

# A Case Study of Direct Assessment of Students' Manipulative Skills in Chemistry Practical: Perspective of Lecturers

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## Abstract

Direct assessment has adopted in matriculation college as an innovative change in assessment method for practical in line with the implementation of outcome-based education. The purpose of this study was to obtain the views of matriculation lecturers on the use of direct assessment to assess students' manipulative skills in titration experiment during Chemistry practical. A qualitative case study approach was adopted, in which four matriculation lecturers were purposely selected. Observation and interview were conducted to obtain their views regarding to the perception, implementation, effectiveness, and critical factors for sustainability of direct assessment. The findings of the study indicated that lecturers positively perceived direct assessment were able to enhance students' manipulative skills in Chemistry practical, by identifying their weaknesses in skills and to increases their motivation in hands-on practical. Several issues such as lack of skills among lecturers and the requiring of excessive effort needed to overcome in order to sustain the implementation of direct assessment in matriculation college.

**Keywords:** Chemistry, Direct Assessment, Manipulative Skills, Matriculation, Practical

## INTRODUCTION

The matriculation programme is a pre-university programme offered by Ministry of Education Malaysia to provide the foundation studies for the students to enroll into first degree level in higher educational institutions. The teaching and learning of matriculation programme is delivered by lecture, tutorial, and practical. In the practical class, students are required to conduct the experiment by reading and understanding the given instructions, applying the learnt skills, and making the appropriate assumptions (Matriculation Division, 2019).

In accordance to the outcome-based education (OBE) practiced in the matriculation programme, the teaching and learning of practical is focused on achieving certain learning outcomes in terms of individual learning (Matriculation Division, 2019). Macayan (2017) stated that the first thing in the implementation stage of OBE was to identify the culminating or exit outcomes. These culminating outcomes were used to explicitly measure what the students to be able to do successfully at the end of their learning.

Similarly, Abdul Karim and Yin (2013) claimed that outcomes served as a guide in the instructional planning of OBE approach. A clear definition of outcomes would eventually decide the contents and teaching strategies to construct meaningful learning experiences, and guide the selection of assessments to be implemented in OBE approach. The assessment in OBE approach used to determine how well and how much the students have learnt (Abdul Karim & Yin, 2013). There is a need of paradigm shift in assessment from teacher-centered to student-centered (Macayan, 2017). Therefore, a relevant assessment method, which is student-centered, should be implemented to measure the students' learning outcomes in the OBE approach. It should focus on the ability of students to

demonstrate their skills and competencies at the end of their learning experience.

The learning outcome of practical in matriculation programme is to assess the ability of students to demonstrate the correct techniques in handling laboratory apparatus and chemicals when carrying out the experiments (Matriculation Division, 2019). In order to achieve the required learning outcome, students should be able to demonstrate the manipulative skills in laboratory work. The manipulative skills in Chemistry practical are psychomotor skills to carry out scientific investigation, such as to use and handle science apparatus and laboratory substances correctly, to draw apparatus and laboratory substances accurately, and to clean science apparatus correctly (Curriculum Development Division, 2018; Matriculation Division, 2019). On the other hands, Abrahams and Reiss (2015) employed a term called "practical skills" instead of manipulative skills, which was referred as the competency of an individual to manipulate of a particular piece of apparatus or equipment in the context of science practical.

In terms of the methods used to assess students' manipulative skills in science practical, there are basically two main assessment methods, known as post-laboratory write-up and formative assessment of skills development (Wright, Read, Hughes, & Hyde, 2018). The use of post-laboratory write-up, namely scientific report, was widely and commonly adopted to assess a large number of students in a practical class (Wright et al., 2018). Nevertheless, the formative assessment in Chemistry practical included on-site observation (Chen, She, Chou, Tsai, & Chiu, 2013), use of recorded video for post-laboratory review (Towns, Harwood, Robertshaw, Fish, & O'Shea, 2015), portfolio (Wright et al., 2018), and school-based continuous assessment (such as Science Practical Work Assessment, PEKA) (Lian & Yew, 2013).

