# Talapang: AR/VR Frog Dissection Software in Teaching STEM Biology

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*Abstract:* **Until now, most of the Filipino students learn the concepts in frog anatomy through the traditional method. Needs assessment was done and students gave negative feedback with regard to the traditional frog dissection method. One of the students said, "Knowing that frogs have their own lives, they should not be captured and dissected for educational purposes." Ethical issues in terms of using frogs for dissection- sacrificing frogs' lives for the sake of grades, shall be addressed through the development of the Talapang AR/VR frog dissection Software. According to the results of the study, it was identified that there was an increase in the scores of the students from pretest to post-test. The significant differences in the test scores among the Mo, AVi, and AVg groups and the significant differences between the intrinsic motivation levels of the students indicate that the Talapang software may be an effective tool in enhancing students' academic achievement as well as motivation. There are also positive feedback with regards to the software like, "I feel so great to use such advanced technology. I feel happy to experience the AR/VR software."**

*Keywords:* **frog, dissection, augmented reality, virtual reality, technology in education.**

## I.   INTRODUCTION

Students need to enhance 21st-century skills that involve three domains of knowledge: foundational (to know), meta (to act), and humanistic (to value). The foundational domain of knowledge focus on the human brain, an important part of the human body that is responsible for the cognitive learning process. Bloom et al. (1956) emphasized that the cognitive domains of learning focuses on how a learner recalls, comprehends, utilizes, distinguishes, synthesizes, and assesses obtained information in the process of learning. This foundational knowledge focuses on core content knowledge, cross-disciplinary knowledge, and information, communications, and technology (ICT) literacy so that learners, who are considering themselves as digital natives, would be able to meet the skill qualifications that are needed in the workplace (Kereluik et al., 2013). Enhancing these skills would enable students to become globally competitive as well. The development of an instructional material that would meet the standards of the 21st-century skills in the Philippines through visual technology systems such as AR/VR system would be highly commendable.

### A.   Overview of Augmented Reality and Virtual Reality

What lies behind what we see is something that goes beyond reality. This particular reality is not just about the things that we perceive as real, but we could be able to convert this reality into something that is augmented or virtual (AR/VR).

The concept of AR/VR in Philippine education is something new. In other countries, the AR/VR system is already utilized, especially in well- developed countries. There are differences between virtual reality and augmented reality. The concept of virtual reality focuses on three different elements that would eventually make it virtual- visualizing, involving

oneself in the medium, and interacting with the virtual world (Burdea & Coiffet, 2003; Kuksa & Childs, 2014; Sherman & Craig, 2003; Aczél, 2017). Augmented reality has similitude with virtual reality, but the image that it enhances resembles the real world. This would eventually lift the pictured image, making it realistic and three-dimensional (Mackay, 1998; Azuma et al., 2001; Pandya, 2015; Hilliges et al., 2018).

### B. Frogs, Dissection, and Virtual World

Frogs are an important part of the ecosystem. They play a key role in controlling pest populations as well as they indicate environmental health. They also aid in the prevention of diseases such as dengue, since insects serve as their food. These frogs are also used in educational and medicinal research. Say, for instance, Sy (2014) reported that frog species are part of the Philippine pet trade, such as Rhinella marina, which is used in dissection.

Dissection is the process of cutting apart a certain deceased species. This process enables the students to identify frog parts that have some sort of resemblance in the anatomical parts of a human being. Traditional cutting of frog specimen is still prevalent in the Philippine school setting, leading to a demand for frog supply. However, Sy (2014) reported that there are already recorded 35 exotic frog species in the Philippines, including Kaloula pulchra (Asian painted frog), Xenopus laevis (African clawed frog), and Hylarana erythraea (common green frog). Sad to say, different species of frogs continue to decline because of human inhumane dissections.

Frog dissection may present some sort of hazards because certain frog species are poisonous, such as Phyllomedusa bicolor (giant leaf frog), Phyllobates vittatus (Golfodulcean Poison Frog), and Ranitomeya variabilis (Splash-backed poison frog). Frog extinction can cause a threat to biodiversity and a problem in sustaining ecological balance. Also, the diseased animal is preserved in formaldehyde, which is a chemical that may present harmful effects on the health of the student. Lastly, dissection on a certain point of view teaches students how to be cruel to animals. This emphasizes that biology should not only be focused on studying life but by teaching learners how to give value and respect to every living creature on earth.

To address the concerns with regard to frog dissection as well as to preserve frog species in the Philippines, an alternative way of learning 21st-century frog anatomy in biology is presented through the utilization of AR/VR frog dissection in schools. Through this method, we would be able to identify a possible alternative tool other than the utilization of traditional frog dissection in a laboratory class setting.

## II.   LITERATURE REVIEW

### A. Issues with Traditional Frog Dissections

Dissection of frog species like Xenopus laevis, Rana pipiens, and Fejervarya limnocharis is still utilized as a part of the Philippine laboratory experiments up to this moment. Students were not given a choice of whether to dissect or not since it is part of the school curriculum. That is why there are approximately millions of frog species that are dissected in the Philippines per year, which may lead to its extinction.

There was a study concerning the perspective of sophomore science teachers who have already experienced dissecting frog species. They showed positive reactions such as being curious, interested, and excited in experimenting. Negative reactions were also shown, such as feelings of disgust, stress, fear, sadness, and displeasure. They had also lost their appetite, felt queasy and dizzy, their hands trembled while performing the experiment and their mouth dried (Besoluk & Demirhan, 2016). McCollum (1988) also emphasized that the lecture method in teaching anatomy caused student's scores to increase compared to the dissection process.

Frog dissection is considered an act of animal cruelty, although it may be legal to some countries like the Philippines, but only for research. Blazer (2015) emphasized that according to the People for the Ethical Treatment of Animals (PETA), the dissection process is not ethical and not moral. Although this particular dissection process may present some advantages like promoting hands-