INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN PROGRESSIVE EDUCATION & DEVELOPMENT

OPEN ACCESS JOURNAL

Vol 12, Issue 3, (2023) E-ISSN: 2226-6348

Needs Analysis: Developing an Innovative Instructional Module to Teach Osmosis and Diffusion Concepts

Nor Tutiaini Ab. Wahid[1], Othman Talib[2], Ibrahim AbdulRahaman I Alkhaldi[3]

[1]Faculty of Education, Universiti Teknologi MARA, Malaysia, [2]Faculty of Educational Studies, Universiti Putra Malaysia, Malaysia, [3]Ministry of Education Saudi Arabia, Saudi Arabia

To Link this Article: http://dx.doi.org/10.6007/IJARPED/v12-i3/19217 DOI:10.6007/IJARPED/v12-i3/19217

Published Online: 19 October, 2023

Abstract

In education, learning and teaching activities play a vital role in presenting permanent and meaningful learning to Science students, including those studying Biology. The perception of Biology as a challenging subject stems from students' difficulty visualizing molecular processes and their lack of skills in solving higher-order thinking problems. Bridging this gap in Biology instruction becomes imperative to enhance students' understanding. Thus, the objective of this study is to perform a needs analysis in order to assess the necessity for developing an innovative instructional module to teach osmosis and diffusion concepts for the Form Four Biology curriculum. This study applied the Design and Development Research (DDR), using the ADDIE model (Analyze, Design, Develop, Implement and Evaluate). A research question was formulated for this study; how crucial is the development of an innovative teaching and learning module in teaching osmosis and diffusion concepts, in the view of experts? To seek the answer, semi-structured interviews were conducted involving three field experts. The data acquired from the interviews were analyzed using thematic analysis, facilitated by the use of Atlas.ti software. The key findings revealed four major themes that emerged from the needs analysis: (1) The importance of learning osmosis and diffusion, (2) Problems in Biology teaching and learning, (3) Teaching strategies, and (4) Desired improvements. Based on these themes, it appears that an alternative teaching module is needed to simplify the process of teaching and learning the concepts of osmosis and diffusion for both students and teachers. This study's implication can be observed in terms of practice in the school context, where it provides an alternative tool for teaching and learning Biology.

Keywords: ADDIE, Biology Curriculum, Design and Development Research, Innovation in Science Education, Teaching and Learning Module

Introduction

Biology is considered a tough subject due to its many dynamic and abstract processes, and it is often misunderstood by students as a subject that requires a lot of memorizing facts (Yarden & Yarden, 2010). Students struggle to understand the concepts and various biological

events that are unfamiliar and cannot be seen with the naked eye (Çimer, 2012). Furthermore, it has been acknowledged that static illustrations are inadequate to explain the dynamic and abstract concepts in Biology, which leads to misconceptions among students (Artun & Coştu, 2013). Research has found that students' misconceptions are due to their diverse experiences, and that their ideas and explanations of the natural world are frequently different from those presented by scientists (Tekkaya, 2003). It has been reported that misconceptions are hard to break, especially through traditional teaching methods (Fisher, 1985; Rothman, 2014). When abstracts processes are presented to students in a difficult-to-understand manner, they tend to ignore the new concepts and choose to stick to their pre-existing beliefs based on their own experiences. During examinations, students who are unable to grasp accurate concepts will struggle to answer higher order thinking skills (HOTS) questions correctly, affecting their performance in Biology.

The use of varied teaching approaches in the classroom, for example, inquiry-based learning (IBL) and problem-based learning (PBL), shows that teaching strategies are evolving to adapt to changes in the learning ecosystem. From that point, there has been a strong push for educators to embed HOTS into their classroom instruction through the use of inquiry-based learning (IBL) to promote HOTS. These approaches have been claimed to have not encouraged HOTS among students. A study in the United States by Beal and Cohen (2012) found that the instructional practices commonly used in the classrooms still provide students with questions prepared by the teacher or taken from the textbook instead of solving real-world problems based on their daily life occurrences. The situation in Malaysian classrooms, as described by Dewitt, Alias, and Siraj (2016), shares similarities with the aforementioned issue. It appears that the current practices have not successfully addressed the lacking of HOTS among Biology students.

Thus, there is an urging need to blend in problem-solving with another instructional strategy to enable students to think across lower to higher cognitive levels. It is rather timely to rebrand the instructional strategies and teaching aids in innovative ways to teach Science subjects, specifically Biology, to address new challenges in education. The main objective of this study is to perform a needs analysis in order to assess the necessity for developing an innovative instructional module to teach osmosis and diffusion concepts for the Form Four Biology curriculum. To achieve the stated objective, a research question must be answered; how crucial is the development of an innovative teaching and learning module in teaching osmosis and diffusion concepts, in the view of experts?

Biology Curriculum

The goal of the Upper Secondary Biology curriculum aims to provide students with knowledge, science and technology skills. The skills would help them to see life with a scientific attitude and moral values, enabling them to solve problems by making the right decisions in life (MOE, 2012). Science subjects such as Biology majorly focus on inquiry method and problem-solving. Therefore, scientific skills and thinking skills are the two skills needed in inquiry and problem- solving (Udovic, Morris, Dickman, Postlethwait, & Wetherwax, 2002).

