Jurnal Pendidikan Kimia
Vol. 12 | No. 3 |106 - 115| December | 2020
ISSN: 2085-3653| e-ISSN: 2549-3116
https://jurnal.unimed.ac.id/2012/index.php/jpk
https://jurnal.unimed.ac.id

Analysis of constraints and innovation of chemistry experiment implementation in high school in Deli Serdang, Indonesia

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DOI: 10.24114/jpkim.v12i3.21159

Article history:
Received: 04 July 2020
Revised: 31 October 2020
Accepted: 09 November 2020

Abstract: Practical activities play an important role in science education. Through it, students develop a deeper understanding of standing theoretical concepts, skill, utilization of technology, and methods for investigation with direct manipulation of related materials. Effective use of laboratories is one of the requirements in learning chemistry, especially in experiment material. However, problems that are often encountered in learning in the laboratory are laboratory management which includes the procurement process, application process, and the maintenance process. The research method used was observation, document recording and interview with all chemistry teachers and students at Labuhan Deli Senior High School and Percut Sei Tuan Senior High School, District of Deli Serdang, Indonesia. Stages in the research of this are (1) observation based on National Education Standards, (2) observation of chemistry experiments implementation, (3) observation of constraint and problems laboratory at school, and (4) determine alternative solution. The result showed that area of chemistry laboratory has suitable with BSNP standart, but the standard of facilities and infrastructure category reference scale (PAP), showed less category results. So the settlement by researchers on this problem is to do a simple practicum that can be done in an open space or using the technology (virtual laboratory) to increase the students' skill in industrial 4.0.

Keywords: Chemistry experiment, Laboratory, Facilities, Simple practicum, Technology

1. Introduction

The Industrial revolution 4.0 is a challenge for the education in the world to produce graduates who have the skills to be able compete for working. Chemistry

education is one of the majors that has contributed to producing graduates who have good skills in thecnology, problem solving, and social interaction abilities (Suyanta, 2019). Experiment in the laboratory plays an important role in education sciences. Through it, students develop a deeper understanding of standing theoretical concepts, use of technology, and methods for investigation with direct manipulation of related materials.

In learning with the practicum method, students will be creative, discover, or prove a phenomenon they experience and the concepts they are learning. By learning with the experimental method, it can be a place for the creation of the teacher as a learning facilitator so that concepts that students have not understood theoretically can be explored through practicum (Harefa, 2019).

They also improve their critical thinking skills and clarify important ideas by discussing and debating with laboratory experiments. Interaction social required in laboratory experiments, they were able to interact and develop a positive attitude toward the subject matter. The aim of experiments in the laboratory as the development of understanding related to scientific concepts, problem solving skills, the process of science skills and understanding the nature of science, students are expected to be aware of the relationship between experimentation and scientific theory (Sotiriou and Bogner, 2015).

Experimenting skills is the ability to use reason, thoughts and actions efficiently and effectively to achieve certain results. In this case, the laboratory as a means of honing the skills of students in some schools is still experiencing constraints due to the lack of facilities and infrastructure to support the laboratory, as well as the lack of practicum guidelines. Lack of practicum activities will result in students' laboratory skills tend to be low because the teacher's experience is given only more emphasis on lecture activities and question exercises, so that aspects of student skills are not sharpened and only cognitive aspects are sharpened (Limatahu et al. 2017).

Chemical laboratory experiments are the crucial for guidance chemistry studens and advanced alumnus in skills enforced by employers. A recent description determined the following chemical skills as being the most essensial, devious practical skills, analytical techniques, protected handling of chemical materials, and skill with chemical in measure with the interactive video for teaching chemical theniques as laboratory discussion (Cresswell et al. 2019). In the resolution of scientific problems, students must be role as a scientist and follow the scientific process. With scientific inquiry, students determine problems, develop solutions and alternative solutions to these problems, find information, evaluate information and communicate with their friends (Katsampoxaki-Hodgetts et al. 2015).

