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TEACHING AND LEARNING PRACTICES IN CHEMISTRY PRACTICAL WORK OF MALAYSIAN MATRICULATION PROGRAMME: A NEEDS ANALYSIS

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ABSTRACT

The importance of chemistry practical work in enhancing students' performance and 21st-century skills has been highlighted in the literature. However, Malaysian Matriculation chemistry lecturers were lack of knowledge in the 21st-century pedagogies and practiced the cook-book recipe teaching style which proved ineffective in enhancing students' 21st-century skills. Therefore, there was a need to develop a pedagogical module of chemistry practical work for the Malaysian Matriculation Programme based on 21st- century skills. To develop a comprehensive pedagogical module, it was aimed to identify the needs of the development of the module based on lecturers' views from the Matriculation Programme. Hence, this article focuses on the needs analysis phase attempted to identify lecturers' current teaching and learning practices in chemistry practical lessons. Therefore, there were five chemistry matriculation lecturers have been interviewed and data were analyzed using thematic content analysis. The emergent themes revealed that the current teaching and learning of chemistry curriculum in the Matriculation Programme is exam-oriented. The impacts of the exam-oriented curriculum are pronounced on the learning objectives, teaching and learning activities, assessment, learning hours were towards examination compared to the importance of practical work itself. Then, the issues on limited instructional media and teaching resources also emerged. Hence, it is proven that the 21st-century pedagogies were less been emphasized in the Matriculation Programme practical work lessons. As a result, the development of the pedagogical module of chemistry practical work in the next stage of the research need to be integrated with the 21st-century skills and pedagogies.

Keywords: *Chemistry Practical, Matriculation Programme, 21st-Century skills, Pedagogical Module, Design and Development Resign Design*

INTRODUCTION

The importance of chemistry practical work to chemistry education in enhancing student performance and scientific skills has been highlighted deliberately in the literature (e.g. Hunter et al., 2000; Hofstein & Lunetta, 2004; Oliver, 2016; Pavesic, 2008; Shahlan et al., 2017; Taber et al., 2000). The United Nations Educational, Scientific and Cultural Organization (UNESCO) and International Union for Pure and Applied Chemistry (IUPAC) in 2011 have suggested that the science education curriculum needs to be improved by including hands-on experimentation for a better understanding of science to increase the young people in science as well as to promote scientific literacy for scientific career and development of scientific thinking and experimentation among elementary, secondary school and university students as well (UNESCO, 2011). In essence, evidence from past studies shows that chemistry practical work can enhance the essential 21st-century learning skills among students (Abraham, 2011; Carin & Bass, 2011; Chiechi, 2012; Hofstein & Lunetta, 2004; Hunter et al., 2000; Millar, 2004; Nurzatulshima et al., 2009).

The Malaysian Matriculation Programme was established by the Ministry of Education Malaysia in 1999. It is a 1 or 2-year pre-university preparatory programme that allows students to pursue a degree in public universities upon successful completion. Students were qualified to choose courses in science, technology, or professional accounting streams. In the current implementation, students in the science stream were required to pass Chemistry as a pre-requisite for graduating from the Matriculation programme (Matriculation Division, 2016). The main objective of the chemistry curriculum is to equip matriculation students with basic concepts, correct techniques in handling laboratory apparatus and chemicals, and problem-solving skills in physical chemistry (Malaysian Matriculation Division, 2018).

Similarly, the current policy and syllabus of the Malaysia Matriculation Programmehave highlighted the importance of practical work which is by the 2018/2019 matriculation session, the evaluation of the practical work has changed from 10% to 25% with the practical test (10%) and lab report (15%) (Matriculation Division, 2018). Furthermore, the Malaysia Ministry of Education has stated that practical work and acquisition of laboratory equipment will be the main focus in the Malaysia Science education system by 2019 (Ministry of Education, 2018). Hence, the Malaysian education system is moving further into empowering practical work in science education.

In the current body of literature, the contributions of chemistry practical work can be seen mainly in the development of chemistry content knowledge (Carin & Bass, 2011; Chiechi, 2012; Woodley, 2009; Hofstein & Lunetta, 2004; John, 2016; Millar, 2004; Oliver, 2016; Smithenry, 2010). Significantly, the chemistry practical work activities allow students to construct their logical and inquiry-type skills, problem-solving skills if students would have good cooperation and communication skills during the practical work (Carin & Bass, 2011; Hofstein, 2004, Nurzatulshima et al., 2009). Yet, a chemistry practical work learning session enables students to enhance chemistry application into the real-life context (Abraham, 2011; Hofstein & Lunetta, 2004; Seery, 2015). Hence, in achieving this, the potential teaching approach is open-ended inquiry teaching (Hofstein & Lunettea, 2004; Millar, 2008; Nurshamsidah et al., 2013; National Council Research of America, 2013; Windschitl, 2005). The open-ended inquiry teaching approach has been proven to be aligned with the needs of 21st-century pedagogy approaches (Scott, 2015) which cover the higher-order thinking skills, effective communications, team skills, inter-disciplinary approach, project-based learning, problem-solving, assessment of students by relevant tasks teaching approaches (Aydoğdu, 2009; Barnea, Dori & Hofstein 2010; Buldur & Kartal, 2013, Krystyniak & Heikkinen, 2007; Myers & Dyer, 2006; Zaiton et al., 2015).