To begin with, scientific skills are essential for finding solutions or answers, and making sound decisions (Armbruster, Patel, Johnson, & Weiss, 2009). Scientific skills are grouped into two types, which are science process skills and manipulative skills. On the other hand, thinking skills are mental processes that encourage critical, creative, and systematic thinking, and they

are closely correlated with scientific skills (Curriculum Development Division, MOE, 2012). For example, when observing a laboratory activity, students are expected to utilize specific thinking skills such as characterizing, comparing, contrasting, and correlating what they have seen with the ideas and information that they have obtained.

Biology subject is often characterized as hard to understand, relate to, and apply in other situations. With regards to the abstract and dynamic nature of human biological processes, innovative tools to deliver the Biology content and explain the processes should be explored widely. The advantages of using multimedia to promote understanding and increase overall learning experiences are deemed to be ultra-practical as evidenced in many studies (Harrison, 2013; Reeves, 2000; Yarden & Yarden, 2010). A multimedia presentation combines different forms of content, such as texts, audios, images, animations, and videos, and it is usually presented to the audience using computer applications. A properly designed multimedia presentation will have a significant effect on Science teaching and learning due to its feature that can help in explaining intangible processes (Aksoy, 2012; Hong et al., 2015; Mayer, 1999, 2010).

Why Osmosis and Diffusion?

The study of life and living organisms is Biology. Biology acknowledges the cell as the basic unit of life, and all living organisms are made up of cells. A cell is a vital structure in the body that functions like a small factory, producing important materials for the survival of living organisms. Before all of those important materials can be produced, a cell must first collect raw materials such as food, oxygen, and water. On the other hand, all waste products generated by chemical reactions in the cell need to be transported out of the cell and excreted from the body. It is not an easy task because each cell has a protective barrier known as the plasma membrane that only allows certain substances into the cell. Therefore, there is a need for special transport mechanisms for these materials to enter and exit the cell, and such mechanisms are known as osmosis and diffusion processes.

Scholars argue that students will need to use their imaginations to visualize membrane movements at the cellular and molecular levels for these two topics (Bonney, 2015; Oliver et al., 2017; Oztas, 2014; Wolkow, Durrenberger, Maynard, Harrall, & Hines, 2014). All of these arguments suggest that higher cognitive process is inevitable if students are expected to explain the processes later or to others in their own words, and these activities require communicative and basic scientific skills (Li, Sun, & Cai, 2022; Örnek & Soylu, 2021). As osmosis and diffusion are fundamental concepts, students need to conceptualize these concepts in later chapters that deal with other complex biological processes and concepts such as dynamic equilibrium, solvent, solute, direction of movement, the role of osmosis in plants and living organisms, and the relationship between the quantity of solvent and solute (Artun & Coştu, 2013; Hasni, Roy, & Dumais, 2016; Odom & Kelly, 2001; Oztas, 2014). However, studies conducted over a twenty- year period showed that these two concepts are difficult for students to grasp, with students only understanding them partially or incompletely (Hasni et al., 2016).

Based on previous studies, a few factors led to these problems. Firstly, many Biology terms consist of ‘jargon’ words that are foreign and difficult for many students to understand. For instance, in osmosis, terms like hypertonic, hypotonic, and isotonic are hard to understand because they are unfamiliar terms in students’ vocabulary repertoire. Without knowing the meaning of those terms, students simply memorize the facts related to them, and later found

themselves struggling to apply both facts and terms in any related concepts of osmosis and diffusion.

Secondly, there are many similar properties between the two concepts that lead to misconceptions among students. Both osmosis and diffusion are categorized under passive transport because these movements do not require energy in the form of ATP (adenosine triphosphate). This study believes that there should be an explicit explanation to illuminate the differences and similarities between osmosis and diffusion. Because of their comparable properties, students become confused between the two processes, leading to further misconceptions when explaining and applying both concepts in their examinations (Kramer & Myers, 2013; Sousa, 2016; Udovic, Morris, Dickman, Postlethwait, & Wetherwax, 2002).

Finally, osmosis and diffusion involve several abstract processes that are intangible to students (Kramer & Myers, 2013; Oztas, 2014). The mechanisms in biological processes of osmosis and diffusion involve movements and transportation pathways, as well as interactions between various components in plasma membrane structures, which are difficult to be visualized clearly using static illustrations or diagrams as provided in textbooks (Aksoy, 2012; Elliot et al., 2014; Hong et al., 2015; Mayer, 1999, 2010).

Needs Analysis

This study employed the DDR field and applied the ADDIE model to develop a teaching and learning module for Biology subject. The first phase in the ADDIE model is analyze. The purpose of this phase is to identify potential causes for a performance gap through needs analysis. By completing the needs analysis, this study aimed to determine whether the development of the module can effectively address the performance gap and recommend strategies based on empirical evidence about the module's potential for success in designing and developing it. If the performance gap is determined to be caused by factors other than a lack of knowledge and skills, the ADDIE process should be halted. Figure 1 depicts the three main causes for performance gap, according to Klausmeier and Allen (1978).