The problems in the implementation of practicum activities in schools were the lack of laboratory facilities and the lack of facilities and infrastructure to support laboratory activities, the lack of readiness of teachers and laboratory assistants in mastering basic laboratory techniques (Rahman et al. 2015). In addition the teacher

has the important role in laboratory activities. Laboratory ran optimally if the teacher developed the teaching material to increase the student's skill. Video tutorials were one of the teaching material that motivate students to understand the use tools in the laboratory. Online video tutorial that contains experimental procedures, so that the students did the practicum easily (Polloth et al. 2019).

Based on observation in high school laboratories in Deli Serdang Regency, schools only have a chemistry laboratory. But tools, materials, and infrastructure are not working. So that laboratory use is not effective. This problem requires a solution so that learning objectives can be achieved, one of which is the ability of teachers to manage learning. In the industry 4.0 era, the use of smartphones or other technologies can be used to open chemistry learning applications so that they can be used as alternatives to the minimum use of laboratories. The development of technology and education is inseparable from the development of science. The scientific development process that has been carried out by several experts has had a positive impact on technological development, with the creation of tools called technology products (Hanim et al. 2017). Smartphone tool that can be easily accessed and installed, TCD has the potential to be an effective method to help students who are conducting phenolftalein-based titration experiments independently delayed with minimal support from the instructor (Rathod et al. 2019). Laboratory activities can be done traditionally or virtually depending on the learning objectives to be achieved (Hensen et al. 2020) Based on these descriptions, this study aims to find out constraints and problems in chemistry experiment implementation in high school of Deli Serdang Regency, Indonesia. Students who are well adapted for laboratory activities to successfully achieve laboratory skill and gain the maximal available benefit from the laboratory process. To expedite.adequate student construction and enhance the learning result The facilitation for the preparation laboratory can make the management and standart competency increase. If the tradisional laboratory and the facilitate is less, there is the solution namely the pre-laboratory online it is the combination the visual material (video tutorial, the illustration picture and animation backed with written textual) to laboratory activitie successfully (Gregory & Trapani, 2012).

2. Methods

The population selected in the research was all chemistry teachers and students at SMA Negeri 1 Labuhan Deli, and SMAN 2 Percut Sei Tuan, Deli Serdang Regency. The sample used in this research was determined using probability techniques sampling types of random sampling, and sampling or sample purporsive includes 2 chemistry teachers and 64 students were focused on two schools. Stages in the research of this are (1) observation based on National Education Standards, (2) observation of chemistry experiments implementation, (3) observation of constraint and laboratory problem at school, and (4) determine alternative solution.

3. Results and Discussion

3.1 The Condition of Building and School Laboratory Facilities

From the observation that has been done regarding of each laboratory, data showed that extensive laboratory in each school already proper based on National Education Standards. The condition of the buildings of each high school in Deli Serdang Regency can be seen in Table 1.

Table 1
The state of the chemical laboratory building

School	Lab Area (m^2)	Lab Type	Amount	Information
SMAN 1 Labuhan Deli	16 X 8	Science	2	Suitable to NES
SMAN 2 Percut Sei Tuan	15 X 8	Science	1	Suitable to NES

Based on the National Education Standards, the chemical laboratory area for schools is 15x8 m^2 with a minimum ratio of 2.42 m^2 per participant, one teacher, one laboratory and 32 students. The laboratory is divided into two parts, the first part is used for the preparation room and the second part is used for laboratory activities. From the observation that the school laboratory has a material and equipment preparation room, as well as an experimental room. The laboratory has a permanent experimental table, equipped with a washing basin but tap water is not working, and air ventilation is also good. However, from the two school laboratories a study room is used, because there is still a lack of learning space. Therefore, the tools and materials in the laboratory cannot be used optimally, such as analytical balances, the statistics are not in good condition. Chemical beakers, erlenmeyers, and test tubes made of heat-resistant pyrex and duran materials. Funnel, measuring cup of various sizes, and mortar are also available. Tools and materials at school are not used properly because they do not have laboratory assistants. In SMK Negeri 2 Negara, the carrying capacity of laboratory facilities that are in accordance with the standards include the type of space and public facilities, the number of tools, the amount of chemicals, intensity of laboratory usage, and the usage of tool and materials based on infrastructure standard minimum Permendiknas No. 40 of 2008 concerning the standard of facilities and infrastructure category reference scale (PAP), showed less category results (Samiasih et al. 2013).

