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Problems in The Indonesian Chemistry Laboratory Classes

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Abstract

In this 21st century, the laboratory activity is becoming an important way for improvement and building of students'scientific character. This study aimed to reveal the problems faced in the chemistry laboratory classroom in Indonesia and some alternative ways how to ward them off. This was an analysis of some randomly research reports about chemistry laboratory activities in Indonesian college, senior high school, vocational school, and junior high school both private and public institution. According to the reports, most of problems faced can be categorized in planning, implementation, and evaluation of chemistry laboratorium activities. In planning, the problems came from the preparation of pre-service teachers or teachers alone in competencies and designing the class, the inadequate laboratory facilities, and the laboratory management. In implementation, the problem came from the security and safety, and the practice lesson in the laboratory. In evaluation, the problem came from the lack of supervision, assessment techniques, and lack of reflection of teachers and laboratory officers. Based on these problems, some suggestions possed related to regulation, instrumentation, and sources for increasing the quality of chemistry classroom laboratories.

Keywords: chemistry laboratory classes, problem, planning, implementation, evaluation

Introduction

If we keep attention to the various chemistry learning conducted till nowadays, the appeared tendency was the emphasizing of classroom activities. Holbrook (2005) had investigated some researches in chemistry education and arrrived to the conclusions that chemical teaching generally was unpopular and irrelevant to students, not delivering students to the higher ordered thinking skills, often making a gap between the students' expectation dan teachers' instruction, and monotonous since the teachers were not ready facing the changing and need the guidelines. One of the factors affecting these problems was lack of laboratory classes conducted by chemistry teachers.

Varnai (2001) concluded the result of International Conference in Chemistry Education in Budapest 2000 that the chemistry education process indicated three

particular tendencies. First, chemistry teaching should be based on the experiences, material, and daily phenomena. Studies and comprehensions of chemical scientific should be built on this foundation. Second, reaching the experiences was a nessecity to develop the area of chemical sciences and environments. Third, the use and the publication of information should be carried out through internet and other interactive equipments. Based on these cases, how important it is to do a chemistry practice for making a meaningful learning.

Hunter, Mccosh, and Wilkins (2003) possed a number of reasons why the teachers should teach the laboratory skills to their students, they are (1) laboratory skills increased the students learning about fundamental concepts, (2) the skills gave students the easy approach in order they can expand their manipulative and observative skills, (3) allowing students to see themselves how the chemical reaction is, (4) making fun, (5) the skills were the basic things in studying chemistry, and (6) most of scholars received the jobs that needed the skills. These six skills are the nessecities needed and demanded in 21st century skills. Awaring this demand and reflecting on today chemistry laboratory instructions are correct to discuss the problems faced in management and instruction of chemistry laboratory class in Indonesia. Therefore, the important of this skills for students competencies, we need to do an investigation, evaluation, management, improvement, and repairment on the chemistry laboratory instruction. This paper aimed to reveal the problems faced in the chemistry laboratory classroom in Indonesia and some alternative ways how to ward them off.

Method

This was an analysis of some randomly research reports about chemistry laboratory activities in Indonesian college (especially in teacher training institutions), senior high school (regular and islamic school), and vocational school, both private and public institution. The research reports were obtained from Portal Garuda indexed journal (can be accessed from address http://id.portalgaruda.org) that had similar theme in laboratory in chemistry lesson. We used a random selection to obtain ten

journals about chemistry laboratory activities in Indonesia. The data about the ten journals can be seen in Table 1.

The ten journlas can be classified by four themes, they are preservice teacher problems, senior high school problems, islamic senior high school problems, vocational school problems, and practice report problems. Then, the ten journals' data was analyzed according to their theme, to identify the problems about chemistry laboratory classrooms. Some suggestion was given as the alternative ways to cope the problems identified.