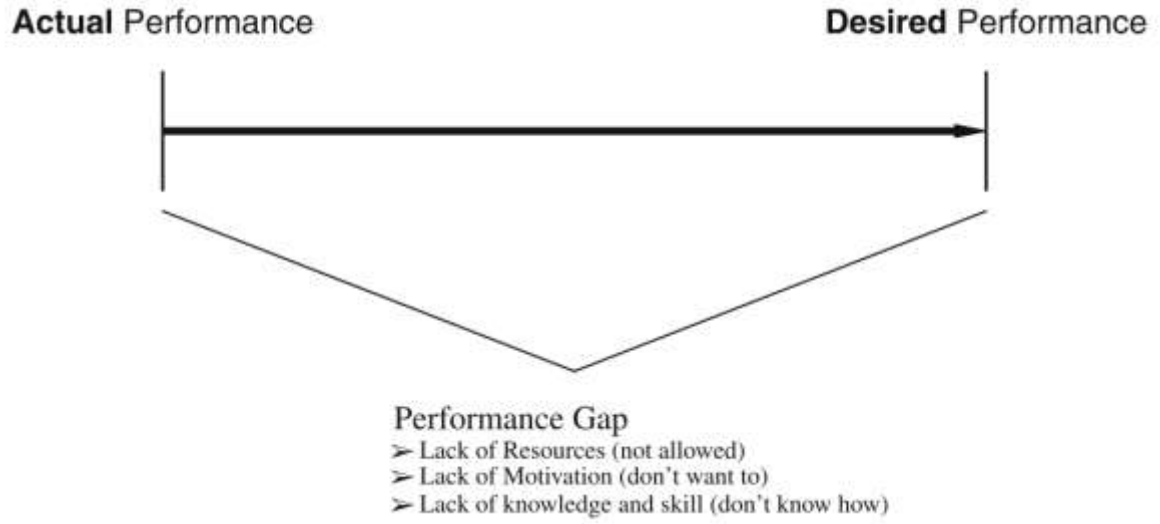

Figure 1. Three Main Causes for Performance Gap (Klausmeier & Allen, 1978)

The three primary causes of a performance gap are: (1) lack of resources, (2) lack of motivation, and (3) lack of knowledge and skills. A performance gap caused by a lack of resources occurs when someone is highly motivated to perform a specific task but has limited access to resources to perform it, such as limited technology and managerial support. Lack of

motivation, on the other hand, occurs when someone has the ability to perform a task but is unwilling to do so. Finally, lack of knowledge and skills occurs when someone has the necessary resources and motivation to perform a task but lacks the intellectual or psychomotor skills to perform it meaningfully. Thus, the main purpose of needs analysis in the ADDIE model will be dedicated to close performance gaps originated by a lack of knowledge and skills.

Methodology

With respect to the research purpose, which was to design and develop an innovative module, an instructional design model called ADDIE was chosen by adopting the development and design research (DDR). For the needs analysis phase, this study utilized a qualitative approach. In order to identify the problems faced by students when learning osmosis and diffusion topics, as well as the need to develop a module to address the problems, semi-structured interviews were carried out with three biology expert teachers from the Klang Valley area. These three teachers were selected based on their years of experience (more than ten years) and their vast knowledge in the field of teaching and learning Biology in schools.

The interview sessions were conducted in a meeting room and the Biology laboratory to suit the needs of the interviewees. The interviews were also conducted in a semi-formal manner to ease the procedure and assure the comfort of all participants. The selection of these experts was based on purposive sampling using experts to choose three expert teachers in the Biology subject. The expert teacher recognition was established in 1993 by the government to encourage promotion amongst teachers. All three teachers had graduated in the Science education field and taught Biology for more than five years. They were subject matter experts in Biology who were appointed by Malaysian Examination Syndicates, MOE as SPM examiners based on their extensive pedagogical content knowledge. One of the experts was a panelist in constructing SPM items.

Teacher 1 is 46 years old and has 22 years of experience teaching Biology at two different schools. She earned a Bachelor's Degree in Science with Education (Hons) from the University of Malaya (UM). She is currently an expert teacher, teaching at a secondary school in Petaling Jaya area. Her current school has also appointed her as the Head of the Science Department. Teacher 1 has been an SPM examiner for over five years, which adds to her experience. Based on her vast experience marking SPM and PT3 papers, she started writing workbooks for Biology and Science subjects, and she has now written six workbooks that have been published by a well-known publisher. She continues to make valuable contributions, and she was the recipient of excellent service awards in 2004 and 2014.

Secondly, Teacher 2 is 38 years old and has worked as a Biology teacher at two different schools for 14 years. She earned a Bachelor's Degree in Science with Education (Hons) from Universiti Sains Malaysia (USM). She is now an expert Biology teacher and the Head of Science Department at a secondary school in Bandar Utama, Damansara. Teacher 2 also has three years of experience as an SPM examiner in addition to her teaching expertise. She received an excellent service award in 2011 and has continuously made outstanding contributions to the schools.

Finally, Teacher 3 is 46 years old and has 21 years of experience as a Biology teacher in two different schools. She graduated from the University of Malaya (UM) in Bachelor's Degree in Science with Education (Hons). She is now an expert Biology teacher at a secondary school in Alam Megah, Shah Alam. She was previously designated as the Head of Science Department, and she is now a Senior Teacher for the Science Department. She is also one of the state

coaches that trained teachers to use English for Teaching Mathematics and Science (ETEMS). For five years in a row, she has made an outstanding contribution as one of the panelists in constructing SPM items. She received excellent service awards in 2005 and 2015.