However, the most common practical work teaching approach is the cook-book style. The cook-book experiments also known as the closed-ended experiments are intended for learners to only prove the theory and concepts behind every experiment (Çepni & Ayvacı, 2006). Because of that, this type of experiment directed to the teacher-centred approach is not aligned with what is needed in teaching 21st century skills in chemistry practical work.The cook-book recipe style teaching approach has been extensively practiced by chemistry teachers globally and also in the Malaysian context. This traditional teaching approach was unable to support the 21st-century learning activities demands as it encouraged teacher-centered instruction and students are too dependent on the teachers' instruction and laboratory manual for conducting the experiments (Abraham & Millar, 2008; Aloyah, 2002). This teaching approach also failed to challenge the students to think and did not test their higher-order thinking skills (Fenelon & Breslin, 2012; Katchevich & Hofstein, 2015; Mamlok-Naman, 2013; Seery, 2015). In fact, in Malaysia past studies, revealed that the chemistry lecturers in the matriculation programme were also practicing the cook-book recipe styles. The main reason is teachers' incompetency in 21st-century pedagogies which resulted in the inability of students to relate the practical work lesson with the daily life practices and chemistry content knowledge (e.g. Izuan, 2005; Lee, 2005; Nurul Fatni, 2016; Salbiah et al., 2014). In essence, the students possess a lower level of science process skills and manipulative skills during chemistry practical work lesson as the negative impact of the ineffective teaching approaches (e.g., Lee, 2005; Izuan Shah, 2005; Ronald & Syakima, 2005; Salbiah et al., 2014; Ronald & Syakima, 2005).

Besides, from the current studies from 2010 until 2017 done on the pre-university level which is compatible with the Malaysian Matriculation Programme, the emergent patterns of the effective practices in chemistry practical work are directed to the needs of pedagogical approaches such as argument -inquiry-based learning (Choi et al., 2016; Grooms et al., 2015), inquiry-based techniques (Frach & Ralle, 2016; Muhamad, 2016; Kapanadze et al., 2016; Muhamad, 2016, Oliver, 2016), critical thinking and problem-solving techniques (Kapanadze et al., 2016), and flipped teaching method (Tang et al., 2016) proven effectively enhanced the chemistry practical work. Moreover, communication skills with argumentation skills (Hosftein, 2016), inquiry learning skills (Frach & Ralle, 2016), and ICT and digital embedded proven effectively in the current researches to improve the instruction of practical work (Bamford, 2011; Cain & Shephard, 2011; Child & Flaherty,2016; Gibbins & Perkin, 2013; Hofstein 2016; McClean, 2011; Oliver, 2016; Tang et al., 2016).

However, most of these initiatives were not integrating the essential 21st-century skills into one teaching approach holistically. According to Sampson et al. (2010), a new study is needed to design more authentic and holistic laboratory activities with an effective instructional method to cultivate students' learning by not putting pressure on them. To date, only a few studies have been done on the Malaysia Matriculation program and other pre-university programmes. Hence, within these 19 years of matriculation programme establishment (1999-2018), which was on attitude of teachers and students toward chemistry experiments and scientific skills level (Izuan; 2005; Fauziah et al., 2014; Lee; 2005; Norazren et al., 2008; Mardiana & Hana, 2013; Nurul Fatni et al., 2016; Salbiah et al., 2014). All things considered, a study of the effective teaching approaches that support the needs of 21st-century education in chemistry practical work has not been conducted in the Malaysian Matriculation programme. Therefore, there was a need to develop a pedagogical module of chemistry practical work for the Malaysian Matriculation Programme based on 21st- century skills.

Hence, to develop a comprehensive pedagogical module, it was aimed to identify the needs of the development of the module based on lecturers' views on 21st-century skills needs in the Matriculation Programme. Hence, this article specifically seeks the lecturers' current teaching and learning practices in chemistry practical work in Malaysian Matriculation College. Thus, the following research question has been formulated: What are the current teaching and learning practices in chemistry practical work for the Malaysian Matriculation Programme?

