**OCCUPATIONAL HYGIENE MONITORING USING PROJECT BASED LEARNING (PBL) APPROACH**

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**Abstract**

**Occupational safety and health (OSH) is an indispensable area across different careers. More and more employers and employees are concerning about their work safety and health and therefore requires high demand of labour entering the OSH industry. Relevant trainings on potential students would become important. The first critical criteria of establishing a safe and health work environment would be accomplished by workplace hygiene monitoring. By closely monitoring the workplace environment, this could reduce the risk of exposing employees to potential hazardous source. The continuous monitoring may include indoor air quality assessment, ergonomic assessment, physical and chemical risk assessment at the workplace. Students could acquire these practical skills through student initiative project-based learning (PBL). Many previous studies showed that practical learning, hands-on activities, and student activism help them to grasp the difficult technological knowledge and hence develop their intellectual processes. As different workplaces may have different scenarios, project-based learning provide an opportunity to let students to work on driving questions to simulate different work environment. Several workplace scenarios will be provided to students and they could work on the topics they are interested in. Then, fundamental workplace hygiene monitoring skills were introduced. Students are required to submit a proposal on the topics selected and they may have hand-on practice on using those monitoring equipment such as VOC and formaldehyde monitor, particle counter, heat stress monitor, sound level meter, etc. Students may discuss among themselves on sampling and measurement strategy, data processing and utilization. Learning progress of students is closely monitored through a series of activities including brainstorming, interview, industrial visit, etc. Instructors would then give the appropriate feedbacks based on student performances from each activity. The overall learning outcomes would be evaluated by final presentation and a poster session. Positive feedbacks from different stakeholders received using project based learning approach. The feedbacks obtained will be used to improve the learning and teaching quality in the next cycle.**

**Keywords:** *Occupational safety and health, workplace hygiene monitoring, project-based learning, safety promotion, student initiative*

**Introduction**

In 2022, the total number of occupational injuries in all workplaces in Hong Kong was reported as 32,026 and the number of deaths was as high as 266 (HKLD, 2022). To prevent occupational injuries and accidents from occurring, occupational safety and health (OSH) is an indispensable area across different industries. Therefore, workplace safety plays an important role in any industry since workers are desire and willing to work in a safe and sound environment. OSH is always a relevant issue among different sectors as workers are at greater risk of work-related health causes and workplace accidents (European Agency for Safety and Health at Work, Web). From World Health and Organization (WHO), OSH is a multidisciplinary activity with the aim to protect and promote the health of workers by taking precautions against occupational accidents and diseases; and to develop and promote healthy and safe work, work environment, and work organizations (International, 2013). Occupational hygiene involves the use of instrument for the measurement of work-related parameters such as noise, heat stress, air and vapor concentrations, etc. Continuous occupational hygiene monitoring therefore provides a scientific basis to improve the workplace safety. The continuous monitoring may include indoor air quality assessment, ergonomic assessment, physical and chemical risk assessment at various workplaces.

Since occupational hygiene monitoring requires scientific approach, in-depth student trainings and guidance such as sampling strategies, equipment instrumentation and data analysis are necessary. Project based learning (PBL) approach would be the most suitable way to provide an opportunity to let students to work on driving questions to simulate different work environment as different workplaces may have different scenarios. PBL is a learning approach during the entire learning process of students. Students could obtain knowledge through a project with a driving question proposed by the teacher. Students need to actively search information and resources by themselves to solve the problems. Recent studies have found that students can learn and improve scientific practices with guidance (van der Graaf et al., 2015). This approach allows students in asking scientific questions and conducting investigations such as collecting information from different sources, doing experiments, and making observations to solve the authentic problems and is therefore considered effective in encouraging students to develop and apply skills and knowledge (Krajcik & Czerniak, 2018). Due to the complexity in design, PBL usually takes the form of group projects (Montequín et al., 2012), which allows students to learn through communication and cooperation skills and a necessary soft skill to work successfully in the future.

The aims of this study are to (1) promote the occupational safety awareness via students’ trainings; (2) introduce a series of students’ trainings on occupational hygiene monitoring by project-based learning approach and (3) evaluate the effectiveness of integrating project-based learning into teaching and learning.

**Materials and Methods**

At the beginning of the course, students were given a PBL project brief comprising of the project title, driving question, project objective, project structure, roles and responsibilities, project path and milestones, assessment rubrics, professional ethics and safety precaution. Students were divided into groups of 4 to 5 and they worked on the same project theme ‘*Formulation and Implementation of Occupational Hygiene Assessment for a Workplace*’ and shared the same driving question ‘*How do we develop and implement a suitable and effective occupational hygiene assessment for a workplace in order to ensure the safety and health of all employees at work?*’. A two-hour lesson was constructed for students to discuss and brainstorm the topic with guidance given by teacher meanwhile. During the lesson, teacher requested students to propose some authentic workplace environment which requires in-depth hygiene monitoring. An interactive and student-led learning atmosphere were established during lesson.

Based on the feasible ideas obtained from the discussion session, students were required to complete a proposal. Several possible workplace scenarios with available monitoring instrument were given to students to choose from (Table 1). Students had to match the suitable instrument with workplace scenarios. The proposal required students to provide background information, sampling and measurement plan and brief working principle of selected instrument. At the same time, teacher had given a brief lesson on sampling strategies and theory and operation of instruments. For example, heat stress monitor and sound level meter quantify wet-bulb globe temperature (WBGT) and workplace noise level respectively. Anemometer measures the flowrate of hoods or ducts which reflect their efficiency. Formaldehyde meter and TVOC meter provide useful parameters for monitoring the indoor air quality (IAQ). These workplace scenarios and instrument were chosen because they could truly reflect the needs of hygiene monitoring for the industry in Hong Kong.

