Introducing active learning component for improving laboratory management of biology and chemistry teachers

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Abstract. One of the challenges of teaching and learning process for biology and chemistry in high school is promoting student-centered active learning beside traditional instructor-focused, teaching-by-telling approach. Learning by laboratory activities attracts the students to be active to participate in the learning process. Active learning technique has also been successfully applied to teach biology and chemistry in multiple environments such as lecture theaters, classroom, laboratories, and online. Based on the challenges, we introduce active learning to high school teachers of biology and chemistry for improving laboratory management through workshops. This paper presents component of active learning which is formulated into a workshop for improving laboratory management. This presentation also encourages other science enthusiasts to organize the similar effort.

1. Introduction

Learning chemistry, as learning natural science in general, is a learning process which involves not only cognitive domain but also affective and psychomotor domains simultaneously. In order to involve affective and psychomotor, learning outside the classroom, such as project-based learning, directed activities or practices in a laboratory, is needed beside conventional learning in a classroom. In learning chemistry, a laboratory plays an important role for understanding abstract materials of chemistry.

Therefore, learning chemistry should not only rely on conventional teaching in a classroom but also active learning in a laboratory. A quick survey of high school teachers who teach chemistry and biology also resulted in importance of a laboratory in learning both subjects to support classroom learning. One important component of learning in a laboratory is active learning that places student at the center of learning, rather than accept students as passive listeners.
Under a science outreach scheme in Universitas Ahmad Dahlan (UAD), Yogyakarta, Indonesia, called Science and Technology for Society (Iptek bagi Masyarakat, IbM), we undertook a workshop to facilitate high school teachers improving laboratory management. The workshop was implemented at two high schools in the city of Yogyakarta since they have actively been cooperating with UAD for educational improvement. From teachers of those high schools, we learn some obstacles in learning chemistry and biology in laboratory, i.e. some schools have limited facilities of laboratory, number of lessons in chemistry and biology are not sufficient to facilitate laboratory activities during the lesson, and insufficient laboratory management skills especially in harmonizing practices and its materials.

This paper presents how active learning strategy is formulated into workshop materials along with laboratory management workshop for teachers of biology and chemistry. It also presents a successful activity on public outreach of science in Indonesia by which some lessons learned for future outreach activities are also discussed. In addition, such a documentation on academic publication regarding education and public outreach on science and technology is needed in Indonesia in order to encourage other science enthusiasts to organize the similar effort.

2. Active learning in laboratory activities
Active learning, a strategy of teaching whereby learners (students) are actively participating in the learning process [1] so that learners are able to engage in higher order cognitive tasks resulting in a better understanding of subject matter [2], has been applied in multiple environments such as lecture theaters, classroom, laboratories, and online [3]. Active learning can be implemented by various methodologies, such as project-based learning, inquiry-based learning, experiential learning [4], just-in-time teaching, contextualized learning, and cooperative learning [5].

An experience of active learning strategies incorporated with laboratory setting has been presented in the development of a method to provide additional respiratory device education and training [6]. It helped pharmacy students to gaining smooth transition between the classroom and the direct patient care environment. Seven laboratory activities accompanied with active learning activities in a jigsaw-style approach are another excellent example of active learning implementation in laboratory activities [7]. Students work in small groups where each of them is assigned to read a different scientific article before discussing as a group how the articles relate with laboratory activity. Another methodology involves pre-laboratory classroom exercise, in which students decide which protocol is used before going to laboratory works [8]. This method drives students to think critically and challenges the preconception that a set protocol must be used within the laboratory. Science writing heuristics (SWH) has been embedded into chemistry experiments to obtain a higher level of interaction and inquiry into laboratory activity [9]. Students in classroom exercises are required to pose questions and provide methods to address these questions in relation to the laboratory exercises, before carrying out laboratory activities.

A creative approach to improve understanding on laboratory activities has been developed by Rand et al. [10]. Students are requested to create an animated instructional video posted on YouTube of a laboratory activities they have carried out, including laboratory set-up and scientific concepts behind the activities. This approach enables students to enhance their communication skills in an engaging and collaborative approach too. This practice is also potential to be extended by endorsing students to communicate science and technology via YouTube for outreach purposes and to become global educators in their own right [11,12].

3. Program overview
During the workshop, teachers were introduced to active learning concept and strategies, and afterward were facilitated to design laboratory activities in biology and chemistry by employing active learning principles. The workshop aims to assist teachers to understand active learning principles and design implementation of active learning on their laboratory activities.