3.2 Problems and Experiment Obstacles: Student and Teacher Responses

Observations carried out by giving questionnaires to students and teachers of the obstacles that occur so that the experiment is not implemented. The results of teacher observation can be seen in Table 2.

Table 2
Results of teachers' questionnaire from both schools

No	Order of Problems	School 1		School 2	
		Yes	No	Yes	No
A	Amenities				
1	The condition of the laboratory room is inadequate		✓	✓	
2	The unavailability of practical tools		✓		✓
3	Unavailability of practical ingredients		✓		✓
4	Supporting facilities (water, ventilation, gas, etc) are inadequate		✓	✓	
B	Curriculum				
5	Time allocation for experiment is insufficient	✓		✓	
6	There is no practice exam in the national exam, so experiment is considered not important		✓		✓
C	Implementation				
7	Lack of readiness of laboratory assistant in preparing tools and lab material	✓			✓
8	Lack of teacher readiness in guiding practical activities in the laboratory	✓			✓
9	Teacher readiness to do practical activities	✓			✓
10	The teacher is not able to arrange worksheets for practical activities		✓		✓

Laboratory management covers six aspects, namely planning, procurement, use, maintenance, inventory of tools and materials, and destruction of damaged tools and materials. The process of planning the procurement of tools and chemical experiment materials at SMA Negeri 1 Labuhan Deli has not gone well. Based on the results of interviews, it is known that facilities such as laboratory conditions are sufficient, the availability of supporting facilities such as water, air ventilation, gas and others can run well, even the availability of tools and experiment materials is adequate. The main problem is about time. Due to the busy and varied teaching schedules, and the absence of laboratory assistants or experts who can help with laboratory maintenance. Maintenance activities of tools and experiments materials should be scheduled and recorded so that they can provide information about the history of tools and materials, from the beginning of the purchase, use, maintenance, until the end of life (Rosada et al. 2017). Another obstacle is the availability of storage cabinets that are still minimal, so that some tools and materials stored are not in accordance with the specifications. Beside that, the laboratory room is used as a learning facility or permanent class while during the class building process, due to the following problems, the experiment can not be done.

Based on the results of the interview at SMAN 2 Percut Sei Tuan, the experiment was running well where the tools and materials were sufficient, there was a laboratory assistant so it could run well. The problem at SMAN 2 Percut Sei Tuan is

that due to the lack of study space, the laboratory room is used as a learning facility. Then an experiment is carried out in the classroom, where the teacher will ask class representatives to help move tools and materials from the laboratory into the classroom, another problem is that the available time becomes ineffective and learning is inefficient because they have to prepare tools to bring to class and make many students noisy in conducting experiments, because these problems then make the experiment not facilitative.

The use of laboratories is one of the requirements in learning chemistry, especially in experimental material. The use of laboratory facilities must also be prioritized so that the implementation of chemistry practicum runs effectively (Dewa et al. 2019). One of the aspect of the success activities in laboratory is the fasilities of laboratory. The fasilities of laboratory are the storage room and preparation room, the chemical material, chemistry tools, and the condusif room. There are five aspect of success laboratory activities consist of fasilities, integration of model learning, student solidarity, open-endedness and rule clarity). It determine the substantial setting of chemistry laboratory activities and excite the teacher so the students' skiil in chemistry will be increase (Olubu, 2015).

The practicum process ineffective if deficient fasilities of laboratory, the students' approach towards the material which they recognized as difficult and impotent method of learning, so its make the unsuitable activities and the students' achievement get the low score (Arokoyu & Ugonwa, 2012).