METHODOLOGY

Research Design

The main objective of the research was to develop a pedagogical module using Design and Development Research (DDR) which comprised of three phases i.e. needs analysis, design and development, and implementation. Hence, this article focuses on phase one of DDR which is the needs analysis phase attempted to identify lecturers' level of practices toward integration of 21st-century skills (i.e., critical thinking skills, creativity and innovation skills, and digital literacy skills) in chemistry practical work. Therefore, the opinions from the chemistry lecturers from Matriculation Programme have been taken as the main point to validate the development of the chemistry practical work pedagogical module for the Malaysia Matriculation Programme through a semi-structured interview.

Research Participants

Five chemistry lecturers from Malaysian Matriculation Colleges have been interviewed in this phase as shown in Table 1. The purposive sampling technique has been used in selecting the participants. Lecturers from different years of experience with at least 14 years, selected to provide holistic and varied views on teaching and learning practices of chemistry practical work in the Matriculation Programme. From 1999 until 2020, the Malaysian Matriculation Programme has the same standard of chemistry curriculum; all participants had experienced the same type of teaching practices, assessments, learning activities throughout their service. The semi-structured face-to-face interviews have been done within one month, from December 2018 to January 2019.

Table 1
Summary of Lecturers' Details Background

Chemistry Lecturer CL)	Higher academic achievement	Current position	Teaching Experience
CL.1	Bachelor of Sc. With Education, Chemistry	Subject Matter Expert, Chemistry lecturer	14 years
CL.2	Bachelor of Sc. With Education, Chemistry	Chemistry lecturer	10 years
CL.3	Bachelor of Sc. With Education, Chemistry	Chemistry lecturer	8 years
CL.4	Master of Sc. (Chemistry)	Chemistry lecturer	10 years
CL.5	Master of Sc. (Chemistry)	Excellent Chemistry lecturer	14 years

Data Collection Procedures

As the research gaps were into the ineffectiveness of method of instruction in teaching chemistry practical work, thus needs analysis has explored the current needs of 21st-century skills for the module development. Consequently in this study, the needs refer to the elements of 21st-century skills needed to integrate into the chemistry practical work, the lacks referred to unmet current needs of 21st-century skills that need to be filled in the chemistry practical work teaching and learning activities and the wants in this study referred to the essentials of teaching and learning activities based on 21st-century skills essential for students to learn and master. Significantly, to answer the research question, method of data collection was via semi-structured interview protocols of the teaching and learning materials and assessment results of chemistry practical works. So, the responses from each sample portrayed the lecturers' current teaching and learning practices in chemistry practical work for and integration of 21st-century skills. The instrument used was an interview protocol for semi-structured questions and has been validated by experts in chemistry education. The questions were divided into three parts: 1) Lecturer's demographic details, 2) Lecturers' perception on the current chemistry practical work in Matriculation Programme and 3) Challenges in chemistry practical work lesson. Samples of the interview questions for each section are as below:

i. *Is the current chemistry practical work learning activities in matriculation programme allow the enhancement of Chemistry Content Knowledge understanding?*
ii. *Are the learning activities in chemistry practical work learning activities enhance students' scientific skills?*
iii. *Are students can improve their motivation and interest in learning chemistry by doing practical work? (referring to the current syllabus)*
iv. *Are students are able to relate the real life application with chemistry knowledge by doing practical work? (referring to the current syllabus)*
v. *Is the teaching and learning session in chemistry practical work is meaningful compare to the lecture and tutorial lesson? (referring to the current syllabus)*
vi. *Are you agreeing if the syllabus of chemistry in matriculation is too exam oriented that makes students to neglect the practical work compared to the normal lesson?*

Data Analysis

The data from the phase one needs analysis interview were analyzed qualitatively by using thematic analysis. The analysis involved six steps: prepare and organize the data for analysis, explore and code the data (open coding, axial coding, selective coding), coding to build description and themes, reviewing themes to ensure they fit the data, defining and naming themes, the write-up (creating a coherent narrative that includes quotes from the interviewees) (Creswell, 2012). Hence, Figure 2 is the summary of the procedure for the needs analysis Firstly, the selected participants were given the interview consent letter and face-to-face interviews have been conducted within two weeks of period. Each of the participant's feedbacks were transcribed and thematic analysis on each transcripts have been done within one month.

