



### EXPLORING SECONDARY SCHOOL BIOLOGY TEACHERS' COMPETENCY IN PRACTICAL WORK

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#### ABSTRACT

A competent biology educator should be efficient in the design, organizing, and execution of practical work and the evaluation of practical skills. Nevertheless, according to past research, the participation of students in conducting experiments is inadequate, and the teachers are not guiding them effectively. One of the issues that could lead to this problem is the lack of efficiency of the teacher to carry out practical work. To gauge this problem, a qualitative study has been conducted. The study involves eight biology teachers from eight secondary schools in two states in Malaysia, namely Kuala Lumpur and Selangor. Data were collected through observation at biology laboratory, interviews with biology teachers, and analysis of related documents such as lesson plans. Collected data were analyzed using constant comparative data analysis methods to explain the core phenomenon of this study. Three (3) themes emerged in this study: (i) difficulty in designing and planning practical lessons effectively, (ii) insufficient preparation before conducting practical lessons and (iii) improper evaluation of students' achievement in biology practical lessons. The results of this study offer information on the competence of biology teachers, which can be used to enhance the quality and standards of biology teaching and learning.

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#### INTRODUCTION

The notion of competence has earned a growing interest in education research. Teachers' expertise in teaching and learning is a significant factor in determining student performance. Studies (e.g. Turner et al., 2017) found that teachers' expertise and knowledge in performing science experiments have a strong influence on students' active engagement in science classrooms. Therefore, it is essential for teachers to be well equipped when they begin to teach and continue to develop their knowledge and skills during their teaching careers.

The development of science teachers' competency in Malaysia is a major agenda in strengthening the teaching profession and education quality as Malaysia's goal is to have its education system meets world standards (Ministry of Education, 2013). With the increasing needs and demands from society, teachers are seen not only as information providers but are also responsible for creating and developing a better citizenry. Therefore, the assessment of competencies plays an important role in optimizing educational processes and advancing educational systems. Drawing on Hasse et al. (2014) competencies are characterized as context-specific cognitive provisions that are acquired and necessary to cope effectively with certain circumstances or tasks in specific

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domains. Katane & Selvi (2006) describe competence as a collection of knowledge, abilities, and skills to provide meaningful experience in the organization of activity. Science subjects, such as biology, require both practical training and theoretical studies. The skilled and competent biology educator should, be effective and efficient in the design, preparing and execution of the biology lessons.

Besides, teachers should have the expertise to guide practical work and evaluate practical biology skills. According to Fadzil & Saat (2017), teachers should have a robust and credible knowledge of science, including the mastery of practical skills. Teachers have a significant role to play in instructing students on the proper handling of scientific equipment and materials. Instruction can be interpreted in this context as a structured process concerned with the creation of practical skills through directed practical experience, evaluation, and frequent feedback. For example, through a demonstration, the teacher ensures that students get the proper techniques to use scientific equipment. During practical work in groups, teachers support students, correct and guide the students who experience difficulties in performing the task (Fadzil & Saat, 2017). Furthermore, the teacher's role is more than just a facilitator during practical work but they also need to act as motivators, mentor or coaches (Llewellyn, 2013; Ping & Osman, 2019).

Practical work in this sense is characterized as an experimental activity in which learners need to be actively engaged, both hands-on and minds-on, to observe scientific processes (Fadzil & Saat, 2017, 2019; Sorgo & Spornjak, 2012). Among the aim of practical work is to develop practical skills in the laboratory. Practical skills play a significant role in science education, particularly in higher-level sciences (e.g. chemistry, biology, and physics), and these skills can only be acquired through practical 'hands-on' training. According to Osman et al. (2007), positive attitudes towards science can exist by constant supervision during experiments and continuous evaluation of practical activities. Evidence in science can only be proven by conducting practical work or science experiments. Studies (e.g. Cimer, 2012) revealed that teaching of Biology should be based on developing an understanding as well as the execution of practical. Practical tasks in biology offer incentives for students to do biology instead of reading about biology. Nevertheless, according to past studies, practical skills are usually given the least amount of attention in the course of academic instruction, even though important aspects

of learning may arise in this area (Cossa & Uamusse, 2015; Tesfamariam et al., 2015).