Choosing the laboratory equipment is one of the way to preparation the process laboratory The quality of the equipment make the efficiency of laboratory activities. The coordination with assistant laboratory need to arrange the equipment before the experiment start. It can support the students' skill and educational level (Irwansyah, et al. 2018).

3.3 Students Responses

The next stage is giving questionnaires to students. The number of students as samples was 64 people with random sampling techniques . The percentage of students who chose the answer "yes" and "no" can be seen in the following Table 3.

Based on the results of the student questionnaire in the table 3, it was concluded that all students rarely participated in practicum activities at school, when experiment was conducted many obstacles such as the availability of tools and minimal materials. Then other problems such as teacher initiative in conducting experiment and lack of time allocation also become obstacles in practical activities in schools. Based on the results of observations on the problems found, the innovation that can be done in open space using simple practical materials and tools. This can facilitate the teaching and learning process in practical activities. Practical activities can use natural materials, for example bottles, both glass bottles and plastic cups with a simple experiment (Rahman et al. 2020).

Table 3
Results of students' questionnaire from both schools

No	Statement	The answer	Number of votes	Percentage (%)
1	Do you have / often followed Practical activities in the laboratory?	Yes	30	47
		No	34	53
2	Have you ever experienced "no material" in experiment activities?	Yes	30	47
		No	34	53
3	Are experiment tools available entirely in experiment activities?	Yes	5	8
		No	59	92
4	Did your teacher ever get around the unavailability of materials or practical tools by replacing other tools or materials?	Yes	4	6
		No	60	94
5	Is the time allocated for experiment sufficient?	Yes	3	5
		No	61	95
6	Does your teacher use it often practical methods in teaching?	Yes	4	6
		No	60	94
7	Does your teacher often explain learning objectives before does the practical start?	Yes	9	14
		No	55	86
8	Do you feel difficulty in participate in practical activities?	Yes	19	30
		No	45	70
9	Does your teacher provide guidance when you have difficulty at experiment activities?	Yes	12	19
		No	52	81
10	Do you feel difficulty in understanding work procedures and theory in worksheet?	Yes	23	36
		No	41	64

The development of simple practical tools in natural science learning produces simple practices that proper the eligibility criteria by analyzing the objectives and the material being developed. This proves that research conducted openly and using practical tools and simple materials can produce learning that is efficient and appropriate for students to use and understand (Widayanti and Yuberti, 2018).

Besides, that laboratory activities can increase student innovation, so that can think critically, creatively, productively, be responsible, and be disciplined by using the workbook based on project and character. In laboratory activities with it build the knowledge and the meaning of the active learning process, share, and review every process so that the student can innovate in the industrial revolution 4.0 (Nainggolan

et al. 2019; Sinaga and Silaban, 2020). Other innovations can be made by utilizing internet applications in the era of the industrial revolution 4.0, which is utilizing animated media applications. By utilizing this application, students in schools who lack tools, even practicum material can conduct experiments in an open space by looking at the experimental process that has been done through the application of animation media. The use of animation media on chemical equilibrium material has a significant influence on the improvement of student learning outcomes in class XI on science learning practices (Nurhayati, 2014).

4. Conclusion

Based on the results of research in Deli Serdang District High School that the area of chemistry laboratory has suitable with BSNP standart, but implementation of chemical practicum has not been carried out properly, because the laboratory is used as a learning room and there is no laboratory assistant so that tools and materials are not managed optimally. The standard of facilities and infrastructure category reference scale (PAP), showed less category results. So the settlement by researchers on this problem is to do a simple practicum that can be done in an open space or using the technology (virtual laboratory) to increase the students' skill in industrial 4.0.

Acknowledgment

Thanks to the Principal, chemistry teacher, administrative staff, and students of SMA Negeri 1 Labuhan Deli and SMA Negeri 2 Percut Sei Tuan; Deli Serdang, Medan, because give us the chance to research in their schools, so that this research can be done well. Also, a thanks was given to Staffs and Lecturers of State Univeristy of Medan had given device for us.

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