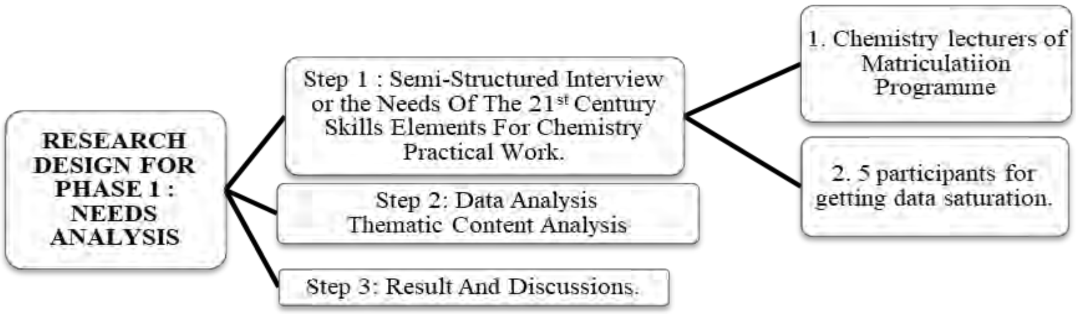

Figure 1. Flowchart of the Needs Analysis Phase Data Analysis

FINDINGS

The themes that emerged from the data indicated perspectives on current practices. The majority of the respondents agreed that the current chemistry curriculum of the Matriculation Programme was exam-oriented. This proven when the participants were emphasized that some of the lecturers do not put so much efforts on practical because the weightage of the examination is more compared to the practical work itself. In addition, the direct impacts can be seen on the student's attitude; students were giving less effort in the practical class compared to tutorial and lecture class which are objectively towards theories and answering techniques.

> *The essential objectives of matriculation programme is based on the CGPA which makes lecturer put so many efforts on the examination... in conclusion, yes the curriculum is exam-oriented not more than that [CL3: 59]*

Thus, six themes emerged from the interview data analysis, namely: learning objectives, learning activities, learning contact hours, types of assessment, teaching materials and resources, and teaching and learning aids and lab facilities as summarized in Figure 2. Quotations on the related themes from the transcripts were presented to highlight the current practices of teaching and learning in chemistry practical work as the needs of the module design and development.

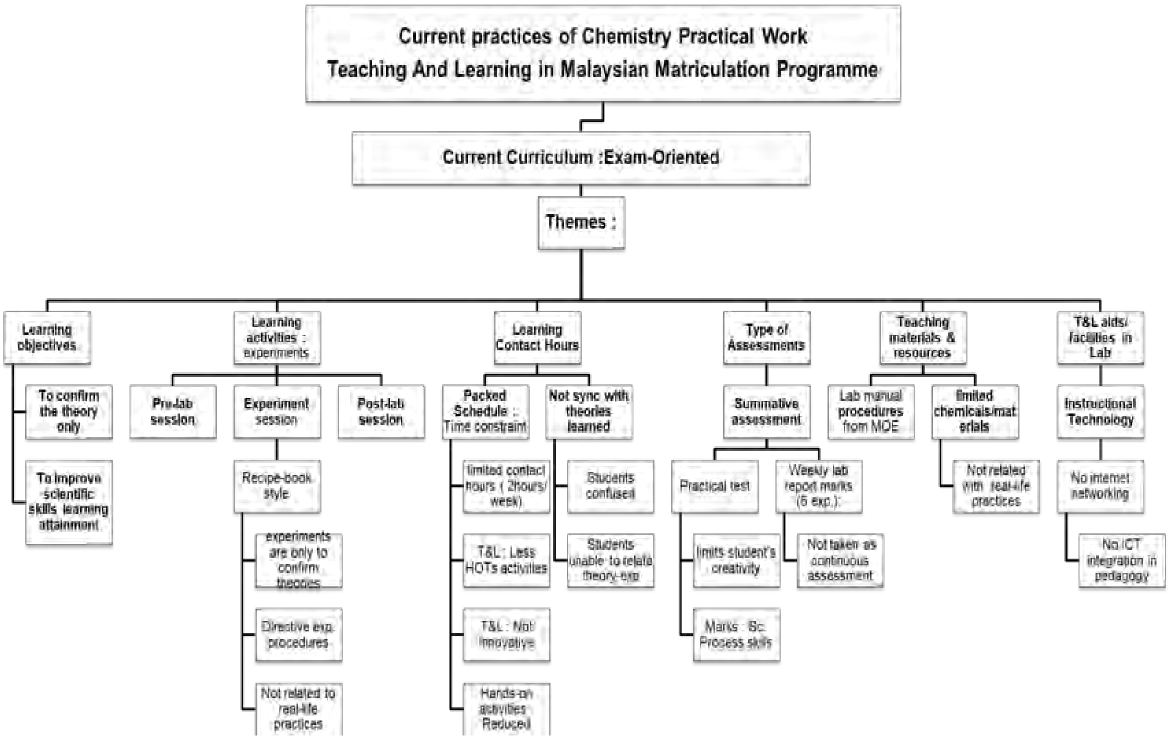

Figure 2. The summary of thematic analysis on current practices of teaching and learning

Learning objectives

From the interview data analysis, almost all the respondents explained that the teaching and learning objectives achieved were currently on the ability of students to confirm the theory only during the experiments and to improve students' scientific skills.

