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**IMPROVEMENT OF FOUNDATION STUDENT PERFORMANCE
IN BIOLOGY THROUGH INTENSIVE STATION BASED
LEARNING APPROACH**

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Abstract:

A growing revolution is underway in teaching introductory science to foundation studies. Recent educational research explains that traditional teaching approaches in large classes often fail to reach many students. To address this problem, we conducted an intensive station rotation-based workshop called "Bio Made Easy" for a group of students who obtained F grade in the first Biology assessment, N = 120. The workshop was designed to improve students' understanding of selected Biology topics by providing

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simple examples, analogy, and explanation of the concept using various active and interactive approaches. The goal was to change the students' perception of biology and deliver the content within a short period of time. The students were divided into small groups and required to complete all stations conducted by different instructors. For each station, students were directed to perform activities that required them to actively participate, interact, and discuss among the group members. A comparison was made between their performance during the first test and the second test of the semester. From F grade in the first test, about 88.3% of the students accomplished higher performance grades in the test 2 assessment. This reflects an encouraging sign that active-learning practice and direct engagement of students in the station rotation-based learning approach improve student performance in biology subject and serve as one of the strategies to motivate students for better grades.

Keywords:

Biology, Station Rotation Based Learning, Grades Improvement, Interactive, Intensive Workshop, Science Education

Introduction

Educational theory suggests that learning science should follow the theory of social constructivism. This theory explains that all knowledge develops as a result of social interaction and thus recommends the learning process should focus on the collaborative process. One of the major problems associated with science teaching is that educators often focus on facts rather than overarching concepts (Minhas, Ghosh, & Swanzy, 2012). Using this learning approach, students are expected to assimilate information presented by the educator and absorb it passively. As consequences, students have the inability to grasp science concepts and tend to internalize knowledge through memorization (Wingfield & Black, 2005).

Of many science subjects, Biology is known for its fact-rich content and could be the least favourite subject to students who do not like reading. Besides that, Introductory Biology Course has been criticized for over-emphasizing facts, memorisation and little on higher order thinking (Momsen, Long, Wyse, & Ebert-May, 2010). Cimer (2012) identified several reasons contributed to the difficulties in learning Biology; (1) educators' teaching style; (2) students' habits in learning and studying the subject; and (3) nature of Biology topics that are considerably hard to understand. Traditional teacher-centred teaching could be an uninteresting way to deliver the content.

Therefore, in developing an effective learning environment for Biology, an instructor should consider the implementation of active learning activities that could retain student's interest and focus. Active learning would be more impactful with adoption of blended learning strategies such as the usage of latest technologies and digital applications, the application of appropriate materials that can be visualised to boost student's interest such as fieldwork and laboratory practical, and the development of online learning materials and topics (N. Hidayati & Irmawati, 2019).

One of the best ways to integrate active and blended learning is through rotation method – learning station/station rotation model. Many studies have discussed the effectiveness of this strategy to develop reflective thinking skills and problems solving ability among students

(Carrió et al., 2016; Rogayan Jr, 2019; Tanner & Allen, 2004). In addition, the effective use of learning stations through face to face discussion, hands-on training, e-learning and direct engagement in the activities can improve understanding and avoid misconceptions in science. Learning stations allow instructor to closely monitor and interact with students and provide multiple ways to deliver the knowledge.

In order to address the problems with poor conceptual understanding in Introductory Biology Course among foundation students, we designed a workshop by implementing rotation method using station rotation model or learning station which include small group tutoring and discussion, gamification and role play, pencil-paper assignment and online visual learning. We named the workshop as “Bio-Made Easy”. In the workshop, students were divided into small groups and were instructed to rotate from one station to another. Most of the activities at the stations involved hands-on manipulation of objects or models which were pre-constructed using very simple materials. These models represent some abstract biological processes that allow students to learn and visualise the concepts in a real situation. In this article, we describe the effects of station rotation method towards students’ achievements specifically in Biology including the benefits and limitations of this learning approach.