Table 1. Data of 10 randomly selected journals about chemistry laboratory activities in Indonesia indexed by Portal Garuda

No.	Reference Name	Theme
1	Susilaningsih, E. (2013). Model evaluasi praktikum kimia lembaga pendidikan tenaga kependidikan [Evaluation model of chemical practice of institution of teachers and educational officials training]. *Jurnal Penelitian dan Evaluasi Pendidikan,* 16,1, 25-39.	Preservice teacher problems
2	Hidayah, F. F., & Imaduddin, M. (2015). Deskripsi keterampilan proses sains calon guru kimia berbasis inquiry pada praktikum kimia dasar [Description of chemistry pre-service teachers' science process skills based inquiry on basic chemistry practice]. *Jurnal Pendidikan Sains*, 3, 1, 8-12.	
3	Udaibah, W. (2014). Analisis pengetahuan calon guru kimia tentang peralatan laboratorium dan fungsinya [Analysis of chemistry pre-service teacher knowledge about laboratory apparatus and their functions]. *Jurnal Pendidikan MIPA*, 4, 1, 57-77.	
4	Wiratma, I. G. L., & Subagia, I.W. (2014). Pengelolaan laboratorium kimia pada SMA Negeri di kota Singaraja (Acuan Pengembangan Model Panduan Pengelolaan Laboratorium Kimia berbasis kearifan lokal tri sakti) [Chemical Laboratory Management in public senior high school in Singaraja (A developmental reference of chemical laboratorium management guideline based local wisdom "tri sakti")]. *Jurnal Pendidikan Indoensia*, 3, 2, 425-436.	Senior high school problems
5	Nuha, D. F., Haryono, & Mulyani, B. (2015). Kontribusi laboratorium terhadap pembelajaran kimia SMA [Laboratory contribution toward chemistry instruction in senior high school]. *Jurnal PendidIkan Kimia,* 4, 1, 82-88.	
6	Darsana, I. W., Sadia, I. W., & Tika, I. N. (2014). Analisis standar kebutuhan laboratorium kimia dalam implementasi kurikulum 2013	

No.	Reference Name	Theme
	pada SMA Negeri di Kabupaten Bangli [Analysis of chemical laboratorium nessecity standards in implementation of Kurikulum 2013 of public senior high school in Bangli Regency]. *Jurnal Pendidikan IPA*, 4, 1, 1-10.	
7	Rahmiyati, S. (2008). Keefektifan pemanfaatan laboratorium di madrasah aliyah Yogyakarta [Effectivity of labaratory useness in madrasah aliyah of Yogyakarta]. *Jurnal Penelitian dan Evaluasi Pendidikan*, 1, 11, 88-100.	Islamic Senior high school problems
8	Putri, A. A. (2015). Pendampingan laboratorium kimia untuk madrasah aliyah mitra UIN Walisongo se-kota Semarang [Chemical Laboratory Guiding for collaboratory madrasah aliyah of a whole Semarang with UIN Walisongo]. *DIMAS*, 15, 2, 151-174.	
9	Samiasih, L. Muderawan, I. W., & Karyasa, I. W. (2013). Analisis standar laboratorium kimia dan efektivitasnya terhadap capaian kompetensi adaptif di SMK Negeri 2 Negara [Analysis of chemical laboratorium standard and its effectivity toward adaptive comptence outcomes in SMKN 2 Negara]. *Jurnal Pedidikan IPA*, 4, 1, 1-11.	Vocational school problems
10	Wulandari, R. A., Hairida, Husna. (2013). Analisis keterampilan komunikasi dalam penyusunan laporan praktikum termokimia pada siswa kelas XI IPA [Analysis of communication skills in thermochemistry report practice arrangement of XI IPA students]. *Jurnal Pendidikan dan Pembelajaran*, 2, 5, 1-13.	Practice report problems

Result and Discussion

Preservice teacher problems in chemistry laboratory classroom

The first problem in this case was the condition and activities in laboratory. The data gave us the information that the appropriateness of content and goals of practice programs were lower than the fluency of practice processes. The problems came from the unideality of rasio of laboratory facilities and practicians number. The recommendation to solve this problems were re-examination/actual supervision of the practicum training system for the intended teacher candidate, planning, tools and materials, see ideal laboratories that can be identified by prospective teachers, proper research techniques, and/or any activities that support teacher competence. And then, require proper training of practicum assistant in carrying out practicum of chemistry by teacher candidate.

The second problem was skills of a chemistry teacher candidate. Prospective teachers tended to act as practical practitioners not prescribed as practicum designers. They just proved the theory without understanding the concept. The prospective teachers still lacked understanding of the importance of laboratory preparation, security and safety of laboratory activities. They had no alignment of understanding in laboratory tools and their functions. And the prospective teachers also have less precise time management in the lab. To solve this problems, the recommendations given are (1) prospective teachers should be taught other than the proper way of practicum is also the way of guidance lab; (2) teaching style of teaching practicum should be taught, if necessary models that have been developed outside Indonesia; (3) they should be prepared their scientific insights and laboratory skills, as well as pedagogic skills in the appropriate laboratory; (4) can be held a special course on how to guide practicum activities at school; and (5) the prospective teachers should be prepared to become instructors or laboratory assistants who master not only laboratory management but also must understand everything in the laboratory (excluding technicians).

