Experienced difficulties of BSE-Chemistry students in physical chemistry and suggested enhancement

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Abstract. This study aimed to determine the experienced difficulties in Chemistry 70 (Introduction to Physical Chemistry) among ten (10) selected BSE-Chemistry students who had undergone Chemistry 70 and two professors of Physical Chemistry. Qualitative research design with purposive sampling was used in this study. It was found that out of the total 10 BSE-Chemistry respondents, majority got a passing grade of 1.50 to 3.00 in Chemistry 70, representing their academic performance for this particular study. They considered “Chemical Thermodynamics and Equilibrium” as “much difficult” and classified “teacher factor” as the primary reason for the difficulty in understanding the subject. Teachers play a great role in the learning of the students in Physical Chemistry. They must be equipped effectively with the concepts needed for the efficient delivery of lessons in the classroom. Moreover, teachers must be able to relate both theories and concepts to real-life situations for the students to have a better understanding of the subject matter. It was suggested that students should be able to master the basic skills and concepts in Math 61 to improve their mathematical skills which are very much needed in the study of Physical Chemistry.

1. Introduction
The wide expanse of the universe poses great challenge for humanity. A human being strives to exist with the environment, thus, every individual needs to find ways to survive and co-exist with the environment.

In order to endure life, each one has to learn more, hence the need to pursue education, that is, to acquire knowledge, skills, values, beliefs, and habits. Education takes place with the guidance of educators, but learners may educate themselves not only in the four corners of the classroom but also from the environment where they live.

Each learner may be able to perceive things and evaluate them as good or bad as he or she enters school seeking to acquire knowledge to continually grow and prosper. It is the teacher in school who facilitates the learning process using different techniques and strategies to ensure holistic development of the learner [1].

In the Philippines, the curricular offerings demand so much effort from each learner if he or she really needs to succeed in the academe. One of the curricular offerings of the Mindanao State University – Iligan Institute of Technology in Iligan City is the Bachelor of Secondary Education
Major in Chemistry or BSE-Chemistry offered by the Department of Science and Mathematics Education (DSME) which admits enrollees with SASE score of not less than ninety (90).

This four (4) year education program is among the difficult courses not only in College of Education (CED) but in the whole institute due to the fact that Chemistry is a highly specialized subject and loaded with other courses from other fields of natural sciences like Physics and Mathematics. Hence, a number of BSE-Chemistry students shift to other programs after finding so much difficulty in the program. This made BSE-Chemistry fall short in number in terms of producing graduates every year.

In this degree course, one of the most challenging subjects is Physical Chemistry which students generally consider as a difficult course because it deals with specific mathematical calculations together with concepts which is needed to be fully understood, otherwise they would not learn anything at all. Thus, the subject was deleted from the curriculum in the past years, but later restored in 2010 because of the recommendation coming from the Commission on Higher Education (CHED) – a development regarded as a return to the old curriculum. Subsequently, because many students found Physical Chemistry difficult, many would flunk and/or retake the subject several times causing them to be delayed in graduating.

Notwithstanding the complaints of students, Physical Chemistry remains an essential course, specifically for those who want to pursue their master’s degree and to those who wish to be future Chemistry teachers.

As a branch of Chemistry, Physical Chemistry demands not only knowledge of theories but more importantly, on having practical skills especially in solving problems in Mathematics. Many students find the subject challenging because it does not only require the ability to identify given facts but also necessitates comprehension and analysis of the problems solution.

However, this requires a thorough background and strong foundation of basic chemistry and mathematics courses to support a more intellectual and broader scope and more advanced study of physical chemistry. It was on this premise that this research undertaking was conceptualized and developed to determine the difficulties of BSE-Chemistry students in the subject Physical Chemistry. In the learning process, it is important to determine the students’ difficulties and learning styles for the teachers to help them look for specific strategies to handle such challenges, to decrease the number of failing grades in this particular subject, and increase the number of BSE-Chemistry graduates in the Department of Science and Mathematics Education, College of Education, Mindanao State University – Iligan Institute of Technology, Iligan City.