Literature Review

Methods in Biology Teaching

In modern education, creativity and innovation are the essences of a learning process. Lectures and direct guidance from educators are now seen to be less germane as traditional oral lectures often fail to encourage meaningful intellectual engagement that is crucial for personal and academic development especially among college students (Smith et al., 2005). Active learning pedagogy has become more prominent in many institutions with an accumulation of evidence showing the benefits of the method in current education.

The selection of teaching methods and design of lessons in Biology would largely depend on the context of the subject and diversity of learning styles among students (Tanner & Allen, 2004). The choice of teaching method is thus a central consideration. Despite the importance of Biology as a study of life, this subject is known for its enormous facts and concepts; and is less intrigued among students. To raise the interest of the students on the subject, effective teaching must be employed. This depends on the educator’s skills to implement innovative learning strategies such as the adoption of active learning that guarantees the interaction among students.

A number of active learning methods in Biology education have been reported. For instance, concept mapping (Ajaja, 2013) service-learning (Begley, 2013) sequential teaching method by incorporating lecture method, student experiment and slide demonstration (Veselinovska, Gudeva, & Djokic, 2011) in-classroom discussion (Sutton-Grier, Rauschert, & Momsen, 2016) problem-based learning (Carrió et al., 2016; Tanner & Allen, 2004) and rotation based learning (Rogayan Jr, 2019).

Concept Mapping

Concept mapping is a technique for visualizing the relationship and connections between different concepts or key ideas (Ajaja, 2013; Kinchin, 2000). The use of concept maps was

explored in Biology learning for high school students (Kinchin, 2000). Students who adopted concept mapping showed a better understanding of the assigned topic - Birds and Mammals compared to traditional teaching. The outcome suggests that the students are able to apply the knowledge in various daily situations and achieve permanent knowledge. Ajaja (2013) examined the effects of concept mapping on students' achievement in Biology. Based on students' reviews, the concept map is helpful in facilitating them to draw the connections among biological concepts, enhancing their critical thinking and obtain consistent achievement in the subject.

In-Classroom Discussion

The use of in-classroom discussion is an important method to stimulate the active participation of students. Through discussion, students can develop scientific thinking by positive argument and research; and advance their understanding of Biology by asking questions, solving problems and explaining biological science concepts using models or other tools. Sutton-Grier and co-workers (2016) conducted a workshop to introduce different techniques to develop structured and effective discussions across undergraduate levels (Biology). Integration of rotation station, chalk talk, snowballing and other techniques in the discussion would expose students to diverse viewpoints and promote engagement of students in the process of science.

Sequential Teaching

The sequential teaching method proposed by Veselinovska et al. (2011) involved three learning strategies; student experiment, lecture method and slide demonstration. Students were offered three topics; protein, cell structure and function and biodiversity with different sequences of three teaching methods to observe the effect on the cognitive achievement of Biology studying. The study concluded that a better retention (remembrance) level in lesson commences with experiment and slide.

Service Learning

Experiential learning such as service-learning is an approach that enhances classroom experiences with community engagement. This method has been widely adopted in the undergraduate study but is relatively rare in life sciences courses or subject (Begley, 2013). The service-learning model was implemented for first-year Biology students in the Introductory Cell and Molecular Biology course (Begley, 2013). Students were assigned with community partners and worked directly or indirectly on Biology-related activities. The feedback was positive. In comparison with other students of all Biology courses, students enrolled in this course attained a higher level of intellectual challenge, learning, and application of concepts

Problem Based Learning

Problem-based learning (PBL) offers a different way of active learning by engaging students to a problem that requires further research besides empowering students to commit to their role in learning. It requires a small collaborative group where students define and analyse the problem, identify related information and share the findings or possible solutions to peers. Carrió et al. (2016) introduced Hybrid PBL to improve long-term knowledge acquisition in undergraduate Biology education. Also, the method has proven to improve problem-solving skills and generic competences.

Rotation Method

Another effective approach in teaching Biology is the implementation of rotation method. This method is one of the six blended learning models which centers around providing different ways to demonstrate learning in the target group of students. Rotation method offers opportunities for every student to make successful progress at their own pace as well as addressing student diversity. Tanner and Allen (2004) suggested that differentiated instruction, a teaching style that stems from multiple pedagogical approaches and not a singular approach is the key to avoiding instructional selection and retaining more students' interest in science. There are four types of rotation models; station rotation, lab rotation, individual rotation model and flipped classroom model (Ayob, Abd Halim, Zulkifli, Zaid, & Mokhtar, 2019). In this study, we are focusing on station rotation model.

