM education, the most answered keywords were practicing critical thinking, solving problems (especially those related to daily problems) and innovative skills. Meanwhile, the weakness of STEM education, according to their answers, were complicated, takes a long time and need more complex learning tools. Regarding respondents' interest in STEM education, 100% of them interested to experience STEM learning. Their reasons were: 1) STEM learning will not only emphasize the academic/cognitive aspects, but also can hone reasoning, critical thinking and problem-solving skills, and 2) through STEM learning, they will get used to learn various fields study in integrated manner.

In addition, their opinions regarding the use of batik context in STEM learning were also explored, including: 1) why the batik context suitable to be used in STEM learning, 2) other STEM aspects, besides chemistry, related to the batik context, 3) themes (eco-friendly dyes alternatives or waste treatment) they prefer for batik context-based STEM learning. Students' perspectives on why the context of batik is suitable as a STEM learning theme were varied. There were those who saw it from the perspective of cultural preservation, in the other side, others saw it from environment, business, industry and arts aspects. Regarding other STEM aspects that are closely related to the context of batik, most respondents answered physics and biology. Physics deals with the concept of pressure.
during printing batik while biology is related to plants that can be used as an alternative material for dyes. It is not surprising that the respondents' answers still revolve around science subjects while the technological and engineering aspects are untouched. It is because the subjects related to STEM that exist in the conventional curriculum are only science and mathematics.

Based on the explanation above, it can be concluded that the respondents were generally able to understand the characteristics of STEM education and showed positive attitudes on STEM learning. Regarding the context of batik, they argued that the batik context can be and will be interesting to be used as a STEM learning context. Specific themes that can be explored are batik waste treatment and eco-friendly dyes alternatives. Meanwhile, apart from the scientific aspect, they have not been able to identify the relationship between Technology, Engineering and Mathematic aspects of the batik context. Thus, STEM learning strategies that will be developed must be able to help students to practice their ability to identify and determine Technology, Engineering and Mathematic aspects of the batik context.

4. Conclusion
Educational reconstruction is needed in the development process of STEM learning. One of its components is analysing learners’ perspectives. Analysing learner’s perspectives on learning context and their attitudes towards it is important as references for developing design and evaluation of STEM learning. In this study, it was shown that students' preconceptions about scientific content of batik and its related chemical concepts were still far from its scientific conception, i.e. zero per cent on chemical concepts regarding fabrics and principle of colouring process and 7% for chemical structure of dye. These were come from students' intrinsic and extrinsic factors (including curriculum structure and learning support). This finding is useful for determining interventions needed in developing the learning strategies. Even so, students showed a positive attitude towards the possibility of using the batik context in chemistry learning. This indicates that STEM learning using batik context is possible to be developed and implemented in high school chemistry lessons.

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