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DEVELOPMENT AND VALIDATION OF LABORATORY ACTIVITIES IN HIGH SCHOOL CHEMISTRY BASED ON SOCIETAL ISSUES

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ABSTRACT – Laboratory works are valuable means to bring into focus, to have students reflect on the meaning and application of chemistry concepts. Chemistry exists in the society and should contribute to the maintenance and aspirations of culture. The inclusion of science-based societal issues in chemistry laboratory activity is an important factor in the reform of science education. Chemistry laboratory experiences should allow students to analyze social problems and understand how science, particularly chemistry is relevant to their personal lives. This paper presents a study on laboratory activities that utilized the Input-Process-Output model of instrument development. The laboratory activities developed included science-based societal issues related to water quality and safety, waste management and conventional energy resources. The study utilized focus group discussion (FGD) to obtain relevant information on science-based societal issues in the community. From the identified science-based issues, three (3) laboratory activities were developed integrating the three (3) levels of science-technology-society (STS) activity introduced by Weisenmayer and Rubba (1999). The results of the study show that the laboratory activities incorporating science-based societal issues provides real life applications of lessons learned in chemistry classes. Students are made more aware and re-active of the different issues in their community that needs immediate attention. Qualitative evaluation of high school and college science teachers showed that the laboratory activities were valid in terms of content and structure.

Keywords: laboratory works, societal issues, science-technology-society approach

INTRODUCTION

The goal of teaching Chemistry indicates more emphasis on environment, word problems, decision making and societal issues. This goal is very important when there are social challenges directly related to Chemistry. Chemistry teachers are including this goal to make chemistry relevant to the concern of all students.

Salandanan (2008) identified significant observations about practices in science education as follows: “science education focuses too much on concepts and principles taught in an isolated manner from the actual developments in the society, science education has become over specialized and the lack of proper information on the ethics of science and the social responsibilities of science personnel.” Incorporating social issues in science activities will promote awareness and interest among students to help solve problems in the community.

Because science and society have impact to one another, it is believed that students should learn to utilize science for improving their own lives and in coping with the changes happening in nature. The teacher plays an important role in providing a real-world connection for the students between the

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laboratory works and the society. Chemistry education is now embracing a new approach in conducting laboratory experiments.Recent studies have used suspension cultures of *C. blumei* to identify important enzymes for rosmarinic acid biosynthesis. The cDNA encoding for some of these enzymes have been isolated and functionally expressed in *E. coli* (Petersen and Simmonds, 2003; Petersen et al., 2009).

Westrum (1991) said that science activities that includes real issues provide context for science learning. Acting on problems of the local environment that have relevance to students increases the chance for participation and action taking.

Wood (1995) stressed that laboratory activities are important for students to fully understand the theories and principle they study in lecture classes. Also, laboratory activities allows students to develop necessary science techniques and manipulative skills.

Laboratory activities are anchored on the constructivist approach of learning. The focus of constructivism is the continuous revision of past learning and "reconstruction" of concepts as the learners interacts with the environment. It says that people construct their own understanding of the world through experiencing things and reflecting on those experiences (Perkins, 1999). It has redefined the roles of both the teacher and the student in the classroom, placing the latter at the center of discussion. Constructivist learning supports re-designing of activities to make it more social and collaboration centered.

A social constructivist teacher creates a context for learning wherein students can become engaged in interesting activities that encourages and facilitates learning. The teacher guides the students as they approach problems and challenges that are rooted in real life situations.

Another theory supporting the inclusion of societal issues in laboratory works is the cognitive learning theory. The advocates of cognitive learning theory suggests that learners should be placed in a learning environment where they investigate and construct understanding in their own effort (Limon, 2001). Another salient assumption of the cognitive learning theory is that individuals are active participants of the learning process.

This study aims to develop and validate a cognitive tool in the form of laboratory activities in Chemistry that are rooted on societal issues. Specifically, this intends to: 1) identify social issues that are science-based and directly affects students, 2) develop laboratory activities appropriate for the lecture course outline for high school students, 3) incorporate the social issues in the laboratory activities, and 4) evaluate/validate the laboratory activities in terms of content, structure and readability.

The succeeding sections will include: Materials and Methods, Results and Discussions, and Conclusion and Recommendations.