Station Rotation Model

Station rotation model or learning station accommodates and combines various pedagogical approaches. It involves creating stations that utilize technology, small group tutoring, games, role-play, pencil-paper assignment, discussion and visual learning.

i. Small group tutoring and discussion

It is well accepted that small-group tutoring and discussion promotes better learning and greater motivation in a more connected learning setting. This method which suits all learners is substantially effective when instructor provides explanation after students have attempted to do the activities, explored the concepts and discussed any questions, ideas and confusion related to the subject. Through discussion and proper tutoring, students' understanding on the subject matter can be enhanced. Wood and Tanner (2012) suggested a model called INSPIRE (Intelligent, Nurturant, Socratic, Progressive, Indirect, Reflective and Encouraging) to describe the characteristics of every expert tutor must have in order to draw students interests to the subject.

ii. Gamification and role play

Gamification refers to the implementation of game elements into the setting of a non-game experience and can be considered as an informal learning environment (Deterding, Dixon, Khaled, & Nacke, 2011). Games are synonymous with qualities that make them fun and easy to understand and learn, easier to memorise the subjects and can be intellectually engaging by providing learning through play (Songer & Miyata, 2014). When individuals play games, they engage multiple senses, that is, for each action, there is a reaction and the results are immediate feedbacks. This stimulates the learning process that arises as a result from the content of the game, then knowledge will develop eventually leading to the mastering of skills through the action of playing the game. Games are often used in higher education to enhance the traditional teaching method (Oblinger, 2004).

Role-play is a moving simulation activity that provides the right set of circumstances for learners to be creative and is also fun and easy to play. When implied, research has shown that it hastens the progress of understanding of the learning materials (L. Hidayati & Pardjono, 2018). Students are given the chance to reflect on learning experiences or real-life situations as it involves the creativity of

producing a scene or a situation that enables the student to respond spontaneously in a controlled environment (Arrighi, Irvine, Joyce, & Haracz, 2018).

iii. Pencil-paper assignment

Written communication is a form of knowledge sharing and is necessary for the psychomotor of students (Heald, Ingram, Flanagan, & Wolpert, 2018; Rogers & Case-Smith, 2002). Studies have shown that when students lack the ability of written communication, it affects their self-esteem, assessments and grades (Stevenson & Just, 2014). When linking force to motion for example in handwriting, it involves the formation of a motor-memory. A study by Smoker et al. (2009) compared the act of memorising, recalling and recognising common words. It was observed that memory is better for words that are handwritten down on paper over words that are typed. This shows that the intricate task of writing down will increase better memory of the subject being studied.

iv. Online visual learning

Visual teaching aid in Biology is important to facilitate students to mentally manipulate abstract concept and visual images. A study conducted by Ibe and Abamuche (2019) revealed that a higher test scores and greater interest development were attained by students who are exposed to Biology lessons with audio-visual technological contents compared to those that are not. Students from two different undergraduate courses; undergraduate introductory anatomy course and an upper-level undergraduate histology course were tested for their visual literacy and mental rotation scores using visual learning approach. Students with low virtual literacy and mental rotation scores appeared to favor passive learning approach such as memorization (Barger, 2016).

Within a course or subject, the small groups of students will rotate through a series of rotation which contains at least one online learning station. A small-learning setting will provide the student with more opportunities to engage in a variety of activities and work collaboratively. This method, though considered not new, has been proven effective with innovations for a different level of students. For example, Biology Learning Station Strategy (BLISS) was adopted to junior high school science students to observe the effects of its implementation on their academic achievement and attitude. According to the study, the intervention of this method has improved student science achievement and attitude towards Biology (Rogayan Jr, 2019).

Methodology

Participants

A total of 120 students from the Centre of Foundation Studies for Agricultural Science, Universiti Putra Malaysia participated in the Bio Made Easy workshop. Selection of students was made based on their first assessment result (Test 1) in Biology during their first semester. The students are in the range of ages from 17 to 18 years old. The implementation of this study was conducted within 9 weeks of study in Universiti Putra Malaysia.