The syllabus is used to ensure students appreciate what they have learned in lectures and relate to practical work. If we read international books, maybe they had used real-life things [CL5: 181]

Haven't reached it yet because our practical work is sticking only to the theory [CL4: 341]
Yes. So the test for them is like to test on their technical skills, writing answer skills, for example, burette has to be 2 decimal place, calculations skills, their error and purposing steps. So, they are being tested in terms of reports and skills. [CL3: 203].

Thus, the learning objectives were too focusing on the improvement of the students' ability in understanding the chemistry theories and scientific skills without any elements of enhancing 21st-century skills.

Learning activities and experiments

From the interview data, the respondents described that the pre-lab session, experiment session, and post-lab session were the learning activities implemented in the chemistry practical work.

Practical work doesn't change very much in terms of the title of each practical work. Maybe there's little change about 1 or 2 topics but overall it doesn't change much.[CL5: 75]
Got... pre-lab, post-lab, and practical test at the end of the semester [CL 3: 23]
We tried to prepare for their pre-requisite however, unfortunately; maybe the objective was not achieved. For example in my class that has a pre-lab session, during the time I asked, what is the function of the certain chemical, they are not able to answer. [CL5: 66]

Meanwhile, the type of experiment was 'recipe-book style' which was to confirm theories and procedures from the syllabus during the practical work.

Yes, Zero. It means follow procedure or what we call in term [terms] of research, cook-book style. They are cook-book recipe style. [CL5: 290]
Most of them just followed the experimental procedures without even try to argue on it... thinking (CL1, 25)
Normally, the only platform is that they explain the procedure and in the meantime, I would ask them about the function and reasons why it occurs like that. Yes... the experiments are only recipe-book style..better to have more organic experiments that giving them more exploration beyond the experimental and theories only...also at the same time activities that would improve Higher order thinking skills of students (CL1, 39)

Then, the experiments were also unable to relate with real-life practices such as alcohol with perfume. Every participant has agreed that the current practical learning activities failed to make students connected with their real-life practices. This is because there are no such learning activities in the practical work allowing students to relate with real-life practices.

In the very limited time of lab session. The lecturer was just explaining the main procedures in the lab and did not explain the relationship of the procedures with other application in life... time is very limited that restricts the lecturer's ability to teach beyond that that [CL3: 47]
There is nothing about it in the lab manual provided. After procedures of the experiments, there are no questions [question] about the implementation of real-life practices [CL4: 48]
Not yet... there are no real-life scenarios like, we take in real perfume or an actual orange to be synthesized...Like electrolysis, we can use lemons but that has never been done before [CL5: 168]

In whole, the learning activities of matriculation chemistry laboratory were cook-book recipe style which were failed to relate with the real-life practices and only emphasized on the theories that students learn for the examination purposes.

Learning Contact Hours

According to the chemistry lab manual 10th edition, the mandatory learning contact hours for each practical session within 18 weeks per semester are two hours per week of teaching and learning plan (Matriculation Division, 2018). Hence, referring to the data interview shows that three of the respondents agreed that the packed schedule of the matriculation programme of chemistry students contributes to the time constraint preventing lecturers and students from exploring more during the lab session.

Time constraint...because we maybe have reduced to only 6 experiments currently from 9 experiments compared to the previous session [CL1: 185]
Previously, they conducted 9 experiments, but now it had been reduced to 6 only [CL2: 22]
The main challenge in the lab is the limited time given, two hours compared to university is different. This is not enough since the matriculation programme is only one year programme only [CL3: 65]
The main factor is from the lecturer itself, they were running [out] of time in a lab and not enough time to explore more about real-life practices during the lab session..even though there is nothing about it in our curriculum [CL4: 48]

The obvious impacts from the limited learning contact hours in practical work are students were having fewer hands-on activities which would reduce their learning experiences in enhancing their scientific skills.

The pros and cons in reducing practical sessions, for example, the amine is not included in the practical work anymore. So students are unable to visualize yellow oil green, green [CL5: 193, 195]

Okay, from my perspective, from what I can see is they had reduced the total number of practical works. This is because they follow this new system, which we called as MQA. So in my personal opinion, it reduced the aspect of handling skill, because of the decrease in the number of experiments. [CL2: 18]

Then, the respondents were also explained that the experiments have been conducted were not synchronized with the chemistry theories and concepts students learned in the lecture class. This made students confused and unable to relate their learning acquisition in practical work when it comes to content knowledge in lecture or tutorial class. Thus, the effect is prone to weaken students' understanding and the application of their skills to content knowledge and long-term retention.