METHODOLOGY

The study utilized the Input-Process-Output method of instrument development. The Preparation stage involved a focus group discussion (FGD) participated in by science and non-science high school teachers. Social issues relevant to the community and to the students were identified through the FGD. The Chemistry instructor anchored the identified social issues with the high school science course content.

The Development stage included the writing and drafting of the laboratory activities. The three (3) levels of STS activities introduced by Weisenmeyer and Rubba (1999) were followed. The three levels are: 1) Presentation of the issue, 2) Exploration of the issue and 3) Action development.

The Evaluation stage involved evaluation and validation of the activities by high school science teachers in terms of content, structure and readability and try-out to intended users. A validated questionnaire with a five point Likert type scale was used for evaluating the activities. For the standard interpretation of data, the following range was used:

Mean Range	Verbal Interpretation
4.21-5.00	Outstanding
3.41-4.20	Very Satisfactory
2.61-3.40	Satisfactory
1.81-2.60	Poor
1.00-1.80	Needs Improvement

Fry's and Microsoft readability index was used to evaluate the laboratory activities in terms of readability.Data gathered for the trichome length and density were analyzed using the one way analysis of variance (ANOVA) at 5% degrees of freedom.

RESULTS AND DISCUSSION

The FGD lead to the identification of relevant issues in the society. The issues identified were water safety, pollution, waste management, energy consumption, climate change and oil price. The number of societal issues to be incorporated in the laboratory activities were trimmed down to three based its appropriateness in the course outline of the high school Chemistry subject.

The format of the laboratory activity included the following: title, duration of the activity, deadline of submission of outputs, appropriate picture/photos depicting the setting of the issue, the three levels of an STS activity. The Presentation of the Issue (Level 1) presented the problem the students should be working on. It included data from a current research or news article from the local newspaper. Exploration of the Issue (Level 2) allowed students to gather pertinent information about the issue at hand. On this level, students are expected to work independently. Key concepts were given to serve as guide of students in doing research work. The key concepts also delineated the focus of the activity. American-based National Research Council (2005) held that instructions should be designed prioritizing observations and gathering evidence as integral towards students developing deep understanding of the content. Likewise, it also promotes deeper understanding of the nature and attitudes of science, as well as skills in scientific reasoning. The Action Development (Level 3) laid down the expected outputs of the students for the activity. It is expected that students will give original works in this level. This allowed students to exercise independent learning, self-expression and provided a venue for showing genuine concern for the community. They also practiced collaboration and community immersion. The expected output of students also promoted interdisciplinary approach to teaching.

Several studies have reported that a more informal atmosphere and more opportunities for more interaction among students, their teacher and peers can bring about improved social interactions and a healthy learning environment that spouses meaningful inquiry and collaborative learning (De Carlo & Rubba, 1994; Tobin, 1990). The three developed laboratory activities were about water quality and safety, conventional energy resources and school waste management (Activity 1, 2 and 3).

Activity 1 talked about the presence of high levels of 17-beta estradiol, a pollutant which is hindering male carps from developing fairly in the lake. This complex scenario was a great material that enabled students to consider a problem with solutions that must employ a multidisciplinary approach. It also directed the students to look at socio-economic impacts this problem.

The United Nations deems water to be at the core of sustainable development as well as key for socio-economic development, healthy ecosystems and vital to human survival (UN Water, 2014). Hence, including a laboratory activity implying water's significance was instrumental in soliciting valuable insights that can drive the youth to act in their local communities.

Likewise, involving Activity 2 on renewable energy and Activity 3 on waste management probed into this line of thinking. Particularly, action development for the third activity suggested that something must be done locally. Further, Kusmawan et al. (2006) found that participation in environmental actions directly involving the community provides the necessary context for the students to more positively interact with their environment.

The first evaluation of the developed laboratory activities by high school science teachers and students yielded comments for improving the format of the activity and the inclusion of more application and relation to Chemistry.

The three laboratory activities were then revised based on the evaluation and comments of the high school science teachers and students. The ratings for second and final evaluation and validation of students were shown in Table 1.

Table 1. Experts' and Students' Evaluation of the Content of the Laboratory Activities.

