Utilization of e-module in polymer synthetic based on green chemistry to improve student high level thinking

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Abstract. Increased thinking at a high level is needed so that students are able to solve the problems faced in their lives based on Islamic values. This study aims to analyze the improvement of higher order thinking skills based on Islamic values on the application of green chemistry-based synthetic polymer e-modules. The research design used was a one-group pretest and posttest with research subjects that were 26 semester VI students of the Chemistry Education Study Program. The results of this study indicate that the application of synthetic chemistry based on green chemistry e-module can improve the ability of high-level thinking based on Islamic values based on the average gain of n-gain 0.647 which is included in the medium category. Learning using this e-module can improve learning outcomes by making learning situations more active so as to better understand the concept of synthetic polymers based on green chemistry. Thus, the application of synthetic chemistry based on green chemistry e-module can improve the ability to think at a high level.

1. Introduction

Nowadays, technology-based teaching materials are needed as a media to assist the learning process [1]. One of the technology-based teaching materials that is effective and relevant to 21st century learning is e-module. E-modules can facilitate students in learning concepts and improving quality and motivation to learn [2]. E-modules presents a visualization of the concept learned because it has characteristics and components such as images, audio, and interactive video so that it is suitable for use in learning [3]. Learning by e-module enables students to get direct feedback and gain complete mastery of subject matter [4] so that it can support in the process of independent learning [5]. The e-module allows students to independently study topics related to abstract and complex materials such as chemistry [4].

Chemistry is a part of science which is widely applied in daily life [6]. Human life cannot be separated from chemical products, one of which is a synthetic polymer. Synthetic polymers have become one of the basic human needs [7]. The most common type of synthetic polymer is plastic. Its practical and durable nature is an attraction for food packaging [8]. However, some types of synthetic polymers used as food packaging have harmful effects on the environment and health [9]. One of them is environmental pollution which occurs because the waste continues to accumulate in a place [7,10].

Synthetic polymer waste is a problem because it takes 100-500 years to be degraded by microorganisms [11]. Efforts in making students aware of this problem include introducing the principles of green chemistry into class learning [10]. This principle emphasizes the use of materials, processes and practices to reduce hazardous chemicals [12]. Green chemistry can be used as a new
orientation in learning [13]. Integrating green chemistry into the education curriculum can improve students' critical thinking, problem solving, and communicative skills needed for continuous understanding [14]. Such as conducting innovative chemical experiments using substances and processes that are environmentally friendly [10]. In addition, incorporating the principles of green chemistry into learning can shape the character of students who care about the environment [15] and are able to deal with environmental issues [16]. So that it can play a role in environmental preservation [15].

2. Methods
The method used in this study is a pre-experimental method with a one-group pretest and posttest research design [17]. The research stages consist of three main stages, namely the preparation, implementation, and final stages.

In the preparation stage, researchers conduct classroom observations, preliminary studies, and adjusting the Semester Learning Plan (RPS), and compile research instruments. E-modules and instruments have been validated and tested on 10 students. At the implementation stage, the process of pretest, then the learning process uses green chemistry-based synthetic polymer e-module, and the posttest to find out the improvement of high-level thinking skills. The final stage of the research is the stage of data processing, data analysis, discussion of research results and drawing conclusions of research results.

The enhancement of high level thinking ability is supported by several research instruments including learning descriptions, Worksheets (LK) that can assist students in using e-modules used, and about higher order thinking skills in the form of a matter of description. Based on the instruments used, an increased level of thinking ability. The increase data was obtained from the results of the pretest and posttest questions which were then categorized into high, medium, and low increase through the analysis of n-gain values using the formula:

\[ d = \frac{\text{posttest score} - \text{pretest score}}{\text{ideal score} - \text{pretest score}} \]  

3. Results and discussion
Increased ability to think high level can be known from the results of the pretest and posttest. Pretest is held before learning, then posttest after learning using synthetic chemistry based on green chemistry e-module is applied. The n-gain values in each cognitive domain of higher level thinking are presented in Table 1.

| cognitive domain | Average Score | N-Gain | Interpretation |
|------------------|---------------|--------|----------------|
|                  | Pretest       | Posttest |          |
| C4               | 1,48          | 2,77   | 0,653        | Middle |
| C5               | 9             | 18,5   | 0,645        | Middle |
| C6               | 4,15          | 7      | 0,597        | Middle |
|                  | Average       | 0,647  | Middle       |

Based on Table 1, an increase in high-level thinking ability has an n-gain of 0.647 which is included in the medium category. The highest level of thinking ability with the greatest increase is in the cognitive dimension of analyzing with n-gain of 0.653, and the smallest is the cognitive dimension of creating with n-gain of 0.597.