One of the factors that might lead to a lack of practical work in Biology is the teacher's insufficient skills in conducting practical work. Biology teacher is required to be proficient in the use of a variety of teaching methods, effective in organizing all the necessary equipment and ensuring the safety of students when doing practical work in the laboratory. Nevertheless, studies conducted locally and internationally (e.g. Mohammad (2007); Fadzil & Saat, 2017; Ng & Nguyen, 2006) found that in-service and pre-service biology teachers lack essential practical skills needed for conducting laboratory work effectively. Consequently, the teachers will have a problem to guide the students to conduct practical skills effectively. A study conducted by Mohammad (2007) concluded that preservice teachers are not very skillful in practical techniques. Awang et al. (2013) also found teachers are also incompetent in handling laboratory equipment and have not been able to perform a systematic and efficient experiment. It may be due to the fact that they do not plan and arranged the lesson effectively (Mahanani et al., 2020). Teachers still have a low level of competence to conduct practical or scientific experiments and, as a result, incompetent teachers have a significant influence on the level of interest of students in the subject (Awang et al., 2013). Failure of teachers to prepare their learning materials, insufficient preparation and inadequate science equipment would have detrimental consequences for the implementation of practical work.

As a result, the disparity between the desired curriculum, the curriculum implemented, and the curriculum evaluated has further widened. Biology lessons did not rely on practical investigations, and students did not participate in conducting experiments regularly. Biology Science lessons were mostly teacher-centered. Seventy-eight percent (78%) of Malaysian students (which is higher than the international average) reported watching teachers demonstrating science experimentation and investigation, instead of doing it themselves. Only forty-seven percent (47%) of Malaysian students agreed that less than half of the lessons had been taught using scientific investigation and experiment. Studies (e.g. Fadzil & Saat, 2017; Ishak, 2014) also found that among the indicators that impede the successful implementation of practical science assessment (PEKA) in school which is related to teachers' competency are teachers' lack of understanding on the concept PEKA, lack of training on the

proper execution of PEKA among science teachers, teachers were lack of proficiency and abilities in evaluation and assessment activities, the inability to choose proper experiments to be assessed, lack of reference for teachers regarding the implementation of PEKA and insufficient monitoring of PEKA at the school level. The aforementioned studies signify a necessity for the researchers to explore Biology teachers' competency in conducting practical work as teachers have shown difficulties in conducting practical work effectively in school. The aim of this study is, therefore, to determine the competence of biology teachers in practical work to ensure their mastery of scientific skills. The study will investigate the following research question: how are the biology teachers' competency in conducting practical work?

### METHODS

This paper discussed biology teachers' competency in conducting practical work. In this section, we describe the study participants, how our data were obtained and analyzed, as well as the validity and reliability of the study. To gauge biology teachers' competency in practical work, a qualitative research methodology has been employed in this study. This study involves eight (8) biology teachers from eight schools in Selangor and Kuala Lumpur states in Malaysia. This "manageable number" of participants provided sufficient information. As mentioned by Patton (2002), there are no rules or guidelines for the size of the sample in the qualitative investigation. Sample size and data analysis are continuous process until a saturation point is reached where no further relevant information may be discovered (Creswell, 2008). Moreover, the number of individuals is not the main concern of qualitative research. Instead, the phenomenon under study is the prime concern (Creswell, 2008).

In this study, four (4) of the teachers were novice biology teachers with less than five years of teaching experience. Another four (4) of them were experienced biology teachers with more than ten years of teaching experience. The min of the participants' teaching experience is 9.5 years (refer to Table 1). All of the teachers have professional background in teaching Biology and enrolled in a Biology Education degree. The schools in this research were purposively selected. The selection of schools was based on 'typical case sampling' merely because such schools represent the typical phenomenon of interest (Merriam & Grenier, 2019). The schools were similar in terms of laboratory facilities, as well as the use of the same biology curriculum.