Oloruntegbe (2010) also indicated several assessment methods, such as authentic assessment, performance assessment, alternative assessment, instead of the traditional paper and pencil assessment, to assess the skills demonstrated and developed by students during the science activities. Meanwhile, Abrahams and Reiss (2015) suggested direct assessment of practical skills (DAPS) and the indirect assessment of practical skills (IAPS) in school science. DAPS was used to determine the students' competency level of a specific skill by requiring the students to demonstrate the skill directly. Therefore, it was usually conducted through the observation of students' physical manipulation of real apparatus during practical. Conversely, IAPS indirectly inferred students' competency level through their written data or report. It was best suited to assess students' understanding of a skill.

Fadzil and Saat (2013) stressed that the assessment of students' manipulative skills was important in order to understand their acquisition and performance in manipulative skills, since the capability of obtaining accurate observation and data in the experiment was directly linked to their manipulative skills. Additionally, the practical work assessment might assess students' knowledge and skills simultaneously (Sedumedi, 2017). It was because students' conceptual understanding in Chemistry might be interpreted in their behaviour, which could be effectively observed during practical work activities (Sedumedi, 2017). Otherwise, Lian and Yew (2013) stated that the continuous assessment of students' science practical skills allowed teachers to assess one or several skills for a small group of students.

Despite of the growing number of studies indicated the importance of assessing students' manipulative skills in science practical, the use of direct assessment of students' practical skills in Malaysia is still very limited (Fadzil & Saat, 2017). Teachers preferred post-laboratory write-up because direct assessing students' practical skills in a large class was logistically impossible to be implemented (Wright et al., 2018). As a result, the lack of emphasis on the direct assessment of manipulative skills have led to the neglecting of conducting experimental work in schools amongst students and teachers (Abrahams, Reiss, & Sharpe, 2013), declining of time and effort amongst teachers to develop students' manipulative skills (Fadzil & Saat, 2017), and increasing tendency of adopting written lab reports to assess students' manipulative skills (Oloruntegbe, 2010).

However, the assessment in the written formats, such as paper and pencil test, and laboratory reports, unable to assess students' behaviour, performance, and practical skills, such as the skills of observation, and manipulating and assembling equipment during the laboratory practice (Abraham, Reiss, & Sharpe, 2013). Oloruntegbe (2010) claimed that on-the-spot assessment, through the direct observation using checklist, was vital to assess students' manipulative skills during the science activities. Likewise, Abrahams and Reiss (2015) also insisted that direct assessment was the most reliable and valid means to assess students' ability to do the practical works.

As such, the direct assessment was introduced and implemented in the matriculation colleges to assess students' manipulative skills during the science practical test, instead of written reports at the end of the experiment. It was an innovative change in the assessment method for science practical, in accordance to the OBE practiced in the matriculation programme. The titration experiment is selected because it involved various types of manipulative skills to be demonstrated, such as handling of burette, handling of pipette, and manipulating of burette for titration. In order to employ the assessment, a checklist was developed to assess the acquisition of manipulative skills among the students during the experiment.

The purpose of this study was to obtain the views of matriculation lecturers in related to the use of direct assessment to assess students' manipulative skills in titration experiment during Chemistry practical. It was to provide valuable insight for the management of matriculation college about the implementation of direct assessment amongst matriculation lecturers. The issues, such as the perception, implementation, effectiveness, and critical factors for sustainability, concerning to the direct assessment of students' manipulative skills in titration experiment were explored. Therefore, the research questions of this study was "What are the views of matriculation lecturers in related to the use of direct assessment to assess students' manipulative skills in titration experiment during Chemistry practical?"

## METHODOLOGY

This study employed qualitative case study approach to obtain the views of matriculation lecturers in related to the use of direct assessment to assess students' manipulative skills in titration experiment during Chemistry practical. It was conducted in a single matriculation college. The participants for this study was selected using purposive sampling technique, in which the lecturers must comply with certain criteria. These criteria included possessed more than 10 years of teaching experience, knowledgeable in Chemistry manipulative skills and direct assessment in science practical. Merriam and Tisdell (2016) stressed the importance of selecting participants who possessed the knowledge of the phenomenon being studied in qualitative research.