Senior high school problems in chemistry laboratory classroom

The first problem was about management system in laboratory. We devided this problem into four parts. The first partition was about procurement of equipment/materials. This partition told us that incidental and bureaucratic trajectories were long enough and tools/materials were incompatible with school needs. The second part was the process of using tools/materials. Some schools used them in learning and research, but in other schools, the usage procedures were only known by laboran, the teacher cannot do anything without the laboran. The third, was about the equipment maintenance process. Followed by laboran, there were some storage tool/materials that were less precise. And the last, was about the process of destruction of damaged equipment/materials. This problem was accompanied by the manager of the lab, there is not yet equipped with waste treatment. For solving these partition problems, we recommend some suggestion based on the partition. For the procurement of equipment/materials, (1) a special committee should be formed to

handle the procurement of laboratory equipment and materials in each school; (2) bureaucratic paths should only be for the administration to be orderly, not to complicate the procurement process of tools/materials at school; and (3) it needs to be done with a study like the minimal tools / materials needed in school for learning. For the process of using tools/materials, laboratory management should make clear administration of the use of tools/materials used during the lab. For the equipment/material maintenance process, the preparation of laboratory layout should be adjusted to its prospect so clearly where the storage of equipment and materials is in accordance with their characteristics and safety and safety considerations in the laboratory. And for the process of destruction of damaged equipment/materials, a periodic examination of the feasibility of equipment and materials needs to be undertaken to determine the immediate operational action possible to support ongoing laboratory learning.

The second problem was about contribution. This problem was divided by three sub-problems, they are laboratory standard, the implementation of practice in laboratory, and the contribution of the laboratory activites to the students achievement. In laboratory standard, we found thatthe minimum area ratio was less than 2,4 m^2, the tool availability was 74-82% and materials were 44-56%. The inappropriateness of this compotitions had a contributition in inefectiveness of the laboratory in class activities. The second, for implementation of laboratory, we found that of the total material of 20-40% in class X, 22-67% in class XI and 11-50% in class XII. The proportion of laboratory activities was far less than the theory activites. The third, we found the contribution of chemical practicum implementation to affective, cognitive, and psychomotor achievement was 73-87%. It was so good, it means that we need a laboratory activites to increase the students achievement. Some suggestion were given to solve theses sub-problems. For laboratory standard, a manual for laboratory management and laboratory management related to laboratory standards should be developed. For the Implementation of laboratory activities, the amount of chemistry practicum is tailored to the needs and conditions of the students. Teachers should be

able to recreate learning modes meaningful for students and keep students' skills up-to-date in lab performance. And the contribution of chemistry practicum implementation to affective, cognitive, and psychomotor achievement will be clearly integrated in practice performance, therefore the success of practicum implementation will increase the achievement of the three domains.

The third problem came from the implementation of the 2013 Indonesian Curriculum. We found that the availability of tools / materials not yet ideal (62.61%), the number of practicum performed for class X = 50.59-54.12%, XI = 43.53-52.94%, XII = 30.59-40%, and some obstacles identified such as: time (100%), technician (87%), multifunction laboratory (87%), students can not use the tool (73%), the number of practiciants were too much (60%), and the number of tools were inadequate(53%). To solve this problem, we suggest that (1) the teachers are trained in planning good practice with the approach or method demanded in the curriculum; (2) procurement and improvement of laboratory quality should also be undertaken to support chemical practicum activities; (3) allocation of time in learning is arranged in such a way that it is sufficient to practice learning.

Islamic senior high school problems in chemistry laboratory classroom

The first problem in this part was about facilities and infrastructure. We found some cases such as the completeness of facilities and infrastructure (61,5%), supporting equipment and security and safety facilities (65%), affordability (85%), maintenance of tools and materials (35%), availability of supporting facilities (electronic) (55%), and inventory of damage (20%). For this problem we suggest that to support student laboratory activities, laboratory facilities and infrastructure also need to be supported by preparing the availability of other supporting facilities such as electricity, water, sewage treatment, affordability and security of building structures, visualization media, multimedia facilities or equipment around the school that can be functioned in learning chemistry.