**Table 1.** Biology Teachers Experience in Teaching Biology

No.	Teacher	Years of Teaching Biology
1	Teacher A	3
2	Teacher B	4
3	Teacher C	2
4	Teacher D	11
5	Teacher E	19
6	Teacher F	20
7	Teacher G	4
8	Teacher H	13

Most of the studies on science teachers' competency have been done quantitatively, which usually includes the use of instruments, such as checklist and questionnaire. On the other hand, this research uses a more effective approach to grasp the competence of biology teachers in the area of practical skills. The research employed a qualitative research methodology, which took four months to gather the data. The findings were based on the analysis of descriptive data from interviews with eight (8) biology teachers and laboratory observations. For this research one-on-one interviews were administered to gain insight into the actual competency of the teachers (Creswell & Poth, 2016). The teachers' lesson plans were also analyzed in order to get a better understanding of the phenomenon. A preliminary study was conducted before the actual study, to test the feasibility and appropriateness of the interview and observation protocol. The interview questions were further refined as a result of the preliminary study.

This research has utilized a constant comparative method of data analysis (Glaser & Strauss, 1999). This involved the process of coding, categorizing and establishing patterns from information that emerged from the data gathered. All the audio recordings were iteratively transcribed and analyzed, where the researchers replicated the data collection and analysis process back and forth until the data saturation point was reached. The refining of thematic structure requires rational and intuitive reasoning in ensuring that the research aims are properly addressed (Glaser & Strauss, 1999).

The interview protocol's validity and reliability has been achieved through peer review. Peer review is considered as one of the most dependable techniques used to enhance qualitative research's credibility and trustworthiness (Merriam & Grenier, 2019). This technique involves the use of external experts in a given field of study. Two scholars in the field of science education have reviewed the interview protocol and the established themes during the data analysis process.

Triangulation strategy was employed to increase the trustworthiness of the analysis. To avoid bias, triangulation is one of the strategies in qualitative research to strengthen and enhance the internal validity of the study. Triangulation refers to the use of more than one approach to investigating a research problem, to maximize confidence in the findings (Bryman, 2006). This research involves data and methodology triangulation. The information came from several techniques so that data were collected at various points in time and from a wide range of sources. In this particular research, prolonged and consistent fieldwork was conducted to enhance the internal validity and reliability of qualitative research (Wallen & Fraenkel, 2013).

## RESULTS AND DISCUSSION

During the analysis of the data, three main themes emerged. The themes are difficulty in designing and planning practical lessons effectively; insufficient preparation before conducting practical lessons; and improper evaluation of students' achievement in biology practical lessons.

### Difficulty in Designing and Planning Practical Lesson Effectively

Designing practical work requires the planning of appropriate scientific experiments to establish interesting learning experiences that can inspire students' interest in biology, to attain a successful learning process. Teacher needs to appropriately design and plan quality biology lessons concerning the effectiveness.

All the biology teachers in this research were optimistic about practical work. They explained that biological concepts will make more sense to the students if the students get to visualize the content through experimenting. For instance, Teacher E mentioned, "we can prove that glucose will be converted into starch and stored in leaves through the process of photosynthesis. The cells in the leaves contain chloroplasts, which contain chlorophyll, which is used to catch the light energy needed in photosynthesis. My

students will conduct the iodine test to prove this and this will enhance their understanding of this concept" (Teacher E, ln 21-23).

Teachers also admitted that through practical work, students gained their confidence to conduct an experiment at higher learning education and strengthen their procedural skills in experimenting. Nevertheless, the findings of this study indicate that biology teachers still have difficulty preparing and designing a robust biology lesson when it involves experiment. During the observation, the teachers only conducted experiments which are compulsory for them to do, as stated in the Biology curriculum. Teacher B admitted that "practical work is not conducted regularly...I just follow the textbook for practical activities and conducted the compulsory experiments" (Teacher B, ln.54-55). Teachers also explained that they fully relied on biology practical textbook in planning and designing biology practical lessons. The teachers argued that the procedure for the experiment should follow the standard textbook procedure so that their students will be able to answer the exam question related to the experiments in Paper 3 of the national examination. Teacher E explained that the marking guideline for the national examination is quite rigid and strict, thus, teachers avoid using other appropriate materials or procedures in their practical lesson, "in case the students cannot answer examination questions related to the experiment" (Teacher C, ln.32).