2. Statement of the problem
This study aimed to determine the experienced difficulties in Chemistry 70: Introduction to Physical Chemistry of the BSE-Chemistry students during the school years 2014-16. Specifically, it sought to answer the following questions:

1. What is the academic performance of the BSE-Chemistry students in Chemistry 70: Introduction to Physical Chemistry?
2. What topics in Chemistry 70 are experienced as great difficulties by the BSE-Chemistry students?
3. Is there a sufficient evidence to conclude that the students find difficulties in the covered topics in Chemistry 70?
4. What are the possible reasons or causes for such difficulties?
5. Is there a significant relationship between the possible reasons or causes and their academic performance in Chemistry 70: Introduction to Physical Chemistry, course?
6. What are the suggested enhancements to address such difficulties in Chemistry 70?
3. Research Methodology

This chapter presents in details the methods and procedures of this study. It includes subjects of the study, research design, instruments of the study, and data gathering procedure.

3.1. Subjects of the study

The subjects of the study were ten (10) BSE-Chemistry students of the Mindanao State University – Iligan Institute of Technology who were officially enrolled in Chemistry 70 ‘Introduction to Physical Chemistry’ during the 1st semester, school year 2014-2015. All 10 respondents were females; 5 of them took the subject during the 1st semester, SY 2014-2015 while the rest took the subject during the 1st semester of school year 2015-2016. Some of the respondents were BSE-Chemistry graduates while others were still taking up their remaining minor courses.

3.2. Research design

The researchers used the Qualitative Survey (in-depth interview) and Purposive-Sampling method of research. The data were obtained through a One-on-One in-depth interview with ten (10) students who had undergone Chemistry 70.

A Physical Chemistry teacher was needed in the study to provide feedback on experienced difficulties of the students and the possible causes or reasons that made Physical Chemistry difficult from their own perspective. Through the said interviews and the gathered experienced difficulties of both students and teachers when they took up and taught Physical Chemistry, revealed the deepest reasons of difficulties.

3.3. Instruments of the study

The instrument utilized in the conduct of the study was the questionnaire that had been face validated by expert educators. The instrument was divided into three (3) parts: 1) Part A was the ranking of the topics according to their level of difficulty; 2) Part B solicited their reasons or causes for considering the subject in Chemistry 70 as difficult; and 3) Part C, an in-depth questionnaire was used during one-on-one interview with respondents.

In Part A, respondents were asked about their experienced difficulties in Introduction to Physical Chemistry with the use of the face validated questionnaire. The respondents were going to rank the topics according to their level of difficulty: 1 as the ‘least difficulty’, 2 ‘less difficulty’, 3 ‘average difficulty’, 4 ‘much difficulty’, and 5 as ‘extreme difficulty’. In Part B, respondents had to put a check mark on the four (4) classifications (Student factors, Teacher factors, and Personal factors and Resources factors) of possible reasons or causes that the respondents experienced when they took Physical Chemistry. Part C was made up of open ended questions which the respondents had to answer accordingly and honestly.

Content validity of the questionnaire had been established by acquiring the Chemistry 70 topic outline from the College of Science and Mathematics (CSM), Chemistry Department for the formulation of the questions and by submitting the original form of the questionnaire to the adviser for comments and suggestions. The questionnaire was composed of questions regarding the experiences encountered at the five (5) chapters: 1) The Ideal and Real Gases, The First Law of Thermodynamics; 2) The Second and Third Laws of Thermodynamics; 3) The Chemical Thermodynamics; 4) Equilibrium; and 5) Phase Equilibrium.

3.4. Data gathering procedure

As soon as the questionnaire had been face-validated by the chemistry experts and Physical Chemistry educator, respondents were requested to answer the formulated questionnaire and checklist. For those respondents who were not in the vicinity of Iligan City, they were contacted via cell phone, Facebook chat or video call, asking them regarding their difficulties on the five (5) chapters in Chemistry 70 by ranking the topics based on the levels of difficulty from the least to extreme difficulty.

In Part B, the respondents were to put a check mark on the reasons or causes for difficulties they have personally encountered in Introduction to Physical Chemistry. There were 4 classifications of
possible reasons or causes that the respondents experienced while taking Physical Chemistry: 1) student factors; 2) teacher factors; 3) personal factors; and 4) resource factors.