The problem raised by students to measure the ability to analyze is about the relationship between the necessity of the community in tackling pollution due to the use of plastic in accordance with the content of Q.S. Luqman: 20. Students are required to discover and describe the concept of plastic waste...
that has a negative impact on life. Humans as caliphs on earth are required to be able to manage waste and not make damage. Students are able to relate and analyze phenomena in everyday life regarding plastic waste as a result of not caring about God's call to preserve nature as a sign of gratitude for the gift that God has given fully for human needs and welfare according to the Qur'an Lukman: 20. As which was raised by Krathwohl & Anderson, the cognitive dimension of analyzing involves the ability to solve a problem into its units and determine the interrelationships between units to form clear links [18]. In addition, states that the ability to analyze is required to be able to break the material into main parts and describe how the parts are connected with each other [19].

Some students are not optimal in analyzing the contents of Q.S. Lukman: 20 which is related to the problem of environmental damage caused by human activity. There are also students who answer only to break down from the point of waste material without relating it to the verses of al-Qur'an. As the statement of Harahap that human ability to explore various scientific fields at once is indeed limited [20]. Therefore, the integration of al-Qur'an and science is something that is very much needed nowadays in order to be able to bridge the scientists in the fields of religion and non-religion.

In the ability to think that measures the ability to analyze this, some students have been able to identify the most important and relevant elements to the problem [21], but some students have not yet reached the stage of establishing engagement with the verses of al-Qur'an that according to the information provided [22]. Students have tried to analyze the phenomena or material being studied that is integrated with the Al-Qur'an verses [23].

On questions that measure the ability to evaluate, students are required to judge a conclusion. Assess included in the cognitive dimension of evaluating, because it makes a consideration based on existing criteria and standards [24]. Findings on questions that measure the cognitive dimension evaluate this, including the n-gain cognitive dimension evaluating greater than the n-gain on the creating cognitive dimension. This is due to the fact that some students at the pretest and posttest were able to provide an assessment of the information or phenomenon that was provided along with reinforcement with verses of al-Qur'an. In the ability to think that at a high level of evaluation, students have been directed to the conclusion of the evaluation stage based on existing criteria with good problem solving stages, namely understanding the problem by applying information associated with the verses of al-Qur'an to prove the conclusion. Evaluating leads to the assessment of a phenomenon about the impact of plastic waste which can be related to giving a solution idea through the thought process of planning and implementing [11,22], so that it leads to the determination of the extent to which a plan is going well and an appraisal that fits the criteria is produced.

However, some still have difficulties in expressing Islamic views on the resolution of this problem. This happens because of the lack of carefulness of students in analyzing data and the lack of student interest in digging knowledge from other literacy, such as sources that discuss interpretations of the verses of al-Qur'an. So it will be difficult to express the Islamic view of a phenomenon if it is not supported by the right source. The relationship between al-Qur'an and science is expressed as an integration relationship. In this case al-Qur'an and science are interconnected in a study, where it is in the Qur'an. In other words al-Qur'an becomes the basis in a study conducted, then science is tasked with further study of the cause [20].

On questions that measure the level of cognitive creation, students are required to be able to draw up a simple plan of action that refers to Q.S. Lukman verse 20 and Ar-Rum verses 41-42 in reducing waste or treating waste to be more useful. Findings on problems that measure the cognitive dimension of creating this, n-gain is obtained at the lowest 0.597. This means there are still some students who are less able to make generalizations of ideas or ways of looking at things and design a way to solve problems [18]. Based on the n-gain analysis, the cognitive dimension creates, the increase is lower than the cognitive dimension evaluating and analyzing. Through the study of al-Qur'an in the Q.S. Ar-Rum, students realize the importance of providing solutions and making contributions to the completion of environmental waste management. They made a project to manage and process household waste, including plastic waste, in groups for several communities. In this creating cognitive dimension, the way
of thinking of most students has led to the compilation of parts to form a functional unity and produce a new product by organizing several elements into different forms or patterns from before [22].

The novelty of this study is that students are required to have the ability to think at a higher level to better understand their daily lives through their understanding of the content of the verses of al-Qur’an, especially Q.S. Lukman verses 20 and Q.S. Ar-Rum verse 41-42 through the use of this green chemistry based synthetic polymer e-module. With a deep understanding, students will get used to connecting the essence of the contents of the verses of al-Qur’an with the phenomena that occur in their daily lives.

4. Conclusion

Based on the results of research conducted on the sixth semester students of Chemistry Education Study Program at UIN Sunan Gunung Djati Bandung, it can be concluded that the application of synthetic chemistry based on green chemistry e-module in learning can improve higher order thinking skills. In addition, based on the results of research and discussion that have been put forward, there are a number of suggestions that can be used as references, such as the application of synthetic chemistry based e-module green chemistry to improve the ability to think at higher levels carried out using other learning models besides problem based learning like, guided inquiry learning models, project based leaning, and so on. This is intended so that educators can maximize the expected learning outcomes and to know the comparison of research results.