The second was from the teachers themselves. We found that of 94.56% (but monotonous) teaching practicum ability, laboratory utilization 75%, preparation

82.5%, and coaching practicum 62,5%. In addition to both in content and teaching skills, teachers should also have expertise in laboratory mentoring. In the planning of the teacher should consider the possibility of hazard level or safety and safety principle to be aware of. In the implementation, teachers should have facilitated students and readily handle the accidents or work errors committed by students.

The third was about the students themselves. The student acceptance was 57.3%. Students' positive interests and perceptions are grown from the teacher's methods and methods of teaching. Teachers can lead students to meaningful chemistry lessons that can be applied in life. The prepared practice can also be reasoned or form the students' positive perceptions of the chemistry learning.

The fouth was about management. We found that the attainment of management aspects was planning 47%, organizing 47%, implementation 40%, supervision/evaluation 53%, management effectiveness 33%, and support to learning 57.39%. Involvement of all parties in the school is needed to deliver an efficient and effective chemistry lab study. The laboratory should be equipped with a laboratory that is not the teacher itself. Regular checking or supervision of lab quality is required. The laboratory management system should also involve the laboratory developers so that problems can be solved as soon as possible.

The fifth we found that the planning and implementation of activity program had not been good, the implementation had not been good, the safety program was not good, the order and scheduling were not good, the security of equipment and material storage had not been good, and the waste handling had not been good. To solve these problems, we need a collaboration and a supervision to hold the good management system of school chemistry laboratory among the school, goverment, and society or stakeholders that want to participate in building the laboratory skills in students learning.

Vocational high school problems in chemistry laboratory classroom

The problem in this case came from the effectiveness of chemistry laboratories in the achievement of adaptive competencies. We found some cases such as the types of

space and public facilities (53%), the number of tools (45%), the material amount (48%), the intensity of laboratory usage in class (X = 33%, XI = 100%, XII = 59%), the tool usage (58%), and material use (75%).The chemical competence demanded in vocational schools should be different from that in senior high school. Therefore, the organization of chemistry learning in vocational school is conditioned or adapted to the area of expertise taught. Chemical laboratory planning in an intergrated vocational curriculum can also provide the minimal tools and materials available in the laboratory learning.

Laboratory practice report in chemistry laboratory classroom

The problems came from the students' skills of report preparation. We found that the attainment of students in their report was to formulate title and destination (100%), to formulate problem (75.9%), to write down the basic theory of (53.8%), to write down tools and materials (99.5%), writing work procedure (97.6%), presenting observation results (91.5%), discussion (56.7%), conclusion (56.7%), and providing recommendation (55.2%). Preferably in the first aid or meeting of the class of general practicum or learning, an explanation of how to prepare a good practice report. Or at least after the teacher's practicum explains to the student the components to be assessed in the preparation of the report and the maximum criteria achieved from each part of the assessment.

Overall problems

According to the problems discussed above, we can summarize the poblems into three part as shown the Table 2.

As the teacher, required to know about the ideality of laboratory learning in their chemistry learning including chemical laboratory as an unique learning and assessment mode, achievement and performance assessments in chemical laboratories, attitudes and interests of students in the performance of laboratory chemistry (Hofstein, 2004), risk assessment (Stuart & McEwen, 2016), literacy behavior (Shultz & Li, 2016), and the competence of a practicum assistant (Wheeler, Maeng, & Whitworth, 2015).

Table 2. Summary of the problem faced by Indonesian chemistry laboratory classroom

Planning	Implementation	Evaluation
a) Preparation of prospective teachers / teachers both in the competence and design of laboratory classroom learning b) Availability of laboratory facilities and infrastructure **c)** Laboratory management system	a) Principles of laboratory security and safety b) Practical learning activities: frequency of implementation, laboratory activities, and management of learning (time, coaching, and transactional decisions)	a) Supervision of laboratory activities and laboratory management b) Performance appraisal techniques c) Reflection of teachers and laboratory managers on the implementation of the lab

Conclusion

According to the reports, most of problems faced can be categorized in planning, implementation, and evaluation of chemistry laboratorium activities. In planning, the problems came from the preparation of pre-service teachers or teachers alone in competencies and designing the class, the inadequate laboratory facilities, and the laboratory management. In implementation, the problem came from the security and safety, and the practice lesson in the laboratory. In evaluation, the problem came from the lack of supervision, assessment techniques, and lack of reflection of teachers and laboratory officers.Alternative solutions that can be given to overcome the problem of chemistry classroom laboratory encountered in Indonesia is the policy structuring of laboratory management in schools starting from the central level.

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