Student factor is about how the student performed and behaved themselves during the subject. Criteria that comprised student factors were the readiness and preparedness of the student on the basic concepts, their understanding of the lesson during class discussion, how they cooperated and participated in class discussion, how they aimed at getting good grades and how they reacted if the class was cancelled/interrupted or the teacher was not present.

Teacher factor is how instructors present the lesson to their students effectively and keep the positive relationship between them. Under this factor were: relationship established by teacher with his/her students, how firm the teacher was in making decisions, the openness of the teacher to suggestions and opinions raised by the students, the usefulness of the various tools, strategies and techniques used in presenting the lesson, and how the subject matter was systematically presented.

Personal factor describes students’ issues regarding the relationship within their families, financially stability, as well as the spiritual, physical and emotional aspects in their personal lives. Criteria that belonged to personal factors were how the parents were concerned with their studies, an established relationship with their classmates, handling time management, taking other responsibilities to support their study, and being bothered from the other things aside from studying.

Lastly, resources factor mentioned the learning materials that the student needed for the subject as guide or source of information. Resources factors involved: books being sufficient to cater the needs for learning, giving handouts to the learner, using PowerPoint presentations as they presented the lesson, incorporating technology as one of their resources in solving problem sets and establishing peer tutoring with their classmates in comprehending the concepts and even in doing calculations.

In part C, the students underwent an in-depth interview and were asked various questions regarding their experiences when they took Physical Chemistry. The researchers also asked them on how they handle the difficulties they experienced in those times. After knowing the difficulties that students experienced, the researchers proceeded to interview the Physical Chemistry educators to know also their insights on teaching Chemistry 70. The researchers asked the educators regarding the students’ performance and what were their responses to the difficulties experienced by their students. In-depth interviews between the students and Physical Chemistry educators were conducted to find the difficulties experienced by each individual, as a student or teacher in Chemistry 70, and how Physical Chemistry educators could help their students to overcome such difficulty.

After the interview with the students through Facebook and via call, the researchers gathered all the data they obtained from the interview. The data were assessed and evaluated through interviewing the educators. The interview conducted on the teachers included their experienced difficulties in handling the students and the course in general. It was followed by the gathering of answers from the respondents and teachers, compared and listed the congruent responses or significant findings using the triangulation method to successfully assess the responses by both the student-respondents and the Physical Chemistry educators, also known as “mix method” (also known as triangulation) research. The purpose of the triangulation was to give more detailed information in facilitating deeper understanding of the situations between the teachers and students. After analysis, formulation of learning enhancement on Physical Chemistry was done.

The answers given by both student-respondents and Physical Chemistry teachers were recorded including the conversation at Facebook or voice recorder and were then evaluated.

4. Results and discussion

From the grades being collected, it shows that the respondents’ academic performance wherein four (4) or 40% of the respondents were very good performers based on their grades in Chemistry 70; one (1) or 10% was a good performer; three (3) or 30% performed satisfactorily; while two (2) or 20% got a passing grade of 3.00. It could be implied that none of these respondents excelled in Chemistry 70. The students’ anticipation of physical chemistry as a difficult course can greatly affect their academic
performance as well as how the students perceive and deal with the topics; resulted to lower students’ success rate of getting an excellent performance [2].

Using the triangulation method with a survey questionnaire, interview conducted to both student-respondents and Physical Chemistry teachers showed that the topic “Chemical Thermodynamics and Equilibrium” (rank 1) and “Phase Equilibrium” (rank 2) were considered as the most difficult topic in Chemistry 70 since it dealt with theories and laws which were abstract in nature. Dealing with problem solving made the respondents felt uneasy – the very reason why they were not able to grasp the topic well. This may also root from their lack of mathematical skills and basic chemistry concepts.

This contention was supported [3] that many of both high school and university students experienced difficulty in chemistry, specifically on thermodynamic concepts since they never mastered the fundamental concepts in Chemistry [4].

A similar observation was cited [5], this time with Mathematics. The structured course identified certain issues which limit the students to develop their mathematical abilities, thus, sufficient support from the instructor must be available. However, the student themselves still had to do extra effort to master the subject in preparation for higher lessons [6].