Eight semi-structured interview questions were prepared and validated before the interviews. Prior to the interview sessions, teachers were requested to fill out personal details and a consent form. The interviews were recorded and transcribed by the interviewer as soon as the sessions ended. The transcripts were then translated into English for data analysis purposes. The interviews were conducted in six stages, as follows:

1. Introduction
2. Confirming the interviewee's background
3. Outlining the purpose of the interview
4. Getting permission to record the conversation
5. Conducting the interview session
6. Conclusion and appreciation of the interviewee

Data Analysis

Qualitative data are non-numerical forms of information such as interview scripts, field notes, observation lists, video recordings, images, and documents. Turning written data is the process of explaining, understanding, or interpreting social phenomenon (people and situations) from the information gathered (Braun & Clarke, 2013). Qualitative data analysis is usually based on an interpretative philosophy. The idea is to examine the meaningful and symbolic content of qualitative data. The goal is to analytically reduce the data by producing summaries, coding, and memos, as well as finding ways to display data and draw conclusions. The qualitative data from the interviews in this study were analyzed using deductive coding approach via ATLAS.ti software to draw conclusions across the themes that emerged from the analysis of data. The research employed a deductive coding approach, which involves identifying predetermined codes based on a set of identified variables (Braun & Clarke, 2006). From rereading the transcripts, the researcher would selectively code any data that were related to the core variable identified. Figure 2 shows the summary of the steps taken in qualitative data analysis throughout this study.

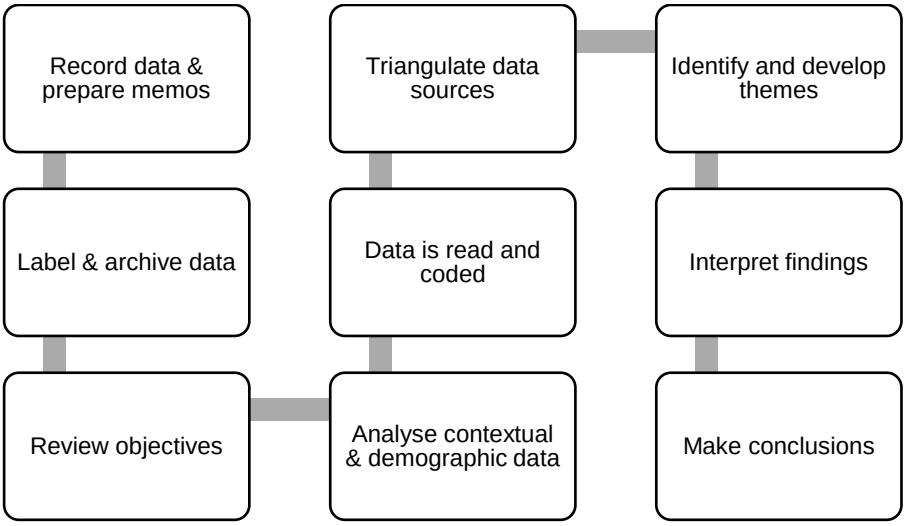

Figure 2. Qualitative Data Analysis

Next, thematic analysis was used to create meaning of the coded data. Thematic analysis has the ability to identify, analyze, and report patterns within data (Braun & Clarke, 2006). These approaches are often used in analyzing qualitative data as they provide a purely qualitative, detailed, and nuanced account of data (Vaismoradi, Turunen, & Bondas, 2013; Virginia Braun & & Victoria Clarke, 2006).

Findings and Discussion

The objective of the analysis phase was to identify the need for developing an innovative teaching and learning module for osmosis and diffusion topics under the Biology syllabus. In order to find the call for developing the module, an interview was conducted with three Biology teachers who are experts in the field in the Klang Valley area. The questions that were asked during the interview sessions were intended to answer one research question, which is: how crucial is the development of an innovative teaching and learning module in teaching osmosis and diffusion concepts, in the view of experts?

Four broad themes emerged from the needs analysis, which are: (1) The importance of learning osmosis and diffusion, (2) Problems in Biology teaching and learning, (3) Teaching strategies, and (4) Desired improvements.

Theme 1: The Importance of learning Osmosis and Diffusion Topics

'Movement of Substances across the Plasma Membrane' is one of the chapters in the Form Four Biology curriculum. This chapter lists three main objectives to be achieved by students, which are: (1) analyzing the movement of substances across the plasma membrane, (2) understanding the movement of substances across the plasma membrane in everyday life, and (3) appreciating the movement of substances across the plasma membrane.

The chapter starts with introducing the structure and function of the plasma membrane. The lesson progresses to explain the movement of substances in and out of the cell through different processes, namely osmosis and diffusion, and the type of movement is based on the type of molecules involved. From the interview sessions, two codes emerged under 'The Importance of Osmosis and Diffusion' theme, which are basic concepts and applications. The emerging theme and codes are summarized using a schematic diagram in Figure 3.

