Construction of Context-Based Module: How OLED can be used as a Context in High School Chemistry Instruction

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Abstract. Teaching materials used in Indonesia generally just emphasize remembering skill so that the students’ science literacy is low. Innovation is needed to transform traditional teaching materials so that it can stimulate students’ science literacy, one of which is by context-based approach. This study focused on the construction of context-based module for high school using Organic Light-Emitting Diode (OLED) topics. OLED was chosen because it is an up-to-date topic and relevant to real life. This study used Model of Educational Reconstruction (MER) to reconstruct science content structure about OLED through combining scientist’s perspectives with student’s preconceptions and national curriculum. Literature review of OLED includes its definition, components, characteristics and working principle. Student’s preconceptions about OLED are obtained through interviews. The result shows that student’s preconceptions have not been fully similar with the scientist's perspective. One of the reasons is that some of the related Chemistry concepts are too complicated. Through curriculum analysis, Chemistry about OLED that are appropriate for high school are Bohr’s atomic theory, redox and organic chemistry including polymers and aromatics. The OLED context and its Chemistry concept were developed into context-based module by adapting science literacy-based learning. This module is expected to increase students’science literacy performance.

1. Introduction
The common problems faced in science education today are how to motivate students and increase their interest in learning science. One of the most widely used solutions is through a context-based learning approaches [1]. Context-based approaches are approaches that adopted in science learning where context and application of science are used as starting points for the development of scientific ideas [2]. Context-based learning can bring science closer to student daily life so that they are more interested in learning it and ultimately the understanding of science itself increases. The development of context-based teaching materials projects in the UK (Salter’s Advanced Chemistry), USA (Chemistry in the Community) and Germany (Chemic im Kontext) is one of the application of context-based approaches.

The application of context-based teaching materials is based on the results of several studies such as students ‘lack of interest in science lessons (Ramsden, 2003), declining students’ interest in science in secondary school (Reiss, 2004; Simpson and Oliver, 1990) and student assumption that science doesn't have relevance to their lives (Reiss, 2000) [3]. Reported by de Jong, meta-analysis has been done by Bennett, Hogarth and Lubben on 66 studies of the effects of context-based learning.
approaches. The results showed that this context-based approach motivate students in their science lessons and enhance more positive attitudes to science more generally [4].

Meanwhile, most of the teaching materials that have existed and developed in Indonesia focus only on dimension of content [5]. The application or context of the knowledge content itself is not much explored. One effort to improve science literacy performance of Indonesian students is to construct context-based module. The topic to be used as a context may refer to the selection principles of science learning-based on PISA: relevant to real-life situations that will still be relevant for at least a decade ahead and closely related to the competence of the process [6].

One interesting topic is Organic Light-Emitting Diode (OLED). This is because OLED is an up-to-date research theme with widespread application and can be made from local resources. An OLED is a light emitter with a thickness of about 100–200 nm [7]. The uniqueness of OLED is the use of organic materials that are easier and cheaper than inorganic materials (silicon). Even, mangosteen and carrots extract can be used as an OLED emitters [8]. OLED is widely used in lights, mobile phones, televisions display, etc.

This study focused on the reconstruction of science content structure of OLED into content structure for instruction and developing it to become context-based module for high school students. The reconstruction is required because not all OLED related Chemistry concepts can be delivered to high school students. This context-based module was developed by adapting the sequences of the Science and Technology Literacy (STL) learning stages proposed by Nentwig et al [9]. By following these STL learning stages, it is hoped that students can develop their thinking process and be able to integrate some Chemistry concepts through the OLED context. Furthermore, through OLED context-based-module, it is expected that students’ science literacy performance will be increased.

2. Method

The research design used in this research is Model of Educational Reconstruction (MER) developed by Duit [10]. The fundamental idea of this model is that the content structure for instruction can not be taken directly from the science content structure. It should be reconstructed in particular by paying attention to the educational objectives as well as the students’ cognitive and affective perspectives. Therefore, besides science content structure, students’ conceptions and educational goals must be equally considered [11].

MER consists of three components, namely: 1) analysis of content structure, 2) research on teaching & learning, and 3) development and evaluation of instruction – and their close interplay [12]. The first stage is conducted through literature analysis of OLED books and journals to obtain scientific perspectives on OLED including its definitions, components, characteristics and working principles. Later, an analysis literature of related Chemistry concepts related to OLED conducted using high school and university chemistry textbooks as references. The second stage is conducted through clinical interviews of high school students to explore preconceptions about OLED. Interview guideline adapted from the Laherto format [12]. The interview questions consist of 13 unstructured-format items. These items were divided into six sections that exploring: 1) general knowledge of OLED; 2) emission process of light and Chemistry concepts that explains the process; 3) OLED structure and its related Chemistry concepts; 4) characteristics of OLED and its related Chemistry concepts; 5) basic principles of OLED and its related Chemistry concepts and 6) student’s interest in OLED-context modules. The third stage is the module construction process through the didactic reduction.