On the other hand, cited the following as possible sources of learning difficulties in Chemical Thermodynamics and Equilibrium [7]: 1) lack of knowledge on the fundamental thermodynamic concepts and application of algorithms due to lack of conceptual understanding; 2) memorization of scientific laws and statements without deep understanding thus resulting to inappropriate over-generalization; and 3) confusion of fundamental ideas and socioeconomic and methodological aspects of the teaching-learning environment.

The checklist revealed that teacher and student factors greatly affected students’ performance on the said subject specifically on the relationship between the teacher and students, the teacher’s portrayal of their role during classroom discussion, the strategies used in line with the topic outline, the openness of the teacher to suggestions and opinions raised by the students, and how firm the teacher was in making decisions. Even themselves, the students have great effect in their performance specifically on how they performed and behaved during the discussion of the lesson, their preparedness on basic concepts, their understanding on the lesson, how they reacted if they have a class interruption, aiming for getting good and high grades, and lastly, on how they cooperate and participate to their discussion.

Based on the triangulation process, it was found out that the teachers are competent when it comes to teaching Physical Chemistry concepts. However, some of the educators were trying to adjust their teaching strategies employed based on the capabilities of their students.

Both chemistry lecturers and learners had experienced difficulties in the subject Physical Chemistry as evidenced by the results of the survey where the lecturers’ perceptions on the students’ learning difficulties were quite different from that of the students [8]. Students were worried about the course content, availability of the resources, the lecturers and the way their teachers taught Physical Chemistry. Meanwhile, the lecturers generally focused on the course related factors such as overcrowded classes, lack of staff and resources as well as the academic background of the students and socioeconomic conditions.

Row mean was the calculated mean between the academic performance (grade) and the four (4) classifications of possible reasons and causes (factors) which made Physical Chemistry a difficult subject. According to the results, the computed $f_1$ (academic performance) of 2.857 indicates that the students’ academic performance did not significantly affect the factors which caused them difficulties in Chemistry 70. Column mean was the calculated mean between four (4) classifications of possible reason and causes (factors) and the academic performance (grade) of the students. The computed $f_2$ of
the column mean (factors) was 9.566 which would indicate that the factors causing difficulties did significantly affect the students’ academic performance on the subject. Interaction mean was the calculated mean of the academic performance and the factors having the computed $f_3$ resulted to 4.950 showing that there was a significant relationship between the factors which caused difficulties and the students’ academic performance on Introduction to Physical Chemistry.

On the other hand, Chemical Thermodynamics and Equilibrium were considered the most difficult topics among the 5 topics in Physical Chemistry as experienced by the respondents. Results could be parallel to the findings [9] that the advanced concepts of “Thermodynamics and Kinetics” was perceived by many students as the most difficult topics in Physical Chemistry. Thermodynamics discusses bulk properties in exploring the behaviour of individual atoms and molecules in the use of spectroscopy, rate and mechanisms of chemical change analysis [10], with the following main divisions: 1) equilibrium, 2) structure, and 3) change.

Chemical Thermodynamics and Equilibrium have several concepts that need internalization by both learners and mentors especially that problem solving in these fields greatly need mathematical skills. As these concepts are not only significant in the academe but also in our daily lives, it is of importance that learners must be exposed to practical or hands-on experiences for better understanding of the lessons. The most important subsets of variables were found to be Chemistry and Mathematics [11]. This contention had been supported [5] stated that, “[an] important skill that is needed to master is mathematics; it is required and recommended by the chemistry department in studying higher mathematics, but the relevance of Mathematics was not explained to the students.” This may be one of the reasons why many students fall short in their academic performance in the subject as the practical significance of the topics isn’t clear to them.

Table 1. Suggested Enhancement to the Experienced Difficulties in Chemistry 70 Topics

