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Research Article

Implementation of the Scrum Methodology in Learning Chemistry to Improve Scientific Literacy: A Review

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Abstract.
This study aimed to review the scientific articles published in international journals related to the scrum methodology and scientific literacy. In addition, the potential of implementing the scrum methodology in chemistry learning to improve scientific literacy is also discussed. This review used articles in Q1 and Q2 categories based on Scimago Journal & Country Rank data. Research data was collected by reviewing the articles with the following stages: determining the topic, searching the articles, identifying the main ideas, making an outline, and synthesizing the article review. The year of publication of the articles is limited from 2017 to 2021 to ensure the topic's novelty. The research data were analyzed descriptively. The results showed that the scrum methodology could be implemented in chemistry learning. It focuses on student-centered learning. The context and examples used in the scrum methodology are a problem and phenomenon that occurs in everyday life, and components in the scrum methodology consist of sprints, roles, and artifacts. It was concluded that the scrum methodology can improve scientific literacy.

Keywords: scrum methodology, scientific literacy, chemistry learning

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1. INTRODUCTION

The problems that occur in life are increasingly complex, ranging from environmental problems in the form of floods, pollution, to forest fires. In addition, problems in the health sector are also increasing with the presence of variants of viruses. Science plays an important role in solving these problems. Therefore, skilled human resources are needed in applying the knowledge they have as a solution to the problem. When it comes to environmental and health issues, then science plays a role in solving these problems. The ability to apply knowledge about science to solve problems or natural phenomena is called scientific literacy. The presence of scientifically literate

human resources is indispensable for the survival of life. Therefore, education aimed at increasing scientific literacy must be developed. One way that can be done is by using appropriate learning methods to improve scientific literacy. The discussion in this review article is about a project-based method, namely the scrum methodology that is studied based on its characteristics, which can improve scientific literacy.

The Scrum Methodology is a learning method that uses phenomena that occur in real life as a context [1]. The concept of The Scrum Methodology is to provide scaffolding for students to discuss and review their work [2, 3]. The Scrum Methodology makes it easier for students to work on projects because it can divide complex tasks into several stages so that complex tasks become simpler [4]. Based on this statement, the methodology can be applied to chemistry learning [2]. Chemistry is a field of science that uses real life phenomena as a learning material. To make a good chemistry learning situation, we must use chemical phenomena that occur in real life [5].

2. RESEARCH METHOD

This article is the result of a literature review [6]. The purpose of this article is to review the literature in the form of scientific articles published in international journals related to the scrum methodology and scientific literacy. The articles reviewed came from international journals that are in the Scopus indexed journal ranking system with Quartile 1 (Q1) and Quartile 2 (Q2) categories based on Scimago Journal & Country Rank data. The year of publication of articles is limited from 2017 to 2021 to ensure the novelty of the topics reviewed. Research data was collected with the following stages: topic determination, literature search, identification of main ideas, outline creation, and article synthesis. Data from various articles were analyzed descriptively. The shortlisted articles source for review can be seen in Table 1 below.

3. RESULT AND DISCUSSION

3.1. The Scrum Methodology in Chemistry Learning

The Scrum methodology is a methodology used in science learning in the form of a project work methodology that can attract interest and improve student learning outcomes [1, 2, 4, 7, 8]. The Scrum methodology uses phenomena or problems that actually occur in students' lives as a learning context. The concept became new for students so that they were enthusiastic about working on projects [1, 7, 8]. One context

Table 1: The shortlisted articles source for review.

Journal	Rank
International Journal of Instruction	Q2
Research in Science and Technological Education	Q2
American Journal of Pharmaceutical Education	Q1
Education Sciences	Q2
Computers in Human Behavior	Q1
Journal of Systems and Software	Q2
Computers and Education	Q1
Sustainability	Q2
Kasetsart Journal of Social Sciences	Q2
Instructional Science	Q1
Chemistry Education Research and Practice	Q1