The novice biology teachers in this study shared that they were not advised to change any procedures or to use other relevant materials in the experiment because the senior teachers wanted the experiment to be similar for every student. This statement has been triangulated with the teacher's lesson plan, which showed that no modification was done to the practical lesson. Moreover, some of the teachers mentioned that they did not get full support to conduct more practical work in biology from the senior teacher. Practical work took much time and effort. However, this study also found that some of the teachers have shown their initiative to further enhance their students understanding in biology, through conducting simple experiments that are not included in their syllabus but still related to it.

The teachers' feedback is in line with other scholars, about the lack of proper training and the required skill to carry out laboratory work (Motlhabane & Dibacha, 2013). Students' are not effectively guided by the teacher's and students' involvement in conducting experiments was still low (Chua & Karpudewan, 2017). The finding indicates that much can be done to enhance biology

teachers' competency in designing a practical lesson, as their capability is very limited. Teacher's ability to design practical lessons is important because previous research suggested that it will have a great impact on the effectiveness of practical work itself (Naumescu, 2008). The lack of competence should be seriously taken into consideration. Abrahams et al. (2013) have mentioned that the success of student practical work depends on the ability of teachers to design the activity and to organize the objectives. Teachers must, therefore, be able to develop effective experiments to provide a better practical lesson in biology teaching.

### **Insufficient Preparation before Conducting Practical Lesson**

Appropriate preparation for experimental biology lessons can be defined as teacher's readiness to implement a successful biology practical lesson by determining the important preparation related to it. For example, the teacher needs to ensure the instruments and apparatus need for an experiment have been prepared before the actual practical lesson took place. This study found that less experienced teachers felt that they still lacked in experimenting skills. They confessed that they need to try out the experiments before the practical lesson to make them feel more confident in conducting it with students. Teacher A mentioned that "some of the experiments were challenging...I remember that I only got the chance to use the apparatus once I entered university. I learned the basic technique of using it. This should be done during secondary school" (Teacher A, ln.57). Teacher G agreed to this statement and confessed that she only mastered the correct technique in using Bunsen burner when she entered her matriculation college (Teacher G, ln.78). The teachers admitted that they need to be trained continuously. The experimenting skills need to be updated from time to time. The following interview excerpt was taken from Teacher C;

*"I need a lot of in-service training such as workshops in handling scientific apparatus. I am the product of PEKA assessment (science practical work assessment). I did not go through the practical examination. My teachers did not provide me with much experience in the laboratory and I did not get much opportunity in conducting relevant practical work when I pursue my bachelor's degree. This kind of skills needs experience and repetition because we cannot be an expert through reading" (Teacher C, ln.102-104)*

Preparation is important to provide students with a good experience during the science experiment. Upon observation in all schools, materials, apparatus, and equipment are commonly prepared with the assistance of laboratory assistants, who usually have extensive knowledge and experience in assisting biology teachers in the laboratory. Teachers also agreed that laboratory assistants play a significant role in ensuring an effective practical lesson. To avoid disturbance in teaching and learning, it is very important to provide appropriate and adequate materials and apparatus to be used for practical activities. However, Awang et al. (2013) and Fadzil and Saat (2019) have mentioned that teachers also need to master the scientific content and acquaint themselves with the proper technique of handling apparatus and materials in the laboratory.

Biology teachers should be proficient in handling and installation of the apparatus as that are parts of their responsibility in the laboratory. If teachers have trouble handling scientific apparatus, they will also face difficulties in teaching and evaluating practical work as well. Previous research also mentioned that the lack of equipment and materials in school laboratories can give a negative influence on students' practical skills (Chua & Karpudewan, 2017; Motilhabane & Dibacha, 2013). However, as opposed to those findings, the observation conducted during data collection for this study has shown that most of the biology laboratories are well-equipped but poorly managed and maintained.

From the teachers' feedback, we can conclude that teachers need in-service training in enhancing their experimental skills, especially to those teachers who went through PEKA program. Science Practical Examination was carried out in the national examination only until 1999. In 2000, the practical examination was replaced by written tests and continuous school-based science practical assessments. While students from Form Four themselves received marks for PEKA and those marks were not calculated into their SPM grades. PEKA program (for e.g Fadzil & Saat, 2019; Ishak, 2014; Phang et al., 2014) have shown many weaknesses that need to be given more attention. Ever since the Science Practical Examination was scrapped, teachers generally reduced the frequencies of engaging students in scientific-practical work. Even the teachers in this study admitted that students are not properly trained especially in the acquisition of science manipulative skills due to this issue.