Arrangement

Students were divided into 8 groups (N = 15) and each group was assigned to one station per session. For each station, only 10 minutes were allocated, and the groups were required to move to another station once the bell was rung. This was repeated until they completed all stations.

Teaching Tools

The station rotation approach has been used as a treatment in this study. Eight stations were designed covering different topics in foundation Biology following the learning outcomes and lesson plan for the semester. For each station, different modules and blended learning approaches were implemented (Table 1).

Table 1: Descriptive Module for Each Station

Station	Module	Description	Blended Learning Model
1	Draw it right! Exergonic and endergonic reaction	A classroom hands-on activity designed to give a better understanding of the free energy, exergonic and endergonic reactions. In this station, the approach was exploratory.	Gamification
2	Speed up and Stop! (Enzyme and metabolisms)	The practice-activity was applied in this station. Hands-on activity was designed to help students to understand the function of enzymes, factors affecting enzyme activity and the inhibition mechanisms.	Discussion and visual learning
3	Light reaction of photosynthesis	The students were given 5 min to see the prepared video and understand the process of light reaction in photosynthesis. Then, they need to choose the activity and complete the task within 5 mins.	Small group tutoring & Online learning
4	Calvin cycle	In this station, students were asked to act (role play) in order to show the process of the Calvin cycle.	Gamification
5	Spot the differences (C3, C4 and CAM Photosynthesis)	The hands-on activity was designed to help students practice their understanding of the differences in photosynthesis that occur in different types of plants (C4 and CAM).	Pencil-paper assignment

6	Glycolysis	In this station, students were allowed to watch the video/diagram of the glycolysis process. Then, hands-on activity was introduced to the students.	Discussion and online visual learning
7	Preparatory reaction and citric acid/ Krebs cycle of cellular respiration	This hands-on activity was designed to help students practice their understanding of the preparatory reaction and Krebs cycle of cellular metabolism.	Pencil-paper assignment
8	Catch the electrons, if you can! (Electron Transport Chain)	The activity was designed to help students practice their understanding of the electron transport system of cellular metabolism. In this station role-play approach was applied.	Role-play

Data Analysis

The effects of station rotation-based approach to student achievement in Biology were measured by dependent T-test. The grades obtained in the first test (Test 1) were treated as pre-treatment, while the second test (Test 2) were treated as post-treatment. The structure of questions for each test were prepared in three sections; Section A (multiple choice question), Section B (structured question) and Section C (essay question). The levels of knowledge in the question were appropriately prepared based on the hierarchy of Bloom's taxonomy; knowledge, comprehension, application and analysis. All questions were verified by the moderation committee. The standard grade rating scale is shown in **Table 2**.

Table 2: Descriptive Rating for the Biology Achievement Test

Marks	Grade
80-100	A
75-79	A-
70-74	B+
65-69	B
60-64	B-
55-59	C+
50-54	C
47-49	C-
44-46	D+
40-43	D
39/ <	F

Results and Discussion

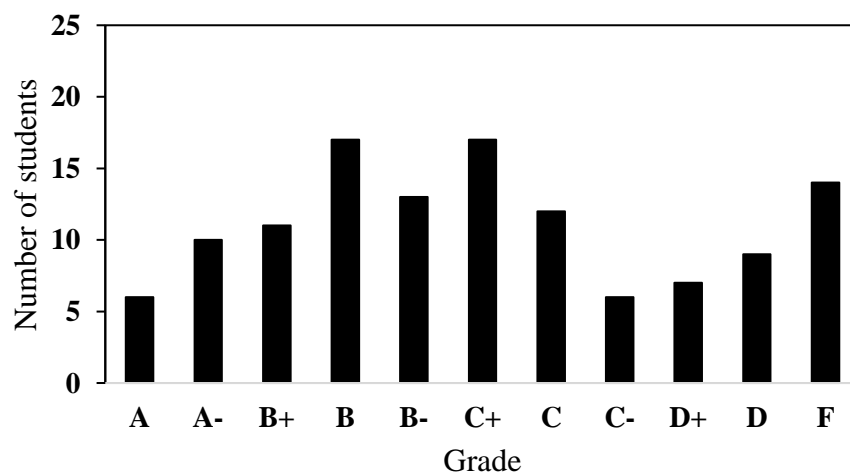
The results obtained from the comparison of pre-treatment (Test 1) and post-treatment (Test 2) of student performance in Biology subject are shown in **Table 3**.