that can be used is the socio-scientific context. Projects with a socio-scientific context can not only improve students' cognitive abilities, but also train students' curiosity, interest, and creativity [1, 2, 8].. Students will be interested in learning if the material provided is consistent and easy to find in their daily lives. Teachers can use phenomena that occur in nature as questions or problems that must be solved by students through the scrum methodology. To solve these problems, students are directed to use the knowledge they have. Therefore, students are stimulated to seek more knowledge about how to solve the problem of a phenomenon. The process of seeking knowledge can be done through various ways such as reading material on the web, articles, and books; watching videos [9]; as well as conducting experiments [8]. The framework used in the scrum methodology is intended to help students learn when they are working on complex real-world tasks [3, 4]. The division of complex tasks into several stages makes it easier for students to work on projects [3, 4, 10]. This reduces the risk of project failure because simpler tasks will not burden students and make students more focused on the final outcome of the project [3]. This review is obtained from the case of project work in the company. In most cases, no one can predict how the project will develop because it is influenced by many factors such as natural factors, funding, human resources, and so on. Therefore, the scrum methodology can be a solution to this problem. Likewise in learning, neither team members nor teachers can predict the outcome of working on a complex project if it is done all at once in one stage [3, 10–12]. Therefore, the scrum methodology is suitable for solving complex projects [1, 3, 11]. The technical work on the project can also be adjusted to the time students have [11].

3.2. The Scrum Methodology Makes Student-Centered Learning

Currently, all levels of education are implementing a change in the direction of learning in the classroom from teacher-centered to student-centered. This change must have careful planning and readiness because basically student-centered learning makes students “overwhelmed” [2]. The concept of the scrum methodology is to provide assistance to students in discussing and guiding students to be active in learning [1, 2]. The teacher only acts as a supervisor to ensure that learning runs smoothly. This concept creates student-centered learning and helps students from being “overwhelmed” by active demands in learning [2, 3, 13]. The freedom that the Scrum methodology gives students in planning, implementing, and determining what kind of product they want to produce makes students more actively involved in the learning process [2, 8]. The activity of exchanging ideas, suggestions, and questions makes students actively construct concepts that are owned by each other and explore the context used in working on projects using the Scrum methodology [2, 3, 13]. Project grants facilitate students work collaboratively [2, 3, 10]. Therefore, in the scrum methodology, students are grouped into several teams. Team formation is carried out with a heterogeneous composition so that students can exchange opinions in finding solutions to existing problems or questions and questions given by the teacher [13, 14]. Heterogeneous team formation methodology can be used based on differences in prior knowledge, experience, and problem-solving abilities [14], as well as independent learning [9, 15]. Team formation by grouping students who have different aspects in a team makes learning more dynamic [9, 14–16]. Forming a heterogeneous team will expand students’ collective knowledge and result in the achievement of better team performance [8, 13, 14]. Of course, the heterogeneous team composition presents many points of view in determining solutions if problems occur while working on the project. This makes students argue a lot to provide views and build students’ abilities to learn and work in teams [8, 13]. The differences in knowledge that students have in teams stimulate discussion and exchange of opinions so as to improve student learning outcomes [8, 14]. One of the activities that make learning centered on students is discussion. Discussion activities regarding concepts and ideas they have about the steps for working on projects can improve students’ ability to explain concepts [1, 2, 15]. Discussions within teams and between teams aim to exchange ideas with friends. This helps students construct knowledge [8, 13]. The activity of exchanging ideas, suggestions, and questions makes students actively explore the concepts they have and the context used in working on projects using the Scrum methodology [2, 3, 13]. One of the assistance provided by the Scrum

methodology is that students can monitor each other's work [1, 11]. That way, students are not afraid of taking wrong steps in working on projects [1–3, 11].

3.3. Context Used in the Scrum Methodology

A context-based approach in the form of relevant real-world problems stimulates students to apply science concepts in everyday life [1, 2, 8]. The context-based approach begins with relevant real-world questions, stimulating students to use science concepts to explore, experience, and evaluate problems drawn from real life [1]. An example of the application of chemistry concepts in everyday life is a chemical reaction modeling project that produces eco-friendly [2]. Environmental topics are part of socio-scientific issues. Socio-scientific issues or problems that become the context in learning the Scrum methodology make learning more dynamic and train students to be responsible for their social environment [1, 2, 7, 8]. The way students are responsible for the social environment is by applying the chemistry concepts they have to solve problems in the social environment. The use of context in the scrum methodology arouses students' attitudes and interest in science learning [2, 8, 16]. When students' interest in science has been formed, curiosity, responsibility and sensitivity to the environment will increase [16]. That way, if students participate in real science projects, students can see themselves as scientists who construct science [8]. To develop the next generation of science literate nation, science education needs to be based on the latest and meaningful socio-scientific context obtained from the real world [7].

