The Mobile Science Laboratory (MSL): A Systematic Review

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Abstract

Experiments and hands-on activities encourage students to be active in knowledge construction. As students carried out experiments and activities, they explored science concepts and retain the knowledge. Currently, a low number of experiments are carried out because some schools are not equipped with updated experimental apparatus, while some schools' laboratories are broken and they do not have enough experimental apparatus. Therefore, a systematic review was made to study the use of mobile science laboratory in previous studies and its need in Malaysia context. The findings show that teachers had developed their pedagogical skills and confidence in laboratory teaching instruction. The students gained conceptual understanding, retained science learning, increased interest in subject and experiment, and interest to choose career in STEM.

Keywords: learning, mobile science laboratory, conceptual understanding

1.0 Introduction

Learning using experiments and activities are important elements in learning as they inject fun, relevance in daily lives (NFER, 2011) and interest for students (William et al., 2003). Experiments are able to enhance students' understanding and interacting with laboratory apparatus (Dziabenko, Ordufia & Garcia-zubia, 2013), investigate the condition of matter, verify the theories and enhance experimenting skills (Ojediran et al., 2014; Sin, 2014), link between experimental observation and concept of theories. Plus, they help students to understand the abstract concept, develop co-operative and critical attitude towards Physics (Ojediran et al., 2014).

Science learning process occurs in an investigative laboratory environment. The laboratory is a need in schools as it contributes to development of students' cognitive and thinking. Even though the role of the laboratory is vital yet not all schools have complete apparatus in the laboratory and some schools have malfunction laboratories, some of the apparatus are broken and outdated (MOE, 2013) and have not adequate laboratories (Deshpande et al., 2014). Therefore, less experiments are carried out by the teachers and students.

In addition, students learn content more than doing experiments. Students' understanding of hard and abstract concept make the students lose interest in learning subject such as Physics. Besides, pedagogical approach in teaching produces boredom in students

learning and students cannot relate daily life context with content that they learnt in class. By doing science, students able to increase their conceptual understanding and increase students' interest in Physics. Students perceived Physics learning is interesting when it shows relevance to effect in everyday life (William et al., 2003). However, most of the students apply rote learning and eventually they do not have enough skills in carrying out experiments as the scientist had gone through. Hence, actions had been taken such as school visits and science fairs. They involves mobility of students to certain places. A study showed that students develop their knowledge when they have interest and positive attitude (Roberson, 2010; University of illinois, 2014). As suggestion, a mobile science laboratory is introduced to cope the problems.

2.0 The Mobile Science Laboratory (MSL)

Laboratory is a need for learning science. Laboratory activities and experiments are the most concern element in learning Physics so that students acquire concrete Physics concepts (MOE, 2008) and science process skill (MOE, 2010). Therefore, the call of mobile science laboratory (MSL) is a solution in providing equal access to pedagogy and facility that supports meaningful laboratory learning experiences for all students (Franzblau et al., 2011). The MSL is a trailer, specialized bus or van replicated as a travelling laboratory (Long et al., 2012; Franzblau et al., 2011; Deshpande et al., 2014) and basically it offers as a service or off-the-shelf version (Erol et al., 2012). The MSL is established in United State of America in 1998 and widely implemented to outreach activities in United Kingdom, India, European countries and other developing countries such as South Africa in 2006 until recent year (Erol et al., 2012). The MSL is developed by the university such as the University of North Carolina, which has established its own Travelling Science Laboratory named Destiny, Lab in a Lorry is developed by Institute of Physics, London (Erol et al., 2012).