Criteria	Experts Evaluation	Students Evaluation
Laboratory activities: 1. show real world application of Chemistry concepts.	Outstanding (4.8)	Very Satisfactory (4.1)
2. have illustrations that help students visualize the problem.	Outstanding (4.6)	Very Satisfactory (4.1)
3. have instructions that are clear.	Outstanding (4.6)	Very Satisfactory (3.9)
4. have a friendly tone.	Outstanding (4.6)	Very Satisfactory (4.0)
5. have words that are within the level of comprehension of students.	Very Satisfactory (4.00)	Outstanding (4.3)

Results in Table 1 suggested a higher mean rating from teacher experts (Mean=4.6) than students (Mean=3.8). The designed laboratory activities were perceived to be socially-relevant, and promoting environmental and social awareness. Despite having a relatively acceptable score in terms of developing interest in Chemistry, it is worth exploring to include activities that may address personal relevance of topics.

These results could have possibly reflected a subtle, though worth noting mismatch between teachers' and students' perception of relevance of topics subject matter being taught (Kidman, 2009). The activities were also seen appropriate to the reading level of high school students. The reliability of the answers of the respondents were established using Cronbach alpha. According to experts, the materials were perceived to have shown real world applications of Chemistry, with fairly acceptable evaluations of structure (Mean=4.5). Students on the other hand have comparatively lower scores (Mean=4.0). This suggested for some revisions on the words used to be able to match comprehensibility of the material with students. Table 2 presents the comparative evaluation of the structure of the laboratory activities by students and teachers.

Table 2. Experts' and Students' Evaluation of the Structure of the Laboratory Activities

Criteria	Experts Evaluation	Students Evaluation
Laboratory activities: 1. have science-based societal issues.	Outstanding (5.0)	Outstanding (4.3)
2. advance the development of environmental and social awareness.	Outstanding (5.0)	Outstanding (4.3)
3. arouse curiosity and enthusiasm.	Outstanding (4.8)	Very Satisfactory (3.7)
4. develop interest towards Chemistry.	Very Satisfactory (4.0)	Very Satisfactory (3.4)
5. enable students to apply Chemistry concepts to real life situations.	Outstanding (4.4)	Very Satisfactory (3.7)
6. integrates concepts and information from other subjects.	Outstanding (4.6)	Very Satisfactory (3.6)
7. are self contained with sufficient information to understand each task.	Outstanding (4.4)	Very Satisfactory (3.7)

Table 2 showed that both teacher and student respondents gave positive feedback on the structure of the laboratory activities with mean responses across different aspects of the laboratory activity structures ranging from Very Satisfactory(`3) to Outstanding (`4-5). This means respondents perceived the activities to be socially-relevant.; promote awareness of environmental and societal issues; arouses students' curiosity; develops interest towards Chemistry; increases applicability of chemistry concepts; build multi-disciplinal understanding, and with readily comprehensible instructions for tasks.

SUMMARY AND CONCLUSION

This study is a serious attempt to humanize science. Academicians use different approaches to increase students' interest in science. Laboratory activities served as vehicles for integration (Bybee, et.al. 2008). A well-planned laboratory activity convey science concept and carries message that has societal importance. Science education must always be linked with real-life issues and applications to keep in line with the demands of the society.

The inclusion of social issues in laboratory activities showed interrelationship between things and events. It also developed among students a sense of social responsibility. Even at a young age, high school students were made to act locally on problems that have relevance to them.

RECOMMENDATION

This research work is an initial attempt to deviate from the usual cook book laboratory activity by using social issues as the ground for laboratory works. It is necessary to develop a rubric for evaluating the output of the students in the Action Development level. Curriculum developers should integrate this approach to the science school laboratory program. That way, the well-thought of policies and projects of students will be given proper venue for possible implementation. Their actions, and suggestions should be given high value and should not be treated as a mere requirement in class.

STATEMENT OF AUTHORSHIP

The first author (Aprhodite M. Macale) conceptualized the research problem, did literature search, lead the FGD, developed the laboratory activities, gathered data for the evaluation and validation of the laboratory activities and undertook the initial write-up. The second author (Abriel S. Bulasag) provided valuable inputs during the evaluation of the laboratory activities. Much of his contribution came in analyzing the data and in writing the final paper. This work is original and no other person's work has been used without due acknowledgement.

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