Consequently, the laboratory apparatus is constantly developing with the introduction of new technology all the time. It is hard for the teachers to understand the manual by themselves and this led to difficulty in using the apparatus effectively. Previous studies (e.g. Fadzil & Saat, 2019) mentioned that effective implementation of practical lesson will produce good results in the experiment. This study supported this opinion, namely the implementation of effective biology lesson may produce a good result and outcomes of the experiment. Practical lesson will be more interesting if it is conducted in an organized and structured way (Abraham & Millar, 2008). Practical skills are an essential part of scientific research and therefore facilitate scientific literacy among students. Biology teachers must, therefore, acquire proficiency in practical skills on a multitude of levels. They should have the knowledge and understanding to teach the practical skills confidently.

#### **Improper Assessment of Students' Skills in Biology Practical Lesson**

Teachers should have the skills to develop practical lesson and assess practical skills in biology which include assessment of knowledge, scientific skills, and learning progress of individual learners. Assessment is the process of collecting data to determine the achievement of learning objectives. The findings of the current study revealed teachers' difficulties in assessing students' skills during practical lesson. All of the teachers who participated in this study mentioned that they did not directly assess students' manipulative skills in handling scientific apparatus, as illustrated in the following interview excerpt;

*Teacher D: Honestly, I do not have time to assess my students' manipulative skills. I assess their understanding through reports submitted after the experiment.*

*Researcher: So, the assessment is to find out their understanding of the experiment?*

*Teacher D: Yes, if the students can complete their laboratory report, I assumed that they have already acquired the skills. (Teacher D, ln.132-139)*

Some of the teachers mentioned that they only observe students' skills in handling scientific apparatus during the experiment. The students work together in a group and teacher will correct the students' mistakes and inappropriate techniques. One of the teachers argued that the assessment of students' acquisition of the manipulative skills is not important as the skills will not be assessed directly in the examination. Teacher A ex-

plained that the assessment of skills in handling the apparatus and conducting the experiment is not very important because "PEKA did not train students in acquiring manipulative skills ... not hands-on skills. It is more to the copying of the report. The student will experiment for a while, then copy it ... This is an improper implementation of practical work, but this is the reality at school" (Teacher A, ln 154-156).

Teaching and learning assessment is administered to obtain feedback and to determine student's progression. The assessment function is to provide the teacher with feedback to improve the learning process and to implement remedial activities for students until they can improve their skills (Hasse et al., 2014; Turner et al., 2017). The results of this study demonstrated that the assessment of the practical skills of students was not carried out competently. A strategic and comprehensive step needs to be taken for the benefit of teachers and for them to be able to assess the practical skills of students in biology lessons. Development of the related practical competencies needs to be supported so that the teachers can master a range of skills and become effective laboratory practitioners as mentioned by previous researches (e.g. Copriady, 2014; Hidayah, 2019). Teachers training programs should be aware of this issue and should provide much training in practical skills and laboratory management for pre-service teachers. Without adequate training, the quality of biology teachers will be compromised.

#### **CONCLUSION**

Teachers' competence is a pillar for the safe and reliable implementation of practical lessons in biology. This study aims to determine the proficiency of biology teachers in practical work to ensure their mastery of scientific skills. Three (3) main themes emerged during the analysis of the data in this study. The themes are namely the ability to design and plan practical lesson effectively, ensuring appropriate preparation before conducting practical lesson and improper evaluation of students' achievement in biology practical lessons. The results of this study are essential for the provision of information on the competence of biology teachers and to enhance the quality and standards of biology teaching and learning. Biology teachers need to be well-versed and knowledgeable of scientific skills. Teachers need to have high capabilities and skills in developing instructions for the laboratory lesson. Thus, the government shall provide continuous in-service training to improve teachers' practical skills and

conceptual understanding to assist in producing a scientific literate society.

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