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References

[1] Farida I 2016 The Importance of Development of Representational Competence in Chemical Problem Solving Using Interactive Multimedia Proceeding Third Int. Semin. Sci. Educ. 259–77

[2] Nugraha A, Subarkah C Z and Sari 2015 Penggunaan E-Module Pembelajaran Pada Konsep Sifat Koligatif Larutan untuk Mengembangkan Literasi Kimia Siswa Pros. Simp. Nas. Inov. dan Pembelajaran Sains 201–4

[3] Syamsurizal, Haryanto and Chairani N 2015 Pengembangan E-Modul Berbasis Keterampilan Proses Sains Pada Materi Kesetimbangan Kimia untuk Tingkat SMA Pros. SEMIRATA 2015 Bid. MIPA BKS-PTN Barat Univ. Tanjungpura, Pontianak 655–61

[4] Perinpasingam S and Thivilojana P 2014 Development of a Science Module through Interactive Whiteboard Can. Cent. Sci. Educ. 6 31

[5] Putra K W B, Wirawan I M A and Pradnyana G A 2017 Pengembangan E-Modul Berbasis Model Pembelajaran Discovery Learning Pada Mata Pelajaran “Sistem Komputer” untuk Siswa Kelas X Multimedia SMK Negeri 3 Singaraja J. Pendidik. Teknol. dan Kejur. 14 40–9

[6] Shamuganathan S and Karpudewan M 2017 Science Writing Heuristics Embedded in Green Chemistry: a Tool to Nurture Environmental Literacy Aamong Pre-University Students Chem. Educ. Res. Pr. 18 386–96

[7] Rizki M, Irwandi D and Bahriah E S 2016 Pengembangan Buku Suplemen Kimia Berbasis Sains Teknologi Masyarakat Pada Materi Kimia Polimer J. Tadris Kim. 1

[8] Pratomo H and Rohaeti E 2011 Bioplastik Nata De Cassava Sebagai Bahan Edible Film Ramah Lingkungan J. Penelit. Saintek 16 172–90

[9] Smita Talaviya F M 2012 Green Chemistry : a Tool in Pharmaceutical Chemistry NHL J. Med. Sci. 1 367–77

[10] Karpudewan M, Michael Roth W and Sinniah D 2016 The Role of Green Chemistry Activities in Fostering Secondary School Students’ Understanding of Acid–Base Concepts and Argumentation Skills Chem. Educ. Res. Pr. 17 893–901
[11] Karuniastuti N 2014 Bahaya Plastik Terhadap Kesehatan dan Lingkungan Forum Teknol. 03 60–8
[12] Sharma S K, Chaudhary A and Singhc R V 2008 Gray Chemistry Verses Green Chemistry: Challenges and Opportunities. Rasayan J. Chem. 1 68–92
[13] Wardencki W, Curylo J and Namiesnik J 2005 Green chemistry-current and future issues Polish J. Environ. Stud. 14 389–95
[14] Afiyanti, Cahyono E and Haryani S 2014 Keefektifan Inkuiri Terbimbing Berorientasi Green Chemistry Terhadap Keterampilan Proses Sains J. Inov. Pendidik. Kim. 8 1281–8
[15] Sudarmin 2013 Kemampuan Generik Sains Kesadaran Tentang Skala sebagai Wahana Mengembangkan Praktikum Kimia Organik Berbasis Green Chemistry Univ. Negeri Semarang 20 18–24
[16] Ricardo A 2016 Pelaksanaan Pengendalian Kerusakan Lingkungan sebagai Akibat Pertambangan Emas Ilegal di Sungai Menyuke Kabupaten Landak, Kalimantan Barat Fak. Huk. Univ. Atma Jaya Yogyakarta 1–10
[17] Fahrudin M F N, Subekti H and Anggaryani M 2014 Implementasi Model Guided Inquiry untuk Meningkatkan Keterampilan Proses Sains Pada Materi Kalor dan Perpindahannya J. Pendidik. Sains e-Pens a 2 278–83
[18] Anderson, L.W. Krathwohl D R 2010 Kerangka Landasan untuk: Pembelajaran, Pengajaran, dan Asesmen. Terjemahan oleh Agung Prihantoro. Pustaka Pelajar.
[19] Wowo Sunaryo K 2012 Taksonomi Kognitif. (Bandung: Remaja Rosdakarya.)
[20] Harahap A 2018 Integrasi Alquran dan Materi Pembelajaran Kurikulum Sains Pada Tingkat Sekolah di Indonesia: Langkah Menuju Kurikulum Sains Berbasis Al-Qur’an J. Penelit. Medan Agama 9 21–46
[21] Syahida, A. Dan Irwandi D 2012 Analisis Keterampilan Berpikir Tingkat Tinggi pada Soal Ujian Nasional Kimia. Cent. Sci. Educ. 7 77–87
[22] Gunawan I and Palupi A R 2012 Taksonomi Bloom-Revisi Ranah Kognitif Kerangka Landasan untuk Pembelajaran, Pengajaran dan Penilaian (Madiun: Badan penerbit PGSD FIP IKIP PGRI)
[23] Djudin T 2011 Menyisipkan Nilai-Nilai Agama Dalam Pembelajaran Sains: Upaya Alternatif Memagari Aqidah Siswa J. Khatulistiwa I 151–60
[24] Widodo T and Kadarwati S 2013 Higher Order Thinking Berbasis Pemecahan Masalah untuk Meningkatkan Hasil Belajar Berorientasi Pembentukan Karakter Siswa Cakrawala Pendidik. 32 161–71