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Blended Learning Supported Chemistry Course: A Systematic Review from 2010 to 2019

Anggiyani Ratnaningtyas Eka NUGRAHENI[a], Arum ADITA[b], Niwat SRISAWASDI[c*]
[a]*Chemistry Education Department, Faculty of Mathematics and Natural Sciences, Yogyakarta State University, Indonesia*
[b]*Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Purwokerto, Indonesia*
[c]*Division of Science, Mathematics, and Technology Education, Khon Kaen University, Thailand*
*niwsri@kku.ac.th

Abstract: The implementation of blended learning in chemistry is rapidly growing over the past decades. However, trends and issues in the application of blended learning in chemistry are still lacking systematic reviews. This study conducted a meta-review to analyze issues related to blended chemistry learning and then present the issues of learning strategies and specific chemistry course obtained from studies published in academic journals, indexed by Scopus database in the last decade, 2010-2019. This report offers a unique contribution in terms of visualizing the trend of blended learning in chemistry. The results revealed that the implementation of blended learning in chemistry courses has increased over the past ten years. Moreover, it was also found that most pedagogic design in blended chemistry learning is problem-based learning. In terms of subject, general chemistry is the most often taught with blended learning.

Keywords: Blended learning, hybrid learning, flipped learning, chemical education, chemistry learning

1. Introduction

It is an undeniable fact that the rapid growth of technology in this modern era has significantly influenced many aspects of human life as well as education. In context of education, technology might offer easy and quick access to unlimited learning resources. The rapid development of digital technologies offered more chances to design and develop innovative learning approach with mobile devices in preparing schools and students for a future (Panjaburee & Srisawasdi, 2018). With the technological affordances, students can access and learn any learning materials from anywhere and anytime they want and by anyone. It is not a new thing to find teachers make use of technology to deliver the materials during the teaching and learning process, or the other way around, students explore the material that they are now learning from the internet to enrich their understanding about it. The integration of technology in the education process has inspired many education experts to propose innovation in the teaching and learning process, one of which is blended learning.

In 21st century education, pedagogies of digital learning has become more important in context of science education (Srisawasdi, Pondee, & Bunterm, 2018). The development of blended learning has brought a transformation to education in all subjects. Particularly, applying blended learning in a chemistry course is an interesting issue. Many studies revealed that blended learning can be one of the effective ways to foster the quality of chemical education. For instance, blended learning supports a shift in students' conceptual understanding of the rate of chemical reaction topic significantly more than the traditional learning (Olakanmi, 2016). Additionally, blended learning can also increase students' outcomes significantly (Bernard, Broś, & Migdał-Mikuli, 2017). Although there have been many studies that disclose the implementation of blended learning, there are some areas that still must be discovered further. For example, distribution of blended learning in chemistry course, specific chemistry course that might be taught with the support of blended learning, and learning strategies that could support blended learning, particularly in the chemistry classroom. These issues can be used as

references for educators and researchers who want to apply blended learning, especially in chemistry class. Since there are no studies that reveal these issues yet. This paper reports literature analysis of blended learning in chemistry to better understand its implementation and trends.

2. Literature Review

Blended Learning

Blended learning is a model of learning that represents an opportunity to integrate online instruction which offers innovative and technological advances with the traditional instruction which offers direct interaction and participation (Thorne, 2004). In broader sense to Thorne (2004)'s idea, Bersin (2004) described that blended learning is a model that integrates different training "media", such as technologies, activities, and types of events to create an effective training program for a specific audience. Meanwhile, Watson (2008) explained that blended learning is the integration of face-to-face learning and online learning to facilitate improve the classroom experience and extend learning through the innovative use of information and communications technology. Moreover, Graham (2006) described that blended learning is combining face-to-face instruction with computer-mediated instruction. At the simplest definition, blended learning is a combination of online-mediated and face-to-face instruction (Reay, 2001; Rooney, 2003; Sands, 2002; Ward & La Branche, 2003; Young, 2002). Blended learning is used interchangeably in research literature as "personalized learning", "differentiated instruction", "hybrid learning", "technology-mediated instruction", "web-enhanced instruction", or "mixed-mode instruction" (Krasulia, 2015). To clarify the blended learning, there are four major models i.e. rotation model, flex model, self-blend model, and enriched-virtual model (Staker & Horn, 2012). Furthermore, the rotation model has four sub-models; station-rotation, lab-rotation, flipped-classroom, and individual-rotation, and the most popular model is the flipped-classroom.