The module that have been constructed are tested for its readability and feasibility. Readability test is conducted using Fry formula. The feasibility assessment is undertaken by Chemistry and Indonesian teachers, including language, presentation and graphics.

3. Result and Discussion

3.1. Scientist’s perspective about OLED

OLED is a light emitter with a thickness of about 100–200 nm [7]. The advantages of OLED compared to inorganic LEDs and LCDs are better color resolution and lower power consumption to
operate. In addition, with its thickness OLED can be used to create thin and flexible displays [13]. The basic structure of OLED is the organic material positioned between the cathode and anode made of transparent conductive glass, usually indium tin oxide, ITO (indium tin oxide).

Light emission on OLED occurs by making the organic molecule in an excited state. This process is then followed by the decay of electron pairs and holes (electron defects) back to their ground state resulting light emission. However, excitation in organic molecules is difficult. Excitation of organic molecules will only occur if the molecule exhibits an intrinsic conductivity both for electrons and holes and an energy level alignment as found in inorganic semiconductors. The key to electrical conductivity in the polymer is the existence of a conjugated system [14]. The conjugated system is a system in which the position of the double bond and the single bond are alternating with each other.

The overlap of π orbitals of the conjugated system between organic molecules induce an unfolding in the HOMO and LUMO level, originating narrow bands that consist in energetic steps called bandgap (of organic semiconductors that act like the similar bandgap of inorganic ones) that usually range from 1 eV to 4 eV. This bandgap is corresponding to the minimum energy to generate an excited state. This bandgap usually decreases with the increase of the delocalization, because the π electronic system increases [7]. The smaller the bandgap, the lower the bandgap energy, the easier the organic molecule will be excited.

Although the key to the conductivity of the polymer is the existence of a conjugated system, it does not necessarily make the polymer electrical conductor. An interference is required through the removal of electrons (oxidation) and the addition of electrons (reduction). This process is called doping. Through the redox principle, electrons will move easily and flow along the molecules to create an electric current [15].

Light emission on OLED takes place through a process called electroluminescence. Electroluminescence is a non-thermal generation of light resulting from the application of an electric field to a substrate. Emissions on OLED devices are explained through the principle of electron-hole recombination. When electrons and holes recombine, a high-energy quasiparticle is formed. These quasi-particles are called excitons, which are similar with single molecules, but with more high energy. This exciton produces light when it decays [13]. The basic principle of the electroluminescence process occurring in OLED is illustrated in Figure 1.

![Figure 1](image.png)

Figure 1. Principle of electroluminescence in an OLED (Banerji, Tausch & Scherf, 2013).

Based on Figure 1, the electroluminescence process can be described as follows: 1) Charge injection: using a power supply, the electrons are drawn from the anode to form a hole, then the electrons are forwarded to the cathode so that the electrons are excessive; 2) Charge transport along the polymer layer from one molecule to another in opposite directions and 3) Charge recombination (electrons and holes) to give an exciton that emitting light when it decays [14]. The wavelength of the
light emission produced depends on the exciton energy. Therefore, we can control the color produced by regulating the energy through the selection of the organic material. This is the advantage of OLED displays [16].

3.2 High school Chemistry concepts related to OLED

Science content structure of OLED can not be used directly as content structure for High School Chemistry instruction. Therefore, it is important to analyze the relevance of chemistry concepts related to OLED to the ongoing curriculum. The purpose is that the instruction experienced by students is appropriate with the level of cognitive for high school students.

![Figure 2. Scheme of context OLED and its related Chemistry concept.](image)

Figure 2 illustrates the linkage between the OLED concept as an innovation concept with High School Chemistry concept. Those related High School Chemistry concepts are:

1. Bohr’s Theory about energy level, to describe light emission process
2. Periodicity, to describe electrical conductivity of semiconductor
3. Organic compound, related to basic material of OLED
4. Polymer, especially conductive polymer
5. Alkene and aromatic compound to describe conjugated system
6. Redox and electrolysis, to describe principle of OLED that makes conductive polymer can emit lights.