Table 3: Comparison Of Pre- And Post-Treatment Of Student Performance In Biology Subject And Dependent T-Test Bar Graph Of The Mean

Group	Pre	Post	Percentage of improvement (%) *
	Number of students with grade F		
1	15	1	93.3
2	15	1	93.3
3	15	6	60.0
4	15	1	93.3
5	15	1	93.3
6	15	1	93.3
7	15	2	86.6
8	15	1	93.3
Total	120	14	88.3 ^a

*The percentage of improvement was calculated based on the number of students obtained a higher grade than F per total number of students obtained F grade during Test among them. **a** is standard error mean with P value < 0.05.

From the results obtained, on average there was 88.3% improvement in Biology grades of all students from different groups. In this study, improvement in grade is defined as a student passing the test with >40 marks. Figure 1 shows the distribution of student's grades in Test 2 for Biology subject.

**Figure 1: Distribution of Grades Among Students in Biology Subject During Test 2**

Based on the distribution of grades among students in Biology subject during Test 2, the highest number of students achieved was grade B and C+. Six students showed outstanding achievements by obtaining grade A in Test 2 after failing their Test 1. This result implies that the station rotation strategies contributed to the improvement of student's grades in their examination. In agreement, several studies have shown that the use of station rotation-based

learning has improved student understanding and achievement in the examination (Aqel & Haboush, 2017; Rogayan Jr, 2019).

Through the workshop conducted, several criteria were identified in helping student performance during their examination through station rotation based learning approach; (1) Teachers and students have more engagements and interactions, (2) Students are encouraged to show their creativity through different learning styles; and (3) Teachers and students have flexibility in grouping and instruction practice;

Teachers And Students Have More Engagements And Interactions

The station rotation-based rotation method applies a small-learning setting that provides students with more opportunities to engage. Besides, station rotation involved a hands-on activity with the application of models or technologies. For example, in this Bio-Made Easy workshop; exploratory approach implements in Station 1; the practice-activity approach in Station 2; and hands-on activity in Station 5 and 7 gave student experience on the real situation of the biological process and observed the immediate effect of positive and negative response. The feelings, touching and observation on the model given improve their understanding of the topics. The small-group dynamic makes it easier for teachers to gauge students' progress and support them in developing their skills. Through this engagement and interaction process, teachers could identify the strength and weaknesses of the student.

Students Are Encouraged To Show Their Creativity Through Different Learning Styles

In this Bio-Made Easy workshop, the students were asked to work independently and collaboratively. Collaboration among student encourages student creativity (Collard, 2014). They have to find ways to complete the task, solve the problems, gather the information and know-how to use the technology. Lin, Wong, & Shao, (2012) reported that students who help their peers in completing the learning activities felt that their collaborative skills had improved. This collaborative skill leads to a higher confidence level and self-satisfaction. Collaboration also encourages cooperation within the group members (Friend & Cook, 1992). At the same time, students learn specific skills and manners such as presentation, negotiation, coaching and influencing others (Barrett & Donnelly, 2008). This situation could be observed from role-play activity implemented in Station 4 and 8. Role-play activity had been effective in achieving the three major learning domains: affective, cognitive and behavioral (Rao & Stupans, 2012). By making students take the role of another person, they practice empathy, which leads to more self-reflection and awareness. Hidayati and Pardjono (2018) reported that student's response shows that the role-play is an exciting activity, provides an opportunity for students to be creative, and easy to be applied. Rogayan Jr (2019) who found a similar finding reported that students engaged in learning stations helped one another and perform better compared to a student in a regular or traditional classroom setting. Students that participate in station rotation blended learning are gaining the skills they will need for the future. On the other hand, the use of technology such as video presentation and visualisation that implemented in Station 3 and 6 improves student's memory towards the topics discussed. This could help in understanding and imagining the complicated process of Biology such as photosynthesis and glycolysis. Several studies also proved that animation or learning through visualisation improve student memory and learning experience in the various field (Aloraini, 2012; Berney & Bétrancourt, 2016; O'Day, 2007).