The syllabus in the practical work wouldn't tally with what they learn during tutorial or lecture class. [CL2: 76]

Sometimes the learning that occurs in practical work definitely will help them understand in lecture however, sometimes our practical is earlier than the lectures, thus we are forced to asked [ask] the students to look for information first. [CL5: 79]

Yes, correct some of the lecturers need to explain the theories and concepts first to students before students start their experiments. This situation happened when they didn't learn the theory behind the experiments first, the effect is it's hard actually for them to relate it during the lecture class [CL3: 19]
Students can't understand and relate the content knowledge with the experiments because the topic discussed in lecture class was [does] not tally with the experimentation. Lecturers need to explain it first to students [CL 4: 28]

The impact of this is obvious on student's mentality which sees practical work as only a time-wasting lesson. "They just block their mind on their own, that why it's hard for them to relate. They just kind of wasting their time in the lab" [CL2: 70]

Hence, it was proven that the current chemistry practical work lesson was packed scheduled with limited contact hours which were not allow teachers to anticipate the higher order thinking skills and less innovative during the lesson. Furthermore, the direct effects were on students' learning attainment which the laboratory activities unable to connect the theories learned with experiments students handled with.

Type of Assessments

From the data interview analysis, the type of assessment was the summative assessment (practical test). The practical test was evaluated by using the standard rubric.

Yes, the pre-lab, post-lab session, practical test at the end of the semester [CL 4: 23]
No marks for science process skills have been taken before the practical test being introduced this semester. But some of the lecturers {lecturers] had observed their students randomly in the lab but no marks are recorded. But, sometimes I would just be warned students to be alert as I will take their marks. Eventually, no official marks were given during the hands-on practical activities [CL3: 57]
Because based on the rubric, if the students achieved points within 17-20, they will score 10, while 14-16 points will get 9. So it is quite easy to gain marks. [CL2: 193*]*

The practical test implementation drives a teacher to put more focus on student ability and science process skills than the previous one. One of the participants agreed that the implication of the practical test was more positive for the teacher's awareness in teaching the correct method of the practical test during the lesson.

Lecturers give more attention to student's science process skills and handling apparatus skills currently if we can compare to the previous one in which no practical test has been conducted. so the lecturer gives so many efforts in helping and guiding students to attain better and correct handling apparatus skills and at the same time will improve student's weaknesses [CL3: 57].

In contrast, the respondents also revealed that the practical test limits student's creativity and learning skills were restricted to only scientific skills namely science process skills and manipulative skills. Marks were not given for the weekly lab reports of six experiments within one semester. Thus, students tend to neglect the importance of having practical work for each week, "*Yes. So the test for them is like to test on their technical skills, writing answer skills, for example, burette has to be 2 decimal place, calculation skills, their error and purposing steps. So, they are being tested in terms of report and skills." [CL3: 203]*

Overall, the effects of summative assessments in practical work limits students' creativity and the assessments were not thoroughly able to evaluate students' progress and performance from the beginning of the semester until the end.

Teaching Materials and Resources

The data interview analysis shows that the main teaching materials that have been referred by the majority of the lecturers were only on the lab manual procedures provided by the Matriculation Division, Ministry of Education.

The main factors why did lecturers were not able to relate each experiment with the real-life practices is because of the limited time in the lab and there is nothing about it in the lab manual provided. After the procedures of the experiments, there are no questions about the implementation of real-life practices. [CL4: 48]

It means follow procedure or what we call in term [terms] of research, cook-book style. They are cookbook recipe style which referred to only lab manual given by division [CL5: 290]

Besides, the data interview analysis reveals that the chemicals and materials prepared for certain experiments were very limited and unable to support the big number of students in one short lab session.

Limited chemical reagent is provided to certain groups of students which limits student's chances to conduct their experiments on their own. They need to share it among the three of them... some may get lost during the experiments with nothing they can do [CL3: 65]

Real-life substances are not used. Moreover, sometimes there are limitations towards chemical substances, so the changes are unclear. For example, by default, ciller miller should react in benzoate but it reacts with ethanol only [CL5: 161]

Thus, the Matriculation Programme should transform the teaching materials and resources which not only restricted on lab manual procedures but there is a need to expand the teaching and learning materials towards the up-to-date materials with what have been implemented by others pre universities' develop countries.

Teaching and Learning Aids and Facilities in Lab

From the data analysis conducted, it was clear that lecturers faced limitations in using information and communications technology (ICT) during practical work lessons due to the insufficient ICT facilities.

Lack of ICT facilities provided in the lab… it's hard for lecturer to use it for induction teaching set [CL1: 30]

The problem concerning the lack of internet in matric is also one of the restraints…. sometimes there's some problem with the facilities, like ICT problem while we're teaching…It's a good thing, to implement technology integration, but make sure that the facilities are complete and in good condition [CL2: 294, 423]

The final theme emerged from the interview data analysis shows that Matriculation Programme has to improve the internet networking and ICT supports in laboratory.