According to a study by Franzblau et al., (2011) an online survey was carried out to find out effects of MSL to teachers' professional development and their perception towards visiting MSL compared to visit local museums, local industries, local university and local natural settings, and the effect on students' attitude and cognitive levels were measured. STEM subjects were focused in the study. 178 students of various ages and grade levels were chosen. They were categorized into three grades: elementary school, middle school and high school. The greatest number of samples, 75 students are in high school (grade 9-12). The samples were 17 teachers. Descriptive analysis was used to analyse data. Sample from teachers were chosen with two characteristics; lack extensive science teaching experience and responsible for approximately 75 students per se. The findings for teachers were good in improving their professionalism with activities, experiments aligned to the curriculum. Their perception towards MSL was positive. Eventually, students' attitude in transferring MSL learning to other situations and interest in doing more lab-based science are quite moderate with 56.2 % and 66.9 % correspondingly although there is strong agreement that it affects positively on students' attitude. Students' level of cognitive increased significantly in retaining science learning, understanding scientific concepts and improving performance on high-stakes test. But, using evidence-based reasoning and giving students' insight into the scientific method are two elements that show no significance in the research.

Study by Long et al. (2012) used quantitative method in which instruments used were questionnaire and test, and for qualitative method, observation, semi structured and unstructured interview were used. The main focus was the samples from the rural area school students with lack of fund for laboratory, no laboratory space, outdated equipment and students who are not allowed from taking Standard of Learning (SOL) exam for Chemistry. The test needed students to acquire the skill in using computer, graphic calculator and probeware for gathering data. The samples were 9100 students from 38 high schools in rural

areas in Southwestern Virginia and inner-city Richmond. The researchers chose the teachers based on the characteristics;

(a) Lack of teachers in Chemistry background
(b) Teachers' lack of training
(c) Teachers' low expectation for science students' learning

These characteristics contributed to low achievement in Chemistry. In the study, the researcher used Mobile Chemistry Laboratory (MCL), the ChemKits program, teacher workshop and curriculum developed by the College of Arts and Science of Virginia Tech according to SOL exams. The study was for a three-year period and the groups of students were; MCL group, ChemKits Group and control group. The ChemKits group was the group of students who used low technology ordinary apparatus in school and conducted experiment as guided in the ChemKits module. The MCL group was a group of students who experienced advanced apparatus and investigation in conducting scientific inquiry. The findings showed SOL exam scores increased tremendously in three-year period compared to control group. Whereas ChemKits program also showed increasing SOL exam scores better than the control group. The important role for teachers' pedagogical skills in carry out experiments and active learning proved an increase in students understanding.

A study was carried out by Erol et al. (2012), a quantitative study which was planned to close the gap between rural area teachers and urban teachers with teacher training, for experiment-based science teaching skills. The samples used were 223 teachers and they were chosen from certain background: no in-service training, majority of them had served for almost 1 to 5 years and most of them had science education background. The Modular Mobile Education: Science Experiments (MOBILIM) was a project that provided hands-on and demonstrated practical activities. It also provided internet resources for the teachers to exchange experience and share formal, non-formal and informal activities. Teachers' views on MOBILIM were very positive since it was flexible in time management and its' accessibility. Teachers strongly agreed that the MOBILIM has raised their pedagogical skills.

A study by Franzblau et al. (2011) students' interest shows moderate effect and for cognitive level effect, MSL shows less effect in evidence-based reasoning and students' giving insight into the scientific method. The construct is analysed using survey only. In comparison, Long et al. (2012), used both quantitative and qualitative study and involved teachers and students as the respondents. The teachers were lacking in in-service training. Lack of teachers in this field is the problem that much related to Malaysian context. Also, the study by Erol et al. (2012) used teachers as respondents in the study. It showed teachers play important role in developing students' performance in science specifically in STEM subjects. Teachers who lack in pedagogical skills in teaching scientific skills influence students' level of understanding and student's cognitive level. The module developed such as ChemKits in the study by Long et al., (2012) showed teacher were able to use it according to the experiments with apparatus available in school. The module with inquiry approaches helped teachers in coping with students' learning problems in doing experiments. Besides, workshops are important for teachers to enhance their skills in using new apparatus and pedagogical skills with MSL apparatus (Long et al., 2012; Erol et al., 2012).