Two types of data collection method were employed in this study, namely observation and interview. The observation was conducted to collect the first hand encounter of how the direct assessment being carried out in the laboratory. The consent was obtained from the lecturers prior to the observation, and the non-participant role was adopted during the observation. It was used to be unobtrusive as possible without interacting with the students and lecturers, in order to avoid influences on their behaviours and views for the study (Creswell, 2013). Apart from that, the semi-structured interviews were conducted after the observation and guided by open-ended questions. It used to be conducted in either English or Malay Language, so that they could express their view clearly in the language of their own preference.

Thereafter, the data collected from observation were written in the form of field notes and the interviews were transcribed into verbatim transcripts. The framework analysis approach, which consisted of five key stages known as familiarisation, identifying a thematic framework, indexing, charting, and mapping and interpretation, was adopted to analyse the multiple data sources in this study (Ritchie & Spencer, 1994). A thematic chart, or matrices, across all respondents based on the prior categories, namely perception, implementation, effectiveness, critical factors for the sustainability of direct assessment, was constructed, so as the data could be coded under these categories.

## RESULTS AND DISCUSSION

There were four lecturers voluntarily to take part in the study, and all of them met the required criteria for the study in terms of years of teaching experience, knowledgeable in Chemistry manipulative skills and direct assessment in science practical. The lecturers' demographics were shown in Table 1.

**Table 1: Demographics of the lecturers**

| Pseudonym       | Gender | Years of teaching experience |
|-----------------|--------|------------------------------|
| Lecturer 1 (L1) | Female | 15                           |
| Lecturer 2 (L2) | Female | 13                           |
| Lecturer 3 (L3) | Male   | 12                           |
| Lecturer 4 (L4) | Female | 10                           |

### Perception on Direct Assessment

All lecturers indicated that direct assessment was a form of assessment that emphasised on assessing students' hands-on skills in conducting the titration. The following excerpts supported this finding:

- ...required the lecturer to observe how they do the experiment, their skills, their techniques. (L1, Interview)
- ... is assessing how students carry out their experiment in the lab. (L2, Interview)
- ... a form of assessment that carry out in the lab, evaluating the skills and techniques of students when they are doing titration in the lab. (L3, Interview)

Nonetheless, one lecturer mentioned the difference between direct assessment and assessment using written laboratory reports:

...is different with the current assessment we used. Before that, we assess students' performance from their lab reports' marks. But, the lab report does not tell us how they do the experiment. Cannot know their technique correct or not. Sometimes they even can cheat in the report. But, by using this type of assessment, direct assessing their work in lab, I can unless know, assess their ability of doing the experiment. So, many areas can look into, how they use pipette, burette, and how to determine end point of titration. (L1, Interview)

Although Oloruntegbe (2010) claimed that assessment might bring different perceptions and conceptions to different groups of people, the findings of the study revealed that the matriculation lecturers are clear about the basic principles of direct assessment in science manipulative skills. In order to improve the implementation of an innovation, Lian and Yew (2013) suggested that it was necessary for the early stage of teachers' concern, namely awareness about the innovation, to be resolved before they were interested to learn and implement the innovation. Therefore, the clarity about the basic principles of direct assessment shows that the matriculation lecturers are prepared and ready to adopt this new assessment method to assess students' manipulative skills in Chemistry practical, which is introduced by Matriculation Division.

### Implementation of Direct Assessment

Based on the observation in the laboratory, it was found that all lecturers were actively observing how the students conducted the titration by walking around in the laboratory, with the aid of checklist. The following excerpts illustrated the implementation of direct assessment among the lecturers:

- She walked tables to tables to observe how students conduct the titration. She checked how students rinse the burette using distilled water. Then, marked it in the checklist. (L1, Observation)
- She used to check students whether able to perform the skills and techniques correctly as stated in the checklist. Walked from tables to tables. Observed closely. (L4, Observation)

From the interview, all lecturers also admitted that it was essential to walk around the laboratory to observe and assess their students' manipulative skills during the titration:

- I prefer to walk around the laboratory... to observe how they do the titration. For example, it is important to check how they control the stopcock... how they swirl the conical flask. (L2, Interview)
- When I assess students in the lab, I will walk around. From table to table. (L3, Interview)

On the other hand, the observation also found that some lecturers used to give advice or hints to the students when they used to perform mistakes, or repeat the same mistakes during the assessment, as illustrated in the following excerpts:

- When she noticed that student X is not placing white tile under the conical flask, she gave signal by pointing to the white tile in the basket. (L1, Observation)
- He told student Y to control the stopcock of the burette and swirl the conical flask simultaneously... When he noticed student Y not following the instruction for the next titration, he raised up his voice to remind student Y. (L3, Observation)

The characteristics of the direct assessment adopted by the matriculation lecturers, such as make close observation in front of students, is congruent with the characteristics of direct assessment of practical skills indicated by Abrahams and Reiss (2015). Abrahams and Reiss (2015) claimed that such observation would give high validity and to ensure students performed correct practical skills that were being assessed. Malana (2016) also agreed that the well supervision was required to ensure students obtained the basic laboratory techniques.

Meanwhile, the findings of this study revealed the use of a checklist to conduct direct assessment of students' manipulative skills during the practical. According to Fadzil and Saat (2019), manipulative skills rubrics provided the clear and explicit standards to guide teachers in making the assessment of secondary school science learning. Therefore, checklist with clear scoring rubric is an appropriate assessment tool in implementing the direct assessment of students' manipulative skills during Chemistry practical. It provided holistic guideline to both lecturers and students about what and how the manipulative skills could be assessed.

### Effectiveness of Direct Assessment

In terms of the effectiveness of direct assessment, two main issues were emerged from the findings of the study, namely to help students to identify their weaknesses of skills in titration, and to increase students' motivation in hands-on practical. The following quotes supported these findings:

- Students could know which skills they are not doing well or correctly... for example, most of them are very weak in determining the end of the titration, like how to get a pale pink colour. We could let them know their weaknesses after the assessment, or directly point it out during the experiment (L1, Interview)
- Some students come to my cubicle after the assessment... to check their marks... where they did wrong, they will ask. (L2, Interview)
- Although the student M has completed four titrations, student M still want to do another titration. (L3, Observation)
- I will allow the students to repeat the titration as many time as they want, if the time is still available. (L4, Interview)

It revealed that the direct assessment would provide opportunity for students to identify and spot their weaknesses in manipulative skills when conducting the titration. It is the importance of implementing direct assessment to assess students' manipulative skills in Chemistry practical. Malana (2016) asserted that assessment on the specific techniques was essential to help students to learn their manipulative skills in Chemistry practical effectively. Alternatively, the psychomotor domain taxonomy proposed by Ferris and Aziz (2005) stated that the acquisition of psychomotor skills in science laboratory among high school students was mostly depended on their mastery in the lower level. It implied that if the matriculation students are able to master the manipulative skills in the lower level, such as handing and operating tools, they could probably perform the manipulative skills in the higher level, such as using tools to achieve consistent and effective work outcomes.

Instead of enhancing students' competency in practical work, this study also found that direct assessment increases students' motivation to conduct hands-on practical. Their motivation is stimulated by the desire to obtain more accurate result, which would directly affect their performance in the written report. In order to enhance students' interest in science learning, it is important to provide authentic and hands-on learning experience, such as directly involving them in activity based practical (McFarlane, 2013). Therefore, the implementation of direct assessment provides an authentic, or on-the-spot

assessment platform that emphasised on the acquisition of manipulative skills when the students are conducting their experiment.

### Critical Factors for the Sustainability of Direct Assessment

All lecturers indicated that the effort for preparation and performing the observation during the practical was critical for the sustainability of direct assessment in Chemistry practical.

- I spend a lot of time to prepare.... For example, before the assessment, I need to read through the items in the checklist. Not just read through, I need to understand each item. What this item assessed about. If I still cannot understand, need to discuss and confirm with other lecturers. Then, make arrangement for students... who sit for the test in first week, second week. (L1, Interview)
- The lecturer is checking the apparatus and chemicals at each table. Then, the lecturer is searching her pocket file to get the name list and checklist for assessment before instructing the students to enter the laboratory. (L2, Observation)
- It is not easy to conduct observation during the experiment... because there are too many students in the class. The students need to split into two or three sessions. (L3, Interview)
- I need to observe many students at the same time. Many classes to observe because they divide into many sessions. And need to pay attention to every student, look carefully how they conduct the titration. (L4, Interview)

