Review of learning modules in chemistry education

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Abstract. This study discusses the use of learning modules in chemistry education. In this study, relevant articles were collected. After being collected, 20 related articles were obtained about the use of learning modules in chemistry education. The articles obtained are identified where there are several points obtained, namely the type of module, the chemical topics discussed in the module, the pedagogical approach used, and the results obtained after using the module. From these points, there are 2 types of modules, namely printed modules, and electronic modules. The topics of chemistry presented are basic chemistry, analytical chemistry, organic chemistry, and environmental chemistry. In use, modules can be used independently and in groups, with the results obtained after application of modules can be in the form of cognitive, affective, and psychomotor. Based on the analysis of the article, the dominant learning module developed is an electronic module in which the constructivist pedagogical approach. The dominant module on basic chemistry topics. The results obtained after the use of modules are the majority of modules that can improve learning outcomes and improve student concepts.

1. Introduction

Modules are written material that can be used as a basis for learning [1]. Modules can also be interpreted as teaching materials for educators [2]. Although there are currently many scientific education studies on this ready-made teaching material, educators lack modules in learning. So the teacher is required to make and develop the module [2]. In making learning modules, it must start from the daily life experiences of relevant students, so that they are motivated in the use of modules [3].

At the moment the module is not only a written teaching material such as a textbook, but the module is considered an interactive textbook that presents the subject matter to students and through interactive exercises which enable them to assess and improve their understanding of the material. Electronic module is designed to complement conventional textbooks and other learning materials. The potential benefits of digital learning from statistical textbooks are that students can be allowed to get their help through interactive exercises. From the answers of students, they can know about the answers from the right or wrong [4].

Modules that are designed today do not only affect the learning outcomes obtained by students in the form of conceptual knowledge but can overcome individual interests in learning chemistry. In the current study, an attempt was made to overcome the problem of individual students' poor interest in science education and the need to stimulate classroom practices by initiating a type of learning module that was carefully crafted together with a teaching approach. Such modules are expected to explicitly support students 'needs for competence, and linkages, stimulate student self-directed learning, and enhance the role of intrinsic motivation in students' classroom experiences [3].
The pedagogical approach contained in the learning module focuses more on content coverage and fundamental foundations. But in the process, inadvertently ignoring the development of thought processes and professional skills. Therefore, a pedagogical approach based on active student participation is needed, not passive [5]. One of the pedagogical approaches used in chemistry learning modules is the constructivist approach, where students build their knowledge about phenomena by using interpersonal and individual experiences through reflection [6].

Thus the modules presented in learning chemistry are conceptually packaged, the need for scientific inquiry methods, cooperative learning, and emphasizing student decision making [3]. So that in using modules in learning can overcome the difficulties students encounter while studying chemistry [3,7]. However, there are not many explicit reports on the use of modules in chemistry learning. Lack of literature on learning modules is one of the obstacles educators in designing modules that will be made [2].

Therefore, the need for a literature review study on the use of learning modules in chemistry education. Wherewith the information from the review of the literature review can help educators in designing learning modules. The review outlines and examines existing literature, highlights modules used whether print or digital based, and pedagogical approaches followed in chemistry education. The purpose of the writing of this article is to review how much research on the scope of the use of modules in chemistry education.

2. Methods
In this study investigating and analyzing articles that have been published to obtain data on the use of modules in chemistry education. To obtain the data, several steps are carried out, namely the collection of relevant articles, identification of articles, and analysis of the identification of these articles. Article collection is done by searching through a digital database search on Google Scholar regarding learning modules in chemistry education, where publishers of articles sought are like the American Chemical Society (ACS), SpringerLink, Elsevier, Royal Society of Chemistry and others. In a google scholar search, it is done by typing keywords such as chemistry modules, modules in chemistry learning, use of modules in chemistry learning, and learning modules in chemistry education. In the search for relevant articles, there are criteria used in the selection of articles, namely the article publishers must be indexed Scopus, articles published in the conference process are not included, the subjects in the article are high school students and students. After collecting articles, 20 articles related to learning modules in chemistry education were obtained. The articles obtained are identified and analyzed. Each article is identified by title, then looked at from the abstract to the results obtained. Based on the identification of articles obtained several points as the focus of analysis of the article review, namely the grouping of modules, the chemical topics discussed in the module, the pedagogical approach used, and the results obtained after application of the module.

3. Results and Discussion
3.1. Module types
In the article examined, modules are grouped into 2 groups, namely the printed module and the electronic module. From the articles reviewed, there are 12 articles that discuss the electronic module and 6 articles that discuss the printed module. There are 2 articles that discuss both types of modules (print modules and electronic modules) [15, 19]. The use of electronic modules is dominant rather than printed modules because it can represent abstract concepts from chemistry through macroscopic, submicroscopic, and symbolic representations. This is because there is technological assistance in the module [8, 10, 11, 20]. A module is said to be electronic if the module presents subject matter through interactive exercises [4] and concept visualization can be in the form of videos, animations, simulations, virtual laboratories with the help of technology [6, 8, 15] and can be integrated with the internet [4]. While the printed module is the material presented using only paper sheets without the aid of technology in the delivery of material. The grouping of articles reviewed can be seen in table 1.
Table 1. Module types

| Module types     | References                  |
|------------------|-----------------------------|
| Printed module   | [2, 3, 5, 12, 13, 15, 19, 20]|
| Electronic module| [1, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19]|

3.2. Chemistry topic

In the article examined, the topic of chemistry contained in the module is divided into several main topics, namely basic chemistry, environmental chemistry, analytical chemistry, and organic chemistry. The main topic of chemistry that is widely discussed in the modules studied is basic chemistry, which is divided into several materials namely solution, benzene, alcohol, quantum mechanics, energy and heat, chemical equilibrium, redox, acid base, electrochemistry, chemical bonds and polymers. Table 2 presents the chemistry topics discussed in the modules contained in the article. Based on the table it can be seen that the most widely discussed chemical material is electrochemistry [8, 9, 10, 11].