Table 1. Choices of workplace scenarios and available monitoring instrument.

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| **Possible Workplace Scenarios** | **Available Instruments** |
| 1. A chemical testing laboratory with several fume hoods in operation.  2. Indoor & outdoor areas where several steam generators in operation.  3. A factory where several heavy manufacturing machineries in operation.  4. An indoor space where painting work using latex paint and thinner in operation.  5. A manufacturing area where production of adhesives of furniture in operation | 1. Heat Stress Monitor 2. Anemometer 3. Formaldehyde Meter 4. Sound Level Meter 5. TVOC Meter |

Meanwhile, teacher arranged five practical sessions to familiarize students with the scenarios listed in Table 1 and allowed them to have a hand-on experience in operating the instrument. During the session, students worked in group to think of the measurement flow. The problem-solving skills resembles the steps of scientific research and involves a research approach (Sari et al., 2019; Tambunan, 2019). After each session, students needed to hand in a report summarizing the findings and data treatment. This simulated the workplace assessment report across the industry.

The performance of students was closely monitored by continuous assessment and end of semester assessment. Continuous assessment includes group progress assessment evaluated by the teacher on collaboration skills, responsibility skills and communication skills. End of semester assessment includes student demonstration on the operation of instrument and data treatment and analysis. Students will be assessed based on their technical skills such as instrumental preparation, sampling techniques and data analysis.

Finally, students were required to complete a feedback and reflective journal. A simple questionnaire was sent to industry partner for their feedbacks.

**Results and Discussion**

The learning effectiveness of PBL approach on occupational hygiene monitoring was evaluated by comparing student performance before and after adopting PBL. After using PBL approach, students showed significant improvement on final practical demonstration. Without using PBL approach, students reported difficulties in understanding the complicated concepts and instrumentation of the monitoring equipment, and therefore in the past the mean score in all assessments was not very high. After the adoption of PBL approach, a significant improvement of student’s mean score was observed. Through PBL, students could know the theory of different occupational hygiene monitoring techniques. For example, heat stress appears when heat gain is greater than heat loss, inducing a loss of homeostasis and an increase in body temperature (Most and Yates, 2021), finally may cause heat stroke for prolonged exposure. Prolonged exposure to high noise level may cause sensorineural loss, damaging the hair cells in cochlea. Students are especially required to measure the workplace noise levels for certain work process in the future such as grinding, pile driving, etc. In Hong Kong, it is mandatory by the Labour Department to carry out noise assessment at the construction sites. Therefore, students should learn to operate the sound level meter and the related theory behind. Besides, excessive exposure to formaldehyde and volatile organic compounds (VOCs) may cause irritation in lung airways and even carcinogenic (Pappas et al., 2000). Sources of exposing formaldehyde and VOCs include oil painting, releasing from furniture and carpet, etc. Indoor workplace air quality assessment can protect workers’ health. Occupational hygiene monitoring provides an alternative way to safeguard the health of workers and reduce the number of occupational injuries, thus promoting the public awareness of occupational safety.

For students' feedback, the majority satisfied with the process and outcomes of PBL, and the skills obtained are useful in their future career, however, some students reflected the difficulties in searching information, planning and writing of the proposal. All students agreed the adoption of PBL approach in occupational hygiene monitoring could effectively help to understand the concepts and instrumental operation theories. Improved performance on practical skill test confirmed the acquisition of the lifelong skills. For feedback from industry partner, they agreed that the PBL contents are very related to real world situation and industry linked. They also reported it was not difficult to understand what must be done in PBL project. Overall, industry partner was satisfied with the performance of the project aims and outcomes.

PBL is a learner-cantered approach which engages students in deeper learning by empowering them to learn more related content and various skills in authentic contexts. It was observed from this PBL that it emphasizes on putting students at the centre and highlighting students’ independent experience, teachers’ roles also shift from more dominating to more facilitating roles. Wang (2022) also pointed out that adopting PBL leads to benefits such as supporting students acquiring content knowledge as well as cultivating students’ cooperation and team spirit. From the classroom observation, teacher discovered that students were eager to raise questions regarding the technical skills. The learning atmosphere was also improved since students became a key role throughout the whole learning process. Besides, students were able to apply what they read and analyse the workplace scenarios in connection with what happened in the real world. Therefore, PBL can be used as an effective approach to develop students’ critical thinking development which is an essential soft skill in their future work.

**Conclusions**

It can be observed from this study that the original complicated theory of occupational hygiene monitoring could have a better understanding towards students using PBL approach. Students showed significant improvement in their assessment results. At the same time, both students and industry partner welcomed and showed positive feedbacks with the adoption of PBL approach in learning occupational hygiene monitoring. Since occupational hygiene monitoring is an indispensable aspect of OSH in Hong Kong, cultivating the motivation of students’ learning in this area can therefore promote the awareness of occupational safety among them. It is therefore suggested the adoption of PBL learning in other modules to facilitate the classroom learning atmosphere, especially for some difficult-to-understand concepts.

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