Since the workshop did not focus on active learning, we did not discuss deeper on its concept and implementation. Here, we emphasize five skills which are suitable with student’s laboratory activities;
3.1. Understanding on student’s characteristics
Each student has curiosity and also imagination on everything they like. These curiosity and imagination are the base of critical thinking and creativity. Learning activities should be managed in order to flourish those critical thinking and creativity. During laboratory activities, a teacher is suggested to acknowledge student on his/her attainments, to ask challenging questions, and to encourage students to perform experiments in order to grow their critical thinking and creativity.

3.2. Recognizing the student individually
Since students come from family whose various background and skills, active learning implementation requires teachers to recognize the diversity. Students in a class do not necessarily work on the homogenous activities, however, they do different activities based on their learning pace. Students engage in peer-tutoring, those who are relatively superior, help the others. By recognizing students individually, teachers find it easy to optimize students in their learning.

3.3. Developing the critical and creativity thinking, and problem solving
Life is about problem solving. It requires critical thinking and creativity; critical in analysing problems, and critical in creating alternative problem solving. They grow from curiosity and imagination embedded in a child since they are very beginning. Therefore, teachers need to develop them, by i.e. giving assignments and asking open questions to the students.

3.4. Evolving a classroom to be an attractive learning environment
An attractive classroom in which student feels at home is suggested in promoting active learning, such as by attaching students’ attainments on the wall of the classroom. The attainments could motivate other students and creating an inspiration to the other students too. A teacher could use the attached students’ attainments as the references during learning.

3.5. Utilizing the environment as a learning source
The environment (physical, social, or cultural) is the source of learning. Chemistry and biology find it easier to utilize environment for both media of learning and object of study. Students also feel happier when learning with their environment, i.e. outdoor learning activities.

4. Component of active learning material
The workshop consists of four activities divided into (i) classroom/laboratory activities and (ii) implementation and post-workshop activities. All of participant teachers together joined classroom/laboratory activities in the same time whilst the implementation and post-workshop activities were carried out depending on each teacher participant’s schedule. Each activity and the program are listed in the table 1. Ninety minutes were allocated for each classroom program. The participants were divided into several groups for program assignments.

In the what-and-why active learning, participants were introduced to the concept by videos demonstrating active learning in a class as shown in figure 1(a). Participants observed interesting points and listed salient features from the videos afterward. In addition, participants discussed with their group members the opportunity and possible obstacles if demonstrated active learning from the videos are implemented in their classes. Results of the group discussions were presented by each group representative.

In the development of active learning, an example of active learning strategy, called jigsaw-style approach, is simulated among the participants. It consists of three elements: (1) grouping of students into small and heterogeneous groups, so that each group members are assigned to learn different part of a particular topic which is being studied, (2) each group representatives who are learning similar topic are gathered into a new group called “expert group” and learn further into the topic they are assigned to, and (3) members of “expert group” return back to the initial group to explain the topic they have been assigned to and learnt in “expert group”.

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Table 1. Workshop activities and programs.

| Activity                                      | Program                                                                 |
|-----------------------------------------------|-------------------------------------------------------------------------|
| Classroom (including laboratory simulation)   | 1. Training for active learning in school                                |
|                                               | (1) What and why active learning                                        |
|                                               | (2) Development of active learning                                       |
|                                               | (3) Development of syllabus, lesson plan, and evaluation instrument    |
|                                               | (4) Simulation of lesson                                                |
|                                               | 2. Training for laboratory management                                   |
|                                               | (1) Tool and material inventory management                             |
|                                               | (2) Risk management                                                     |
|                                               | (3) Work safety                                                         |
|                                               | (4) Waste management                                                    |
| Implementation and post-workshop              | 3. Assistance during implementation in the teaching and learning activities |
|                                               | 4. Monitoring, evaluation, and following up                             |

The participants’ activities during active learning simulation by jigsaw strategy is shown in figure 1(b).

![Figure 1. Activities on; (a) video demonstration of active learning, and (b) active learning simulation.](image)

In the development of syllabus, lesson plan, and evaluation instrument, as well as simulation of lesson, the similar method with the development of active learning as mentioned above is applied.

5. Conclusion and suggestion

Active learning technique has been successfully introduced into a laboratory management workshop of biology and chemistry teachers. Since active learning is rather an instructional strategy than laboratory management, it does not require a detail and deeper explanation of active learning. Therefore, a brief and concise introduction about the concept and strategy is needed so that the focus of the workshop is still maintained in the laboratory management. We find our introduction on five skills of active learning in laboratory activities and component of active learning material in the workshop are brief, concise, and yet applicable. Hence, we encourage more science teachers receive this active learning introduction as well as laboratory management skills.

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