Table 2. Chemistry topics contained in the module

| Chemistry topics | References |
|------------------|------------|
| Solution         | [7, 12]    |
| Benzene          | [3]        |
| Alcohol          | [3]        |
| Quantum mechanics| [13]       |
| Chemical environment | [1, 4, 14] |
| Phase charge     | [7]        |
| Stoichiometry    | [6, 7, 15, 16] |
| Energy and heat  | [7]        |
| Chemical equilibrium | [2, 7]     |
| Analytical Chemistry | [5, 15, 17] |
| Organic chemistry| [16, 17, 18]|
| Redox            | [2, 15]    |
| Acid-base        | [2, 15]    |
| Electrochemistry | [8, 9, 10, 11, 15] |
| Polymer          | [20]       |
| Chemical bonds   | [14, 19]   |

3.3. Pedagogical approach

The pedagogical approach used from the 20 articles reviewed mostly uses constructivist approaches. Nineteen of the twenty articles reviewed referred to constructivist learning theory, both implicitly and explicitly through the instructional design mentioned [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20] A constructivist approach is a view where a student builds his knowledge of phenomena by using interpersonal and individual experiences through reflection [6]. In the constructivist approach, participants are active in learning, the teacher is only a facilitator. Whereas 1 article uses a visual conceptual approach, which emphasizes real-life applications and integrates sufficient visualization [13].

3.4. Use of modules

In the articles reviewed, 16 out of 20 articles apply the use of modules in groups / with friends or with the help of a teacher. While as many as 8 articles implement the use of modules independently by students. The use of modules independently is dominant using electronic modules [1, 7, 4, 17, 19] because the material is presented with the help of technology making it easier for students without the need to work in groups /friends. But some modules are used with animation guidance called pedagogical agents (PAs). Pedagogical agents (PAs) are designed to facilitate work in computer-mediated learning.
environments [8, 9, 10, 11]. Table 3 presents the use of modules by students both independently and in groups or teachers.

| Use of modules          | References                  |
|-------------------------|-----------------------------|
| Group or teacher guidance | [2, 3, 4, 5, 6, 8, 9, 10, 11, 14, 12, 15, 16, 18, 19, 20] |
| Independent             | [1, 4, 7, 13, 15, 17, 19]   |

3.5. The results obtained after using the module

Learning outcomes are a very important part of the review article [21] because they highlight the contribution of modules in teaching practice and the learning process. Table 4 summarizes the results obtained after using the module. As many as 10 out of 20 articles report that learning outcomes obtained after using modules in learning are to improve learning outcomes, this is in line with the improvement of concepts. Nine articles conclude that applying modules in learning can improve students’ understanding of concepts. To measure the understanding of concepts, some use interactive exercises [4] or paper [15] as a measure of conceptual understanding.

In addition to improving learning outcomes, 6 articles report that implementing modules in learning can improve representational skills. This is because the delivery of abstract material is presented virtually where the modules presented are electronic modules. The material presented can connect between representations both macroscopic, submicroscopic, and symbolic [8, 10, 11, 12, 13, 15]. Apart from cognitive, the use of modules in learning can improve student performance [6, 8, 9], interests [1, 3], and process skills [2]. To measure students’ interest, it is done by giving questionnaires to be filled out by them, so that bias can be seen how their motivation and interest during learning [3]. Table 4 presents the results obtained after using the module in learning.

| Influence obtained                  | References                  |
|-------------------------------------|-----------------------------|
| Improve learning outcomes           | [2, 3, 6, 8, 9, 10, 15, 16, 17, 18] |
| Improve representational skills     | [8, 10, 11, 12, 13, 15]      |
| Improve understanding of concepts   | [1, 2, 4, 5, 7, 9, 11, 13, 16, 19, 20] |
| Improve the performance             | [6, 8, 9]                    |
| Improve process skills              | [2]                         |
| Increase interest                   | [1, 3, 8]                    |

4. Conclusion

Learning and teaching using modules in chemistry education is something that is commonly applied at this time. Modules present a variety of chemistry topics ranging from chemistry to high schools to universities. Chemical topics presented can be in the form of basic chemicals, organic chemistry, analytical chemistry, and environmental chemistry. The dominant material contained in the module is basic chemistry. In making modules for the teaching and learning process, it should use a pedagogical approach. The pedagogical approach used is the constructivist approach, in which students are more active in learning, not teachers.

Along with the times, modules are not only presented in paper form but in a digital form called electronic modules. The use of electronic modules today when presenting material is very different from printed modules. The material presented in the electronic module can be in the form of videos, animations, simulations, interactive exercises, and virtual laboratories that make it easy for students. Because the delivery of material with digital can facilitate students in understanding the concept of both the level of phenomena (macroscopic), molecular level (submicroscopic), and symbolic. Making it easier for students to connect between levels of representation of each concept. In addition to increasing representational skills, applying modules in learning from both printed and electronic modules can improve learning outcomes, performance, and interest of students in learning chemistry.
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