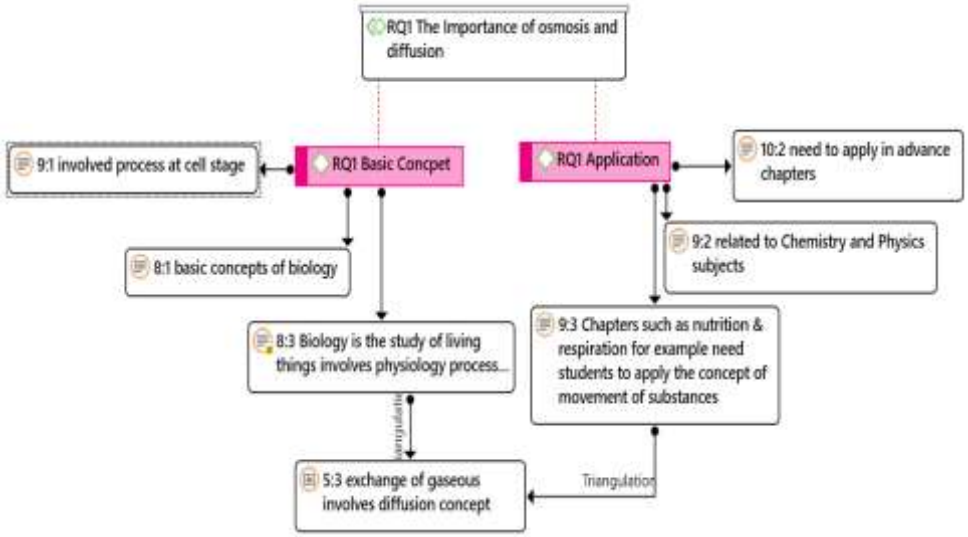

Figure 3. The Importance of Learning Osmosis and Diffusion Theme

All three teachers agreed that osmosis and diffusion are the basic concepts for students to master in order to learn more advanced topics. As Biology is a study of living things and it discusses physiology processes at molecular and cell stages, osmosis and diffusion are crucial concepts to be understood in order to have a clearer picture regarding substances moving across cell structures. Quoting Teacher 3's words, "It is crucial that students can apply the concepts of osmosis and diffusion in other advanced Biology chapters". Teacher 1 supported this statement by stating the examples of the relevant subjects that also require students to understand the concepts of osmosis and diffusion, such as nutrition and respiration.
The content of the Biology textbook later reveals that the concepts of osmosis and diffusion are repeated in subsequent chapters such as respiration, nutrition, blood circulatory system, excretion, and photosynthesis in plants. Teacher 3 said, "Students would not be able to explain clearly the processes involved in respiration, excretion, and nutrition if they failed to comprehend the osmosis and diffusion concepts". This statement was supported by Teacher 2 who later added that students are unable to grasp these two concepts and will most certainly face difficulties to understand other advanced chapters in Biology, Chemistry, and Physics.

Theme 2: Problems in Biology Teaching and Learning
Students face numerous problems when learning Biology. Different perspectives were expressed by all three teachers regarding the problems faced by students during the lesson. Under this theme, six codes emerged, which are difficult terms, a lack of thinking skills, misconceptions, technical, the nature of the topic, and students' attitudes. The emerging theme and codes are summarized using a schematic diagram in Figure 4 below.

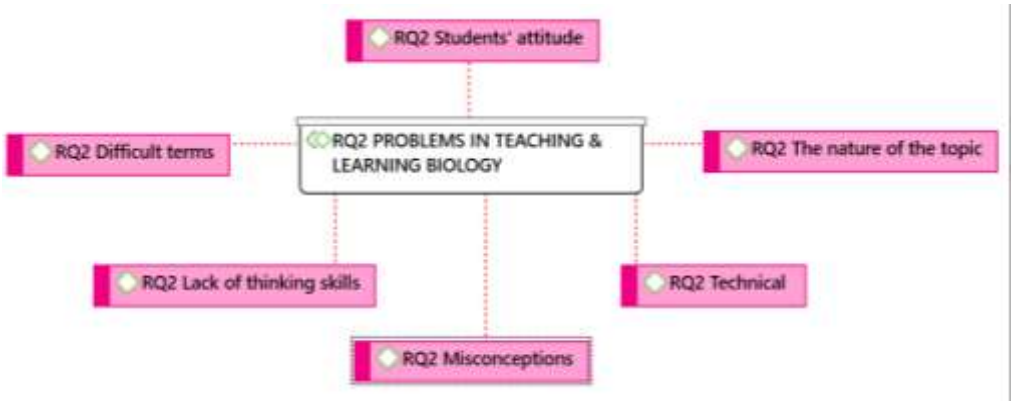

Figure 4. The Problems Problems in Biology Teaching and Learning Theme

From the analysis, it was found that many associated quotations were shared between 'difficult terms' theme and 'the nature of the topic' theme. As Teacher 3 said, "Students are unable to visualize the Biology processes clearly". To make matters worse, students had difficulty understanding the various Biology terms. The other two teachers agreed with this assertion, stating that terms like hypotonic, hypertonic, isotonic, concentration gradient, haemolysis, crenation, and plasmolysis are difficult to be comprehended by students. According to Teacher 2, students struggled to understand the terms because they are presented as jargons.
The lack of thinking skills also became an obstacle for students to master this topic. According to all three teachers, most students are unable to apply the knowledge they have learned to

solve HOTS tasks. Most of the time, students memorize sentences from textbooks and teachers' notes, and fail to provide further explanation in their own words and understanding. Students are seen to face difficulty with analyzing the information given to produce a satisfactory answer. For example, Teacher 2 illustrated students' answers as "Students are always confused to identify and apply the osmosis concepts in hypotonic, hypertonic, and isotonic solutions". She added that students also have difficulties in explaining the causes and effects of different types of solutions on plant and animal cells. Because of these difficulties, there is a high occurrence of misconceptions among students, particularly between osmosis and diffusion concepts.

Students' attitude also contributed to the problems in teaching and understanding Biology. For example, students are reluctant to raise questions during the lesson. Teacher 3 said, "Teachers assume students understand the lesson taught because not many of them ask questions". Teacher 2, on the other hand, remarked that students are not asking questions because they do not comprehend the information delivered by teachers and are not trained to do so. Teacher 2 also added that the absence of questions among students is probably because of a lack of prior knowledge. All three teachers agreed that this attitude will affect students' learning culture, and, subsequently, their understanding of the topic.

All teachers agreed that classroom activities and experiments have the potential to reinforce students' understanding. However, time constraint eluded teachers from delivering different activities and experiments in the classroom. Teachers also need to rush through certain topics to ensure that all topics in the curriculum specification are covered in time. Teacher 3 clarified: "I always need to attend teachers' meeting outside, and sometimes it takes two or three days and even one week straight. My students cannot proceed to learn Biology because the relief teacher is not a Biology teacher". As soon as she returned from the meeting, she needed to hasten her lessons to avoid exceeding the time allotted to complete the syllabus.