Previous Studies about Blended Learning in Chemistry

There have been numerous published studies of implementation blended learning in chemistry. For instance, blended learning was implemented in an organic chemistry course (Lo & Tang, 2018). The result indicated that blended learning intervention can promote students' advanced knowledge of synthetic tools. Besides, blended learning was also applied in the chemistry laboratory to optimize students' experience (Kennepohl, 2013). Moreover, blended learning was also implemented in chemical information or cheminformatics course (Baykoucheva, Houck, & White, 2015). The finding revealed that students learned how to find literature and chemical property efficiently. Meanwhile, another study implemented blended learning in chemistry pharmaceutical analysis (Visentin, Ermondi, Vallaro, Scallet, & Caron, 2013). It was found that blended learning can enhance students' involvement. Niroj & Srisawasdi (2014) developed a blended learning environment in Chemistry for enhancing students' conceptual understanding. The study of Jihad et al. (2018) also revealed that blended learning can foster students' conceptual understanding. Based on the literature review, an enhancing number of researchers who are struggling to implement blended learning to foster students' learning, provided educators information to prepare learning activities appropriate for their students. To empower the research and development of chemistry education to become more enlightened, the previous implementation of blended learning has become important to analyze for better understanding in pedagogical development.

3. Research Methodology

Resource

This research study investigated published papers obtained from Scopus database from 2010 to 2019 by searching for the publications whose titles, abstracts, or keyword met the logical condition

("blended" or "hybrid" or "flipped") and ("learning") and ("chemistry"). A total of 430 papers published in the Scopus-indexed journals were appropriate for this study. By removing 138 non-article papers and 4 non-English papers, 76 papers were comprised in the present study by deleting 209 non-related papers and 3 non-available papers. Figure 1 displays the whole steps of searching.

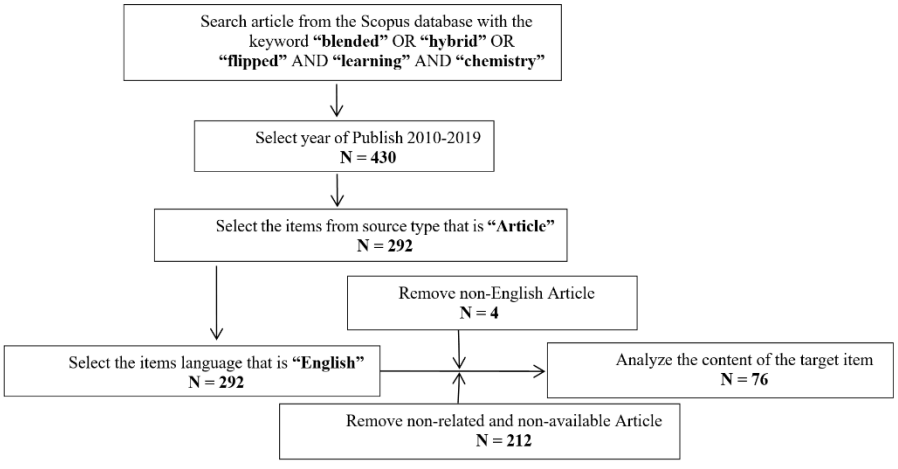

Figure 1. Scopus database searching steps.

Data Distribution

Based on the analysis of searching results, Figure 2 illustrates the papers on the application of blended learning in chemistry from 2010 to 2019. There were no more than five papers were published each year from 2010 to 2014, and the average number was 2.2 papers in the first five years. Even, in 2012, there was no research contribution regarding blended learning in chemistry into the literature. Since 2015, researchers paid more attention to this field, with more than 10 papers were published every year, and the average number was 13 in the last five years. In addition, there were 13 papers published in 2015. In 2016, 10 papers were published and then increased remarkably to reach the highest publication number of 16 papers in 2017. After peaking at 16 papers, these numbers of publications had fallen to 11 papers in 2018. The number of publications dramatic growth in 2019, with a total of 15 papers.

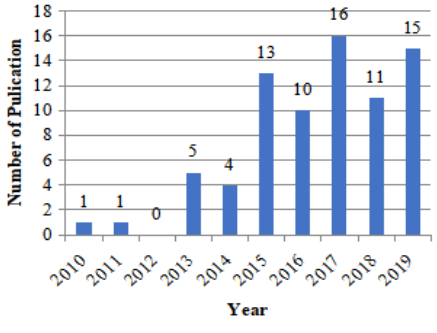

Figure 2. Published paper using blended learning in Chemistry from 2010 to 2019.

Coding Scheme

In the present meta-review study, the categories being analyzed included learning strategies and chemistry courses. Each dimension is explained in the following item:

Learning strategies: According to the search results, this study classified the learning strategies into 11 categories as follows: problem-based learning, cooperative learning, collaborative learning, laboratory learning, inquiry-based learning, active learning, TSOI (translating, sculpting, operationalizing, integrating), self-regulated learning, example-based learning, comparative learning, non-specified approach.

Courses: The course examined in blended learning in chemistry were also analyzed. It is categorized into 10 different courses in the chemistry field as follows: general chemistry, organic chemistry, analytical chemistry, physical chemistry, inorganic chemistry, cheminformatics, pharmaceutical chemistry, biochemistry, forensic chemistry, pharmaceutical polymer material.