| Difficulties in Chemistry 70 | Possible reasons or causes for such difficulties | Suggested Enhancement |
|-------------------------------|-----------------------------------------------|-----------------------|
| 1. Some parts of the Virial Coefficient and Van der Waals’ Equation | The problem sets in Virial Coefficient & Van der Waals’ Equation needed a thorough analysis to distinguish whether the given problem is an ideal gas or real gases. Unclear classification between ideal and real gases. Most of the problem sets dealt on quadratic equation. | Review in Chem 15 is needed in recalling the basic concepts of Gas Laws. Constant practice and solving problems is needed to master quadratic equations. Looking for more resources in the internet and scanning previous notes in Math 2 is highly recommended. |
| 2. Phase Diagram | The dependence of stability on the conditions of the pure substance was too broad and was not taught into simpler concepts. | Go to the library or look for other reliable references in the internet and read more about on the aspects of phase transitions of the pure substances. |
| 3. First Law of Thermodynamics | There were too many problem sets involved that dealt with derivation. Faster pace in dealing with problem sets may cause confusion to the students. | Analyzing and solving problem sets are needed to recall or master the specific mathematical skill in deriving equations. Reviewing Math 51 is highly recommended especially on Derivatives. |
| 4. Chemical Equilibrium and Kinetics | Problem sets were difficult to understand and there were many problem sets that involved integration and derivation. | Constant practice and solving related problem sets is needed to master the derivation or integration part of the problem. A review on Chem 16 is needed in recalling the basic concepts of Chemical Equilibrium and Kinetics. Review on Math 61 is highly recommended also especially the techniques on how to derive and integrate equations. |
5. Engines and Thermodynamics

The applications on thermodynamics in machinery were not explained well by the teacher. The techniques in solving fundamental equations were not introduced properly.

Watching some video clips in the internet related to machinery and Read more About thermodynamics to understand the lesson well. Constant practice in solving and deriving fundamental equations is highly recommended. Techniques in solving math related problems can be found in the previous Math 61 topics.

6. Chemistry 70 (as a subject)

Concepts were difficult to understand, many problem sets and equations involved, and the teaching method was not being utilized well by the Chemistry 70 teacher.

Look for more resources in the library or internet. Mastery on mathematical skills is essential in answering problem sets. Solve problem sets regularly to practice the techniques needed in the problem Peer tutoring to help each other in understanding the concepts and in solving problem sets. Incorporate technology in teaching by utilizing multimedia facilities/resources.

Table 1 shows the suggested enhancement to the difficulties encountered by the students in Chemistry 70 topics. Enhancement was based on the possible reasons or causes that were encountered by the students and how they will respond in dealing with such difficulties. Here are some recommendations also [12] when seeking to support chemistry students with strong foundations in mathematics: 1) the importance of mathematics to any chemistry subject should not be hidden; 2) tutorials and peer-assisted learning sessions; 3) there should be continuum in developing their mathematical skills through all aspects of their major; 4) Universities should consider the appropriate time frame to introduce mathematical concepts; 5) key mathematical ideas, concepts and results must not be hidden from the students rather, presented in an easy manner for them to understand the lessons easily.

5. Conclusions

Majority of respondents got only a passing grade that served as evidence of their academic performance in the subject Chemistry 70 “Physical Chemistry”, with grades ranging from 1.50 to 3.00. Students had difficulty in the dealing with the subject matter: Introduction of Physical Chemistry especially on the topic: Chemical Thermodynamics and Equilibrium, which they considered most difficult. Regarding classifications of possible reasons for causes of difficulties, the following ranked classifications were discovered: 1) teacher factors; 2) student factors; 3) personal factors; and 4) resource factors.

6. Recommendations

1. Teachers must help students in the improvement of the latter’s academic performance in Chemistry 70: Introduction of Physical Chemistry by not depending on only one book but also look on other references;
2. The Physical Chemistry teacher/s must not focus on only one method of teaching but find other ways to present the lesson more effectively by utilizing multimedia facilities/resources;
3. Advise to shift will be given or provide enhancement if the student gets a failing grade in Math 2 and Chemistry 15, as these are the most basic subjects of this course;
4. Chemistry 70 should be taught not only as requirement for passing the subject but also to appreciate its very vitality to actual life situations;
5. There should be a continuum in developing students’ mathematical skills in all aspects (laboratory and lecture sessions) as strong support to understand Chemistry subjects. With this, the teachers need to clarify the significance of the mathematical techniques in imparting lessons directly related to Chemistry;
6. Teachers in mathematics should introduce the essence of having such calculations in the students’ respective courses especially for the BSE-Chemistry students for them to be able to integrate it in their careers as future educators; and lastly,

7. It is recommended that more studies be done in the future with more sets of BSE-Chemistry students in Physical Chemistry as respondents so as to support and enhance further the results of this study.

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