Teacher 2 and Teacher 3 both agreed that using media such as videos would help students in visualizing the movement of substances. However, due to technical problems such as weak or no internet connectivity, teachers are frequently unable to download videos from websites such as YouTube. Whereas for Teacher 2, she preferred to carry out experiments in her class because she believed that by doing so, students will gain a better understanding. Teacher 2 said, "I prefer to carry out an experiment with my students because they can observe the phenomena and experience the real life situation". However, due to time constraint, experiment activities are limited.

Theme 3: Teaching Strategies

Teaching strategies consist of three main codes: static illustration, multimedia, and experiment. The emerging theme and codes are summarized using a schematic diagram in Figure 5 below.

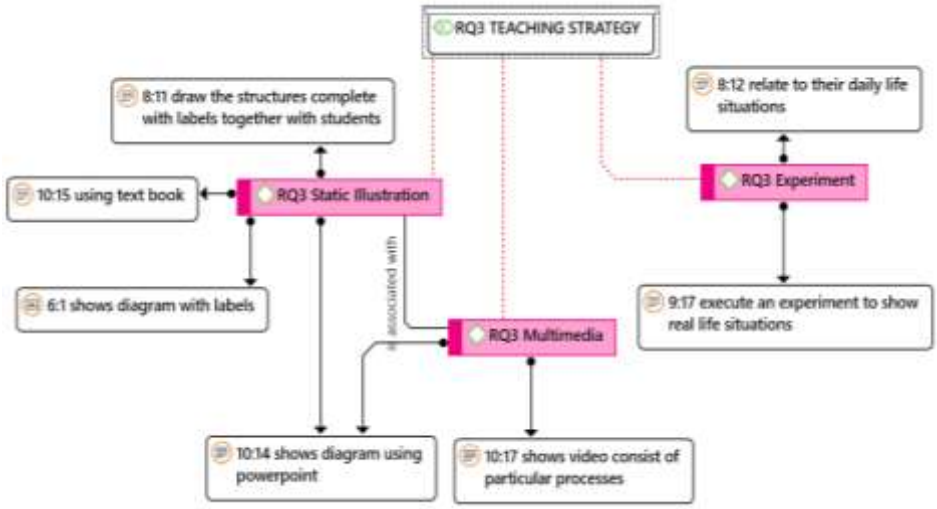

Figure 5. The Teaching Strategies Theme

All teachers agreed that they used a lot of static illustrations to teach this topic to their students. As Teacher 3 said, she preferred to draw the structures on the whiteboard traditionally and ask students to draw them with her. As for Teacher 1, she used PowerPoint presentations to show static diagrams. She agreed that it was quite challenging to show the movement of substances using such diagrams. In contrast, Teacher 2 preferred to refer to diagrams in the textbook due to time constraints that eluded her from preparing other teaching materials for her students.

For Teacher 1, she always used the workbook to familiarize her students with HOTS questions. To enhance their understanding, she would usually ask her students five questions during her set induction. Her justification for using this strategy was to ensure that students understand and remember the previous topics she taught. Teacher 1 also emphasized the importance of repeating information to enable students to retain the information in their long-term memory. Teacher 1 added, “The difficult terms in Biology have to be memorized. There is no other way for them to familiarize themselves with the terms. We, as a teacher, need to play a role to help them memorizing those terms”.

All three teachers held similar views on video presentations. They claimed that video presentations will assist students in visualizing the movement of substances inside living organisms at the molecular stage. Teachers sometimes use videos in the classroom to enhance students’ understanding. All teachers agreed that experiments are advantageous in helping students to experience real-life situations. Through these learning activities, students will be able to apply the concepts taught into real-world phenomena that occur in the cells of living organisms.

Theme 4: Desired Improvements

From the interview sessions, all three teachers voiced out their desired improvements in teaching osmosis and diffusion. The desired improvements can be divided into two categories, which are active learning tasks and technology. Under the active learning tasks code, all three teachers agreed that students should be encouraged to ask questions in the classroom because questions are rarely posed during lessons except experiment activities. By asking questions, teachers can measure two factors: the levels of students’ interests and

understanding. Meanwhile, experiments and group activities will encourage students to communicate and collaborate with their peers. As Teacher 2 said, “Teachers also have to play an important role to engage in students’ learning during an active learning task”. The emerging theme and codes are summarized using a schematic diagram in Figure 6.