4. Results

Learning Strategies

The trend of learning strategies implemented in blended learning in chemistry from 2010 to 2019 is illustrated in Figure 3. The highest proportion is non-specified. It means that many papers did not obviously mention the specific learning strategy. Furthermore, the second-order is problem-based learning (18 papers). Many studies used problem-based learning as learning strategies in applied blended learning with any various methods and approaches. For instance, there is a study that uses a newsworthy story in teaching chemistry (Hibbard, 2019), and Weaver and Sturtevant (2015) applied problem-based learning in the context of Student-Centered Active Learning Environment with the Upside-down Pedagogies (SCALE-UP) approach. The strategy of cooperative learning is in the third rank with 15 papers in total, which is used such as interactive discussion, group discussion, team-based learning. In the analysis, it is followed by collaborative learning, with 11 total papers. Collaborative learning which is used, in this study, such as peer-led team. Laboratory learning is in the fifth rank, with 10 total papers. The sixth rank is inquiry-based learning, and there are five papers. Furthermore, active learning is in the seventh rank, with four total papers. Additionally, TSOI, self-regulated learning, example-based learning, and comparative learning are in the last place, with one paper for each.

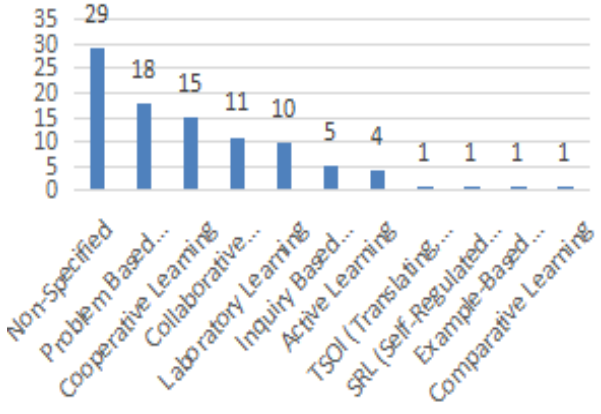

Figure 3. The learning strategies implemented in blended learning in chemistry from 2010 to 2019.

Courses

The specific course in chemistry was investigated in the study. Figure 4 indicates that the top course of chemistry in blended learning is general chemistry (39 papers). Most studies (e.g. Mcdowell et al., 2019; Burchett et al., 2016; Enneking et al., 2019) chose general chemistry as the main subject area to apply blended learning in their classroom. The second rank is organic chemistry (24 papers). A number of organic chemistry classes (e.g. Ealy, 2013; Casselman, 2019) studies applied blended learning in their classroom. Analytical chemistry is in the third rank with four papers, followed by physical chemistry, with a total of three papers. The other courses, such as inorganic chemistry and cheminformatics,

contributed two papers for both. Furthermore, pharmaceutical chemistry, biochemistry, forensic chemistry, pharmaceutical polymer material merely contributed one paper for each.

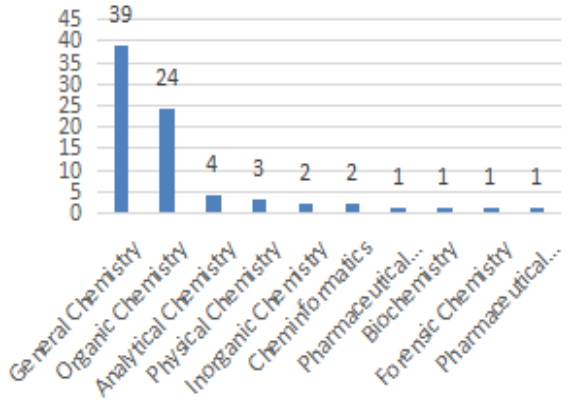

Figure 4. Specific courses of blended learning in Chemistry.

5. Conclusion

This present study performed a meta-review and analysis of implementing blended learning in chemistry from 2010 to 2019. The finding revealed that the implementation of blended learning in chemistry has been continuously increased over the last decade. It implies that researchers paid more and more attention to this field. Meanwhile, the finding also revealed that most studies implemented problem-based learning as learning strategies in blended learning. Nevertheless, many other learning strategies implemented in blended learning in the chemistry classroom, such as cooperative learning, collaborative learning, laboratory learning, inquiry-based learning, active learning, TSOI (Translating, Sculpting, Operationalizing, Integrating), self-regulated learning, example-based learning, and comparative learning. It implies that educators implemented blended learning in chemistry using many various learning strategies. Characteristics of the courses and learners become a consideration to select the appropriate learning strategies. Moreover, general chemistry became the most favorite course to practice blended learning. However, many other courses in chemistry implemented blended learning such as organic chemistry, analytical chemistry, physical chemistry, cheminformatics, pharmaceutical chemistry, biochemistry. It implies that blended learning can implement in several chemistry courses.

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