3.4. Components in the Scrum Methodology

To find solutions to complex problems that occur in the real world, students can use components in the Scrum methodology, namely sprints, roles, and artefacts [2, 4]. This component facilitates students to work collaboratively to solve problems [1, 2, 4, 10] and reflect on their learning progress [4]. The design of each component acts as an aid that encourages students' reflection on how well their design answered the question or problem and how strong the evidence produced supports the argument [17]. Process management skills are required to plan, conduct experiments, and solve problems. Scrum components are expected to help students to plan, direct and monitor the learning process and understanding of subject matter [1]. The explanation of each component is as follows:

1. Sprint

Sprint is a set of stages that students must go through from planning to product creation in the scrum methodology [1, 3, 11]. The stages in one sprint consist of sprint planning, daily sprint, sprint review, and sprint retrospective [1, 3, 10, 11]. In one project that students work on with the scrum methodology, it is possible to have several sprints so that the work is more organized sequentially. This is what makes the scrum methodology able to make complex projects simpler and easier for students [1–3]. The time span for one sprint is adjusted based on the agreement of the team and the teacher [11].

2. Sprint planning

   Sprint planning is the planning stage in one sprint that can improve student project management consistency and ability [1, 3, 10, 11]. The activities carried out are planning activities and division of tasks [3]. Incorporating strategies to organize teamwork effectively and improve the planning process can result in increased student engagement with collaborative learning activities [10]. Collaborative learning occurs through collaboration between teachers and students as well as students and students, which includes discussion, planning, and the exchange of ideas [13]. In order to create a good team atmosphere, where each member is consistent and responsible for the tasks that have been distributed, a document agreement on work deadlines and division of tasks is made [1, 3, 10, 11].

3. Daily sprint

   Daily sprints are in the form of regular meetings that are useful for coordinating work and anticipating irregularities in planning [10]. If the daily sprint cannot be done every day like in a company, then the meeting is adjusted to the time that students have [11].

4. Sprint retrospective and Sprint review

   Students reflect together on the retrospective sprint and review so that the progress of the work can be known by the teacher and group members [1, 4]. This activity can increase students' understanding of concepts by exchanging ideas between team members and teachers [2, 3]. The concept of the two activities is basically the same, namely mutual reflection between fellow students and teachers so that the quality of the products produced is better [1, 3, 10]. The difference lies in the presence of the teacher [11]. The presence of the teacher in the sprint retrospective is not necessary because students are given the opportunity to reflect on their work with fellow group members first with the aim of training students' independence. If the results of the reflection indicate the need for

improvement in project work, then improvements are made before the sprint review. Furthermore, the implementation of a sprint review attended by teachers aims to enable teachers to monitor work progress and provide criticism and suggestions [1, 3, 11]. This reflection activity also invites students to think critically about the importance of applying science in everyday life in this case in project work [2, 8, 17].

5. Roles

   Roles are related to the distribution of tasks that must be done by each member of the team. Roles are divided into scrum team, scrum master, and product owner. Equitable division of tasks in project work creates equity for students [2–4] and increases the nature of responsibility [2, 8, 10]. Scrum team is a team consisting of a group of students with heterogeneous abilities [3, 14]. Scrum master is the leader of the team [3, 11]. Adoption of a scrum master in education can be adapted to the situation. Customizations can be made by rotating the scrum master. This allows each member to gain leadership experience [11]. Meanwhile product owners in education are mostly played by teachers [1, 3, 10, 11]. When going through each stage sprint, students tend to already recognize the advantages of the scrum methodology but still need supervision to follow it on an ongoing basis. In this case, the role of scrum master and product owner are very important to guide the team [3].

6. Artefacts

   Artefacts are documents or tools that can visualize project planning and implementation in the scrum methodology [2, 3]. Documents made at the planning stage are agreement documents on work deadlines and division of tasks, including part of artefacts. Artifacts that are often used in the scrum methodology adapted to the field of education are the product backlog, task lists and plans, and scrum boards [1, 11].

7. Product backlog

   Product backlog created by the product owner contains the requests that must be fulfilled in making the product [3, 4]. Product backlog is designed in such a way by the product owner according to the conditions, abilities of the scrum team, and learning materials [4].