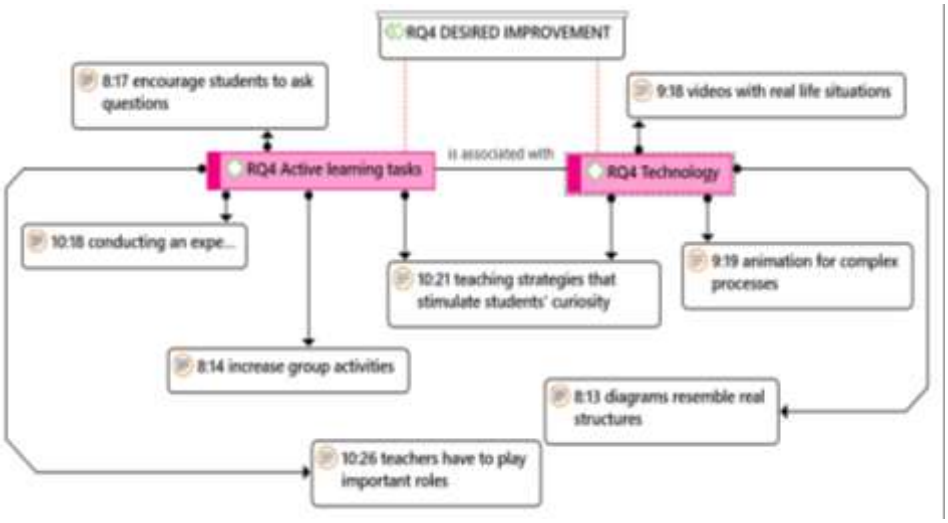

Figure 6. The Desired Improvements Theme

Under the technology code, all three teachers agreed that videos, animation, and diagrams that resemble real structures could facilitate students visualize the structures and processes of osmosis and diffusion within cells. As Teacher 1 said, "I believe by using technology such as animation or videos can help students to visualize the processes clearly". This was reinforced by Teacher 2 and Teacher 3, who both agreed that visualizing helps most students to comprehend cellular processes better.

From the perspective of all three teachers, it seems that this chapter is crucial for students to comprehend in order for them to grasp the basic concepts in Biology and apply the knowledge across the subject. The main problem that students encounter is their failure to visualize abstract processes in Biology, especially those that occur at the molecular state. Teachers must put a concerted effort to teach their students this concept by using a different strategy. However, the time constraint issue usually prevents them from preparing teaching materials. To make matters worse, technical problems such as weak internet connectivity also hinder them from using technology frequently in their classroom.

It was agreeable that osmosis and diffusion involve many abstract processes that are intangible to students (Kramer & Myers, 2013; Oztas, 2014). The mechanisms in biological processes such as osmosis and diffusion entail movement and transportation pathways, as well as interactions between numerous components in plasma membrane structures, which are difficult to be visualized clearly using static illustrations or diagrams such as those provided in textbooks. These illustrations and diagrams are insufficient to provide insights into the molecular interactions governing the structures and dynamics of biological membranes within cells (Aksoy, 2012; Elliot et al., 2014; Hong et al., 2015; Mayer, 1999, 2010). Based on four themes that emerged from the interviews, it seems that there is a crucial need for an alternative teaching module to simplify the process of teaching and learning Biology for both students and teachers. These research findings aligned with those of Artun and

Coştu, (2013), Çimer (2012), Kramer and Myers (2013), and Yarden and Yarden (2010). To overcome the problems stated, it seems timely for teachers to have a module that can assist in the explicit transfer of knowledge while encouraging students to ask good questions that reflect their higher order thinking skills, as quoted in the words of Mishra and Iyer (2015) that "asking right questions is vital in learning processes to indicate the knowledge and understanding possessed by students".

Implications and Recommendations

With many challenges in teaching Biology, such as a lack of efficient teaching tools, the nature of the subject, and teachers' lack of skills in developing alternative teaching tools, there is a need to develop an innovative teaching and learning module using multimedia elements such as videos and animation. Perhaps the module could include an overview of molecular dynamics in biological membranes, fundamental molecular mechanisms occurring during osmosis and diffusion, as well as the structures of proteins embedded within the plasma membrane. This module was also intended to assist teachers in delivering subject content without having to worry about time constraints when developing teaching materials and the needs for internet connection. Since multimedia has become a crucial element to be embedded in the module, this module will need to integrate the cognitive theory of multimedia learning (CTML). Given the desire expressed by teachers to address students' lack of thinking skills, this study suggests incorporating inquiry learning into the proposed module. This can be accomplished through the utilization of the problem-posing instructional strategy (PPIS), which aims to teach the subject matter while also improving students' lower-order thinking skills (LOTS) and higher-order thinking skills (HOTS).

Conclusion

Based on the findings of the ADDIE model's analysis phase, it is vital that the process of developing the module undergo several rigorous processes and in-depth sub-studies prior to testing its effectiveness. During the analysis phase, it was discovered that a needs analysis is a vital step in firmly establishing the needs to construct the module in the first place. It was through a needs analysis that the discovery was made, i.e., there is a lingering problem among students to gain a deep understanding of the fundamentals in Biology. Their lack of understanding consequently leads to several issues, namely students' failure to visualize abstract processes, inability to tackle HOTS, and feeling reluctant to ask questions. It is clearly that the performance gaps retrieved from the needs analysis is originated from a lack of knowledge and skills. Thus, the development of the innovative teaching and learning module to teach osmosis and diffusion are crucial.

Corresponding Author

Nor Tutiaini Ab.Wahid
Universiti Teknologi MARA Fakulti Pendidikan Aras 5 & 7, Bangunan FSK 1, 5 Kampus Puncak Alam 42300 Bandar Puncak Alam Selangor Darul Ehsan, MALAYSIA
Email: tutiaini@uitm.edu.my

References

Aksoy, G. (2012). The Effects of Animation Technique on the 7th Grade Science and Technology Course. *Creative Education*, *03*(03), 304–308. https://doi.org/10.4236/ce.2012.33048

Almomen, R. K., Kaufman, D., Alotaibi, H., & Al-rowais, N. A. (2016). Applying the ADDIE — Analysis , Design , Development , Implementation and Evaluation — Instructional Design Model to Continuing Professional Development for Primary Care Physicians in Saudi Arabia. *International Journal of Clinical Medicine*, *7*(8), 538–546. https://doi.org/. http://dx.doi.org/10.4236/ijcm.2016.78059