3.0 Discussion

Based on Table 1, only few the MSLs have interest in promoting students' interest and deep study in Physics. Plus, apparatus needed in carrying out investigation are enough at urban schools but not in the rural primary schools. Based on the research carried out by Franzblau et al., (2011) and Long et al., (2012) showed that the MSL affects students' attitude and students' cognitive levels improves significantly, and they retain science learning, increase understanding scientific concepts and improving performance on high-stakes test. Teachers also gain benefit as they can have additional pedagogical skills. Teachers view on MOBILIM

were very positive since it was flexible in time management and its' accessibility. Teachers strongly agreed that the MOBILIM has raised their pedagogical skills (Erol et al., 2012). Therefore, MSL in Malaysia is suitable to carry out teaching and learning process that are beneficial in learning development as well as current teaching practise by the teachers.

Table 1 The MSLs in the world

MSL Projects	Domain	Research Objectives are	Type of vehicle
DESTINY	Astronomy, Life Science, Physics	To promotes interest, ensure understanding and demonstrate the relevance of science to all students' lives To provide supports for teachers, schools, and communities by transforming science learning environment creatively and delivery of innovative approaches (DESTINY Traveling Science Learning Program, 2014)	Bus
Lab in a Lorry	Physics, Chemistry, Engineering	Provide hands-on experiments that are carried out inside the lorry (Institute of Physics, 2014)	Lorry
SCI-FUN	STEM subjects	To encourage more young people to consider STEM based career and appreciate the role of science in everyday lives. The objectives are to: (a) Present innovative science experience (b) Take contemporary research topics into schools and public realm (c) Increase awareness of the relevance of science (d) Promote interest in science (e) Provide materials to support science teaching (f) Bring interactive science to rural areas (g) Provide an opportunity for senior pupils to experience a leadership role as it encourages the responsible citizen capacity (University of Edinburgh, 2011)	Lorry
City Lab	Biotechnology, Biology	To help students and teachers explore topics in health, disease and industry through inquiry-based method (Boston University, 2014)	Trailer
Agastya	General Science	To help students and teachers in rural area by providing laboratory and lessons carried out in interesting ways (a) Hands-on and interactive activities (b) Exposure to new ideas and methods for students and teachers (c) Links to school syllabus (d) Peer-to-peer instruction (e) Multiple interaction (f) Science fairs (g) Extensive night and day coverage (h) Cost effective, scalable and replicable mobile labs (i) Mega science fairs (Agastya International Foundation, 2014b)	Minibus. van

Science on the Go	General Science and Mathematics	(a) promote interest (b) Skills developed such as writing, measuring, calculating, forming hypothesis, testing theories, and working collaboratively. (c) Fun learning (d) Hands-on scientific programme University of Illinois, 2014)	Bus
Hemsdale II West London Floating Classroom	Science, Nature, History	To promote science along with history, geography, art and citizenship (Moritz, 2014)	Barge
Bio Bus	Biology, Physics, Chemistry and Earth Science	To provide research grade microscope laboratory and computer lab for hands-on activities (Georgia State of University, 2014)	Bus
Vidnyanvahini	General Science	To help students and teachers in rural area by providing laboratory and lessons carried out in interesting ways To nurture scientific attitude and experience science experiments. Priority is given to small rural high schools with lack of science laboratories and low grants (Deshpande et al., 2014)	Mini bus
MOBILIM	Science, Technology	To improve teacher's pedagogical skills in teaching especially in laboratory work (Erol et al., 2007)	Bus
The Physics Van	Physics	To run exhibits and shows that is suitable for small groups of school students (Department of Physics of University of Illinois, 2014)	Van

4.0 Conclusion

As technology developed in all aspects of life, teaching and learning must be changed as well. Students shows interest in learning when they meet new environment of learning instead of classroom and laboratory. By using apparatus provided by the MSL, students and teachers can have teaching and learning using up dated apparatus that highly cost for the school to own them. The students gain conceptual understanding, retain science learning, interest in subject and experiment, and interest to choose career in STEM, while teachers can develop their pedagogical skills and confidence in laboratory teaching instruction.

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