8. List of tasks and plans

The list of tasks and plans contains the activities that students must do as well as a list of students who are responsible. This list is very useful for project management and planning [1, 3, 10] and encourages students' responsibility and consistency to participate in projects [8, 10]. The agreement document made at the planning stage creates a shared understanding and a good team atmosphere [1, 10, 13].

9. Scrum board

The Scrum board acts as a visualization tool and a source of information on student work progress and is useful as a means of teacher supervision of student performance [3, 10–12]. The scrum board can increase students' awareness and sense of responsibility for the tasks that have been given because students are obliged to write down activities that have been and will be carried out on the board [1, 3, 10]. Coordination of work through the scrum board helps anticipate irregularities in planning [3, 10]. One of the assistance provided by the scrum methodology is that students can monitor each other's work through the scrum board [1, 2, 11].

3.5. Scientific Literacy in Chemistry Learning

Scientific literacy is seen not only as knowledge about science, but the ability to solve problems with the knowledge possessed [2, 7, 12, 15, 18]. Scientific literacy is very important to be prepared because everyone needs knowledge as a reference for thinking in making decisions and solving problems [16]. The more advanced the times, the more complex the problems, both health, environmental, social, and technological problems [15]. Therefore, knowledge of science is not enough, it is necessary to apply aspects of science itself. Knowledge of science is important because finding a solution to a problem requires critical judgment and evidence-based arguments. A science literate person must make rational decisions and reliable conclusions based on sufficient knowledge, while taking into account the drawbacks and risks [18].

A person's attitude in the future is influenced by the attitudes formed at school. In order for future students to become people who are scientifically literate and care about socio-scientific issues, it is necessary to learn in schools that are able to improve scientific literacy skills [2, 7, 8, 18]. There are many ways that teachers can improve students' scientific literacy skills, including with appropriate approaches, strategies for learning methodologies to improve scientific literacy [18], namely learning that integrates aspects of context, competence, knowledge, and attitudes towards science [2, 8].

3.6. The Role of the Scrum Methodology to Improve Scientific Literacy

It has been explained that scientific literacy is the ability to use the knowledge possessed to solve problems in everyday life. This means that the solution to overcome the given problem must go through careful planning. This is in line with the concept of the scrum methodology which has several planning stages in a number of sprints [3, 10, 11]. In addition, the relationship between the Scrum methodology and scientific literacy can also be seen in the similarity in the use of socio-scientific contexts. To develop a generation of science literate people, science education needs to be based on the current and meaningful socio-scientific context that comes from the real world [7]. The application of the scrum methodology in projects to make green chemistry-based products has been proven to improve scientific literacy skills [2]. In addition, other project-based learning such as The GlobalEd 2 Project [7] and Citizen Science [8] also showed a significant increase in students' scientific literacy results. Problems that actually occur in real life that are raised as learning contexts can train students' problem-solving skills which are part of scientific literacy competencies [7, 8, 15]. Scientific literacy refers to the process of proving scientific knowledge through the collection, interpretation, and analysis of data to explain scientific phenomena [8, 18]. This process can be carried out with the stages of the Scrum methodology which is proven to be able to train process management skills, namely planning, carrying out, and completing a project [3, 10, 13, 14]. Planning activities consisting of task formulation and weekly planning have a positive effect on process management in projects and increase student commitment [3]. Process management in the Scrum methodology is useful for students who are required to solve complex real-world problems because when used in a company, the methodology is used to guide employees on complex projects [1].

4. CONCLUSION

This study presents a literature review in the form of scientific articles on the implementation of the Scrum methodology to improve scientific literacy. This review shows that the characteristics of the scrum methodology which are basically applied in companies can be implemented in chemistry learning. Judging from its implementation, the scrum methodology uses phenomena or problems that actually occur in students' lives as a learning context and the scrum methodology makes students use their knowledge to solve problems thereby increasing scientific literacy. The Scrum methodology

also makes learning student-centered through the components it implements, namely sprints, roles, and artefacts. More empirical research is needed to see how far the scrum methodology can be designed to improve students' scientific literacy. This can be a suggestion for other researchers to find the advantages and disadvantages of the Scrum methodology in its use for various 21st century skills.

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