Meanwhile, the lecturers also indicated the difficulties in conducting the direct assessment need to be overcome in order to sustain the implementation of direct assessment for Chemistry practical. These included the difficulty in assessing students' manipulative skills, and the need of training for direct assessment. The following excerpts supported these findings:

- Sometime I am quite confusing... how to assess their skills using the checklist given. At first, I need to understand the items in the checklist. Then, assessing their skills are not easy. For example, should I give them second chance if they make mistake? (L1, Interview)
- Assessing student directly in the laboratory... sometimes are subjective, depend on lecturers. Some lecturer gives marks, some is very strict. (L2, Interview)
- Different lecturers have different technique to do titration. So it is hard to standardise the way to give marks in the test. May be my technique in doing titration is different to others. So, maybe... training is required. So that at least the more experienced lecturer, or those who know the correct technique can show to others. Then, all lecturers will show the same technique. (L4, Interview)

The findings of this study showed that matriculation lecturers need to exert additional effort and overcome several problems during the implementation of direct assessment. The issues, such as the standardisation of assessment and the competency level of manipulative skills among lecturers would influence the consistency in direct assessment. This is parallel to the findings from previous studies that claimed Malaysian science teachers were lack of competence and skills in conducting the authentic assessment of students' manipulative skills during practical work (Fadzil & Saat, 2019).

In addition, the large number of students in a class would add extra workload of the teachers to conduct direct assessment during practical work (Fadzil & Saat, 2019; Hunt, Koenders, & Gynnild, 2011). Oloruntegbe (2010) also claimed that the issue of equity should be emphasised in administering the direct assessment in order to ensure the assessment is fair to all students. As such, the use of a standardised assessment rubric is commonly suggested in previous studies to guide the scoring of manipulative skills. It used to enhance teachers' understanding in assessing manipulative skills based on the clear and explicit criteria given in the rubric (Baharom, Khoiry, Hamid, Mutalib, & Hamzah, 2015; Fadzil & Saat, 2019). Moreover, the moderation was essential and should be carried out in formative assessment to maintain the validity and reliability of the scores given by the teacher (Lian & Yew, 2013).

Likewise, the provision of staff training is essential for the sustainability of implementing the authentic assessment of science students' laboratory skills (Hunt et al, 2011). The matriculation lecturers should be given the training in related to the manipulative skills in practical work, so as to enable them to perform the direct assessment consistently. Therefore, the workshop and training courses

are the ideal learning platforms to enhance the matriculation lecturers' manipulative skills on practical work, and to provide the up-to-date information regarding to the implementation of direct assessment.

Moreover, the sustainability of direct assessment required a great effort in terms of time for the preparation and planning (Oloruntegbe, 2010). The administration of matriculation college plays a significant role in supporting the implementation of direct assessment. The resources, such as the quantity of science apparatus and chemical substances, should be sufficient to support the number of students during the direct assessment in the laboratory. In addition, the lecturers who are willing to devote their time and effort in adopting the direct assessment should be praised, in order to become the role model of other lecturers.

## CONCLUSION

The use of direct assessment to assess students' manipulative skills in Chemistry practical is an innovative change in the assessment method based on the outcome-based education practiced by matriculation college. Therefore, this study uncovers the issues regarding to the implementation of direct assessment of students' manipulative skills in Chemistry practical, from the perspective of lecturers. The findings of this study indicated that the matriculation lecturers are positively perceived about the adoption of direct assessment to enhance students' manipulative skills in Chemistry practical, such as to help them to identify their weaknesses in skills and to increase their motivation in hands-on practical. Although there are several emerging issues regarding to the sustainability of direct assessment, such as lack of skills among lecturers and the requiring of excessive effort, its advantages are overwhelming than the traditional assessment, such as paper and pencil test, and written laboratory report. The implication of this study showed that the direct assessment could serve as a holistic assessment in Chemistry practical, which could assess students' on-the-spot manipulative skills in handling science apparatus and chemical substances. Nevertheless, the provision of institutional supports, such as organisation of training courses, should be continuously given in order to ensure the sustainability of direct assessment amongst matriculation lecturers.

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