Artun, H., & Coştu, B. (2013). Effect of the 5E Model on Prospective Teachers' Conceptual Understanding of Diffusion and Osmosis: A Mixed Method Approach. *Journal of Science Education and Technology*, *22*(1), 1–10. https://doi.org/10.1007/s10956-012-9371-2

Bonney, K. M. (2015). Case Study Teaching Method Improves Student Performance and Perceptions of Learning Gains †. *Journal of Microbiology & Biology Education*, *16*(1), 21–28. https://doi.org/10.1128/jmbe.v16i1.846

Braun, V., & Clarke, V. (2013). *Successful qualitative research: A practical guide for beginners. Thousand Oaks, CA: sage 2013.*

Çimer, A. (2012). What makes biology learning difficult and effective: Students' views. *Educational Research and Reviews*, *7*(3), 61–71. https://doi.org/10.5897/ERR11.205

Elliot, D., Wilson, D., & Boyle, S. (2014). Science learning via multimedia portal resources: The Scottish case. *British Journal of Educational Technology*, *45*(4), 571–580. https://doi.org/10.1111/bjet.12085

Fisher, K. M. (1985) A misconception in biology: amino acids and translation. Journal of Research in Science Teaching, 22(2): 53–62.

Hasni, A., Roy, P., & Dumais, N. (2016). The teaching and learning of diffusion and osmosis: What can we learn from analysis of classroom practices? A case study. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(6), 1507–1531. https://doi.org/10.12973/eurasia.2016.1242a

Hong, J. C., Lin, M. P., Hwang, M. Y., Tai, K. H., & Kuo, Y. C. (2015). Comparing animated and static modes in educational gameplay on user interest, performance and gameplay anxiety. *Computers and Education*, *88*, 109–118. https://doi.org/10.1016/j.compedu.2015.04.018

Klausmeier, H. J., & Allen, P. S. (1978). *Instructional Design*. *Cognitive Development of Children and Youth*. https://doi.org/10.1016/b978-0-12-411355-8.50014-0

Kramer, E. M., & Myers, D. R. (2013). Osmosis is not driven by water dilution. *Trends in Plant Science*, *18*(4), 195–197. https://doi.org/10.1016/j.tplants.2012.12.001

Li, X., Sun, X., & Cai, J. (2022). Integrating problem posing into the mathematics classroom: current advances a nd future directions of research. Current Opinion in Behavioral Sciences, 48, 101213. https://doi.org/10.1016/j.co beha.2022.101213

Mayer, R. E. (1999). Multimedia aids to problem-solving transfer. *International Journal of Educational Research*, *31*(7), 611–623. https://doi.org/10.1016/S0883-0355(99)00027-0

Mayer, R. E. (2010). Applying the science of learning to medical education. *Medical Education*, *44*(6), 543–549. https://doi.org/10.1111/j.1365-2923.2010.03624.x

Odom, A. L., & Kelly, P. V. (2001). Integrating concept mapping and the learning cycle to teach diffusion and osmosis concepts to high school biology students. *Science Education*, *85*(6), 615–635. https://doi.org/10.1002/sce.1029

Oliver, J. S., Hodges, G. W., Moore, J. N., Cohen, A., Jang, Y., Brown, S. A., … Robertson, T. P. (2017). Supporting High School Student Accomplishment of Biology Content Using Interactive Computer-Based Curricular Case Studies. *Research in Science Education*, (May), 1–26. https://doi.org/10.1007/s11165-017-9675-6

Oztas, F. (2014). How do high school students know diffusion and osmosis ? High school

students ' difficulties in understanding diffusion & osmosis. *Procedia - Social and Behavioral Sciences*, *116*, 3679–3682. https://doi.org/10.1016/j.sbspro.2014.01.822

Rothman, K. . (2014). Six Persistent Research Misconception. *J Gen Intern Med*, *29*(1), 1060–1064.

Sousa, C. (2016). Problem-based learning on cell biology and ecophysiology using integrated laboratory and computational activities. *Multidisciplinary Journal for Education, Social and Technological Sciences*, *3*(1), 118. https://doi.org/10.4995/muse.2016.3763

Tekkaya, C. (2003). Remediating High School Students' Misconceptions Concerning Diffusion and Osmosis through Concept Mapping and Conceptual Change Text. *Research in Science & Technological Education*, *21*(1), 5–16. https://doi.org/10.1080/02635140308340

Udovic, D., Morris, D., Dickman, A., Postlethwait, J., & Wetherwax, P. (2002). Workshop Biology: Demonstrating the Effectiveness of Active Learning in an Introductory Biology Course. *BioScience*, *52*(3), 272. https://doi.org/10.1641/0006-3568(2002)052[0272:WBDTEO]2.0.CO;2

Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing and Health Sciences*, *15*(3), 398–405. https://doi.org/10.1111/nhs.12048

Virginia Braun &, & Victoria Clarke. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2006), 77–101. https://doi.org/10.1191/1478088706qp063oa

Wolkow, T. D., Durrenberger, L. T., Maynard, M. A., Harrall, K. K., & Hines, L. M. (2014). A comprehensive faculty, staff, and student training program enhances student perceptions of a course-based research experience at a two-year institution. *CBE Life Sciences Education*, *13*(4), 724–737. https://doi.org/10.1187/cbe.14-03-0056

Yarden, H., & Yarden, A. (2010). Learning using dynamic and static visualizations: Students' comprehension, prior knowledge and Conceptual Status of a biotechnological method. *Research in Science Education*, *40*(3), 375–402. https://doi.org/10.1007/s11165-009-9126-