DISCUSSION

From the findings, it is proven that the Malaysian Matriculation Programme chemistry practical work curriculum was exam-oriented which affects the teaching and learning activities, students, and teachers. Six themes emerged from the interview data analysis. First, the learning objectives confirm the theory and enhance scientific skills learning attainment. Second, the recipe-book style learning activities have been done with pre-lab and post-lab sessions which were unrelated to real-life practices. Third, limited learning contact hours with only two hours of lab session due to the packed schedule of the Matriculation Programme contribute to the fewer number of experiments that reduced student's hands-on experiments learning experiences. Then, summative assessment with practical test with no continuous assessment has been conducted. The lab manual procedures were the only teaching materials and resources that have been referred by the lecturer with no elements of real-life practices, limited chemicals provided, and the limited teaching and learning aids with poor networking and ICT facilities. The summary of effects of exam oriented chemistry practical work are illustrated in Figure 3 and explained in the next sub sections i.e. ineffective learning activities and non-up-dated chemistry practical works.

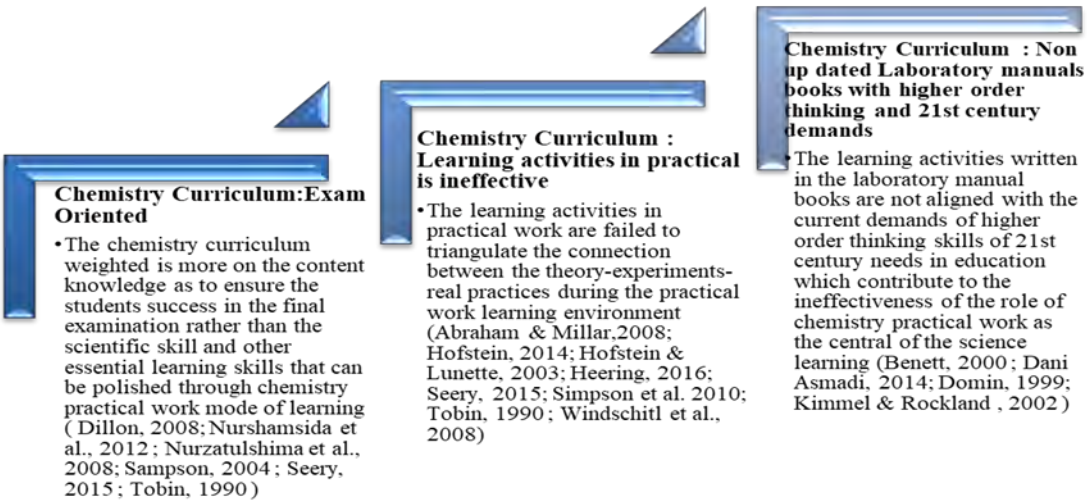

Figure 3. Challenges of the Exam Oriented Chemistry Practices

Thus, the needs analysis conducted revealed that the teaching practices in chemistry practical work in Malaysian Matriculation College were exam-oriented practices. In essence, without the development of the module in the next research steps, the lessons in the chemistry practical work would still be exam-oriented and less able to triangulate the connection between the theory-experiments-real practices during the practical work learning environment (Abraham & Millar,2008; Hofstein, 2014; Heering, 2016; Seery, 2015; Simpson et al. 2010; Windschitl et al., 2008).

The exam-oriented practices effects on learning objectives and activities of Chemistry Practical Work

Ultimately, from the previous researches, there were more negative impacts on the exam-oriented chemistry practical work activities. According to Sampson (2004), the laboratory session has been replaced to cover the syllabus for the sake of examination requirements and limitation of time in a given period of studies. Previous research had failed to prove that students are given a chance to run the practical science work on their own and to construct their knowledge of chemistry with the real investigation in practical work (Seery, 2015). However, in the UK curriculum, developers tried to improve the quality of practical work but recurring problems emerged, such as infusion of cookbook-style teaching (Dillon, 2008).

Furthermore, recent research done in Kenya's high school system showed the inconsistency in the chemistry class that uses a high weighted grading system in implementing the syllabus, which is not a challenging teaching and learning method either (John, 2016). Meanwhile, in Malaysia, the school education system is biased in measuring the success of specific subject which is based on the numbers of A's received in the final examination rather than the quality of students' ability to assimilate scientific skills and practices (Nurshamshida et al., 2012; Nurzatulshima, 2008). The issue of quality in learning activities in practical chemistry also contributes to the designated curriculum problem, which does not support students' ability to understand the concepts behind chemistry experiments. Many types of experiments failed to prove the relationship between laboratory activities and chemistry concepts attainment (Abraham & Millar, 2008; Hofstein, 2004).