3.3 Student’s preconceptions about OLED and its related Chemistry concepts

Student’s preconceptions about OLED are explored through a clinical interview which adapting the Laherto format. The preconceptions include general knowledge of OLED technology, Chemistry concept explaining the characteristics and principles of OLED and student’s interest in using context-based modules that use OLED topic. Overall, these student’s preconceptions are not fully similar with the perspective of science. One reason is that some of those related Chemistry concepts are not taught in high school.
Table 1. Student’s preconceptions about OLED and its related Chemistry concepts

| Student’s Preconceptions | General knowledge of OLED (before picture of OLED sample is given) | General knowledge of OLED (after picture of OLED sample is given) | Emitting light process and it’s related Chemistry concepts | The basic structure of OLED and it’s related Chemistry concepts | OLED characteristics and it’s related Chemistry concepts | OLED working principle and it’s related Chemistry concepts | Student interest in the OLED-context module |
|--------------------------|--------------------------------------------------------------------|-----------------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------|---------------------------------------------|
| Students do not know OLED | Light, flexible and eco-friendly light-emitting technology          | Students do not know the mechanism of light emitting              | Students know Bohr’s atomic theory, but do not know that the process of light emitting can be explained from this theory | It’s similar with electrochemistry, but only some students answer correctly, that is electrolysis | Organic compounds are naturally electric insulators         | Some students are able to identify some of the processes that occur in electroluminescence (electron transfer, charge movement), but do not recognize the recombination process | Students are interested in using the OLED-context module because the material presented is more useful and not boring |

These preconceptions shown in Table 1 are used to determine the starting point of conveying the OLED context of the constructed module. In this case, the development of television display is used to deliver OLED because most students recognize OLED as a television technology. In addition, students’ preconceptions become one of the inputs in the preparation of the text. It is intended that the module is constructed conveniently read by students.

Most students complain about so many theories being taught in schools today. Context-based learning can prevent students from overloaded curricula [17]. Students are interested in using context-based module because it’s more relevant with student’s need. The relevance of science to the needs of students is directly proportional to the interest of students studying science [18]. Thus, the findings in this study reinforce the results of previous studies on the role of context-based approaches in improving student’s positive attitudes (including motivation and interest) to science.

3.4 Construction of OLED-context module

Didactic reduction is conducted to reduce the difficulty level of the concept to be written on the module, making it easier for the students to understand. Didactic reduction is gone through four ways: back to qualitative phase, neglecting process, using picture to help explanation and using historical development. The module is designed based on teaching and learning sequence of Science and Technology Literacy (STL) that adopted from Chemie im Kontext [9]. The constructed module is divided in two part, The Blue Part contains explanation about OLED and The Green Part that explores high school Chemistry concept related to OLED. By adapting STL learning phase stage, it is expected that student’s thinking processes and integrating ability increase. The sequence of the module is:

1. Contact phase
   Television display development is used in this phase as an introduction in The Blue Part that contain explanation about OLED.

2. Curiosity phase
   In this phase, student’s curiosity is stimulated by question about why organic compound that generally isolator can conducting electricity like in television and hand phone.
3. Elaboration phase
   This phase is focusing on OLED explanation, including characteristics and how OLED works.
4. Decision making phase
   The purpose of this phase is to make students get right and obvious answer for question in curiosity phase. In the constructed module, this phase is represented in form of summary.
5. Nexus phase
   This last phase is the decontextualizing phase from all of content that has been submitted. In this module, nexus phase is presented by giving example of some organic compound to be analysed by students whether it can be used as OLED raw material or not.

3.5 Review result of the constructed OLED-context module
The feasibility test was conducted by three High School Chemistry teachers and one Indonesian teacher. Referring to the feasibility score percentage of teaching materials according to Slavin, it can be concluded that in terms of language, presentation and graphics as shown in Table 2 the constructed module can be declared feasible.

| No. | Criteria     | Assessment 1 | Assessment 2 | Assessment 3 | Assessment 4 | Average   |
|-----|--------------|--------------|--------------|--------------|--------------|-----------|
| 1   | Language     | 80 %         | 85 %         | 80 %         | 80 %         | 81.25 %   |
| 2   | Presentation | 85 %         | 80 %         | 80 %         | 85 %         | 82.5 %    |
| 3   | Graphics     | 80 %         | 80 %         | 85 %         | 80 %         | 81.25 %   |

Readability test of the constructed module used Fry formula. Three representative samples are selected to be tested. The grade reading level is determined from the intersection of the average number of sentence and the average number of syllables per hundred words by plotting it to the Fry graph, which is in this study is level 11. This means that the module is appropriate for high school.

4. Conclusion
The current teaching learning trends are shifting towards a context-based approach. OLED as an up-to-date and relevant topic to students' daily life is an appropriate theme to be used as a context, including in Chemistry instruction. The reconstruction process is needed to adjust the OLED science content structure to be appropriate for high school instruction so that it meets the criteria for being a context. In this study, reconstruction of OLED content was performed using MER by combining scientist's perspective, student's preconceptions and curriculum objectives. The module is constructed by adapting the STL learning sequence, divided into two parts: Blue Part (contains explanation about OLED) and The Green Part (explores high school Chemistry concept related to OLED). Interview result shows that context-based modules help improve students' positive attitudes toward Chemistry and emphasize the relevance of Chemistry in everyday life. On this basis, it is hoped that students' science literacy performance can increase.

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