Teachers And Students Have Flexibility In Grouping And Instruction Practice

In this blended learning approach, the teachers used a different style of delivery methods with and without the aid of technology. Station-based rotation combines various learning styles, such as presentation, role play, problem-solving, demonstration and collaboration. Providing various materials for the student to interact with; and options for expression allow students flexibility as they work with ideas and communicate. It is important to provide information in a way that is accessible to all learners. This is because each student is unique due to their background, cultures, knowledge and other factors. This concept of learning was discussed in detail by Algozzine and Anderson (2007), which called this learning style “differentiated instruction”. Differentiated thinking empowers teachers to be responsive rather than reactive to the unique and individual personalities, backgrounds, and abilities found within students (Rogayan Jr, 2019). Since the teacher is not part of the rotation, flexible groups can be assembled and reassembled according to the student's needs as identified by ongoing, formative assessments and teacher observation.

Limitations

Each station has to strictly follow 10 min of time allocation. Bell was rung after 10 min to indicate station transition. All instructors need to wrap up their activities and students need to move to the next station. Some of the instructors tend to exceed the time and mismanage to complete all the tasks. Moreover, some of the students were still engaged with the activity when the bell is rung. Fixed-time station rotation-based learning, in this case, does not provide sufficient time to master the basic concept of Biology.

Planning of the activities for each station is very crucial and critical by the instructors, especially for F grade students. The organization of the learning outcome and activity was prepared ahead by discussing the subtopics among the instructors. The most challenging factor in the planning stage was designing the activity that suitable for the time allocation for each station. Each task must be created and designed effectively without overlooking the fun elements to give an impactful moment to the student.

Some of the activities at the stations involved gamification and discussion. This led to a loud and noisy situation at the particular stations. Even though the classroom was spacious, such activities create a loud and noisy environment at the particular stations and not conducive for other students to learn. Students were distracted by the noise and unable to give full attention to the instructors. In conducting station-based rotation teaching, students and instructors must be able to appropriately manage the noise levels at their stations (Kracl, 2012).

Suggestion For Future Research

A survey should be conducted among the F grade students in order to identify the causes of their performance. Identifying the root causes of poor performance in Biology subject will help the instructors in creating effective ways for station rotation-based teaching. For instance, if the main reason for the underperforming is lack of interest in Biology, the activity of selected stations should connect the technology with Biology. Illustrating the biological concepts in an interactive way through multimedia materials such as video, podcast and others will help to enhance the interest of the students towards Biology. Motivation to learn Biology can be nurtured throughout the activity. Another important element that the instructor needs to take

into account in the survey is the individual's learning style (audio, visual and kinaesthetic). This needs to be matched with the activities in station rotation based.

Optimising the time for each station by depending on the activity and level of difficulty is vital in developing a systematic station rotation-based learning. Flexi-time station-based rotation allows students to engage with the activities at their own pace and move on to the next station when they are ready. Thus, the students will have ample time to improve their understanding and have chances to ask questions to the instructor. A pilot simulation of flexi-time station rotation based should be conducted in a small group to predict and troubleshoot all shortcomings of the activities at the respective stations.

The station rotation-based learning has very limited time at each station. Hence, an effective way of delivering a lesson in a short time is very tough, especially for low-grade students. In addition, learning Biology involves a lot of memorisation of terminology and process. Each station should provide an interesting mnemonic as a take-home message for the students. Mnemonic is a powerful tool in improving memory and retrieving information. A concept map from each station also would remind the students of what they have performed at the station.

Conclusion

The station rotation-based learning approach rendered a significant impact on foundation student performance in Biology. Prior to the intensive station-based workshop, the students were performing below the average grade (< 40 marks). However, after the workshop a significant improvement in performance and grading was achieved by the students after Test 2. This reflects that station rotation-based learning is an effective strategy in facilitating the poor performance students in understanding biology and could be implemented in the future for foundation students.

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