In another instance, the learning activities in the practical work curriculum failed to integrate the chemical theory with the industrial application for the first-degree programme in one of the United Kingdom universities. Studies found that only 11% of the chemistry curriculums for K-16 in the United Kingdom were aligned with the chemistry-based technology education (ChemTechLinks, 2004). Sampson et al. (2010) suggested that a new study be conducted to design more authentic and holistic laboratory activities where teachers have the autonomy to suggest the best instructional design to cultivate student learning ability, and not only their grades. Moreover, the literature also suggested that the tasks accustomed were unsuccessful in linking the theory-experiment findings with real-world experience (Abraham & Millar, 2008; Seery, 2015; Tobin, 1990; Windschitl et al., 2008).

Also, the learning activities in chemistry practical work should be able to embrace the scientific method behind the experiments demonstrated by students. However, there are no methods used by teachers in conducting the lesson as students failed to relate the experimental findings with the theories and real practices (Windschitl et al., 2008). It was discovered that many of the practical class activities are based on lab providing only hands-on activity but not the minds-on (Hofstein & Lunette, 2003).

The Effects of Out-Dated Laboratory Manual of Chemistry Practical Work

Research also indicated that the out-dated laboratory manual does not challenge students in creating and synthesizing the new scientific concepts (Kimmel & Rockland, 2002) and does not initiate higher-order thinking skills in lab activities (Bennet, 2000; Domin, 1999). Consequently, students are unable to synthesize a new idea from the experimental findings they obtained. In Malaysia also, various researchers from pre-university level and undergraduate chemistry courses have confirmed that the lab activities mostly covered lower levels of learning skills (Dani Asmadi, 2014; Nurazidawati & Kamisah Osman, 2016). Particularly, in the Malaysian Matriculation Programme, the current laboratory manual (the 4th edition) lacks emphasis on higher-order thinking as it only provides steps of conducting experiments.

Furthermore, as the summative assessment has been implemented currently in Malaysian Matriculation Programme, it was proven that the exam-oriented and out-dated chemistry curriculum has affected effective assessment process which proven based on content analysis of literature in the last 30 years on chemistry practical work assessment practised worldwide (Ornstein & Hunkins, 2009). This study suggested the need for researchers to examine several contributing factors to poor implementation of practical assessments. Thus, the effective assessment needs to be authentic, holistic and inclusive with higher-order thinking, the cognitive domain for the current and future of chemistry practical work needs improvement (Hannaway & Hamilton, 2008; Hofstein, 2004; Ornstein & Hunkins, 2012). Moreover, there is a debate on the current assessment techniques that rely on the final laboratory report. Researchers criticised this as they firmly believed that this method is unable to assess the real students' ability in relation to the experimental findings and theory of chemistry practice (Domin, 1996; Hofstein & Lunetta, 2001; Seery, 2010). On the other hand, lack of guidance and protocols in assessing students have also affected the quality of students' real attainment in practical class (Woodley, 2009; Hofstein, 2004; Ramsey & Howe, 2009). Hence, the current practices of chemistry practical work learning activities and assessments portrayed that the laboratory activities were hands-on but not minds-on. The teaching and learning practices should be more authentic, real-life practices and able to challenge students' 21st-century skills rather than being testing only the cognitive and theory parts.

Ultimately, from the findings of this needs analysis research, shows that a comprehensive module needs to be developed with real-life practices learning activities and experiments, authentic assessment, integration of ICT and media in lessons, innovative teaching strategies and methods. Hence, the development of the module needs to consider the transformation of the teaching and learning activities are towards the current 21st-century pedagogies. This can be done by transforming the curriculum to emphasize 21st-century skills. Besides, without a better curriculum, better teaching, and better tests, the emphasis on "21st-century skills" will be superficial and sacrifice long-term gains for the appearance of short-term progress (Rotherham & Willingham, 2010).

Furthermore, this study limited on the practices done in the scope of Malaysian Matriculation Programme which mainly as the needs analysis phase in order to develop a comprehensive innovative chemistry practical work pedagogical module based on 21st-century skills. Hence, in future, this research can be done in any A-level or pre-university programme, all over Malaysia and globally with anticipation of real-world and innovative chemistry practical work teaching and learning activities. Despite, the findings and effects can also can adapted for implementation in the elementary and secondary science education system with some modifications on the learning activities which need to align with the level of student's thinking and capabilities.

CONCLUSION

This study reveals that the current teaching and learning of chemistry curriculum in the Matriculation Programme is exam-oriented. The impacts of the exam-oriented curriculum are pronounced on the learning objectives, teaching and learning activities, assessment, learning hours were towards examination compared to the importance of practical work itself. Then the issues on limited instructional media and teaching resources and facilities also emerged in this phase. Hence, it is proven that the 21st-century pedagogies were less been emphasized in the Matriculation Programme practical work lessons. As a result, the development of the pedagogical module of chemistry practical work in the next stage of the research need to be integrated with the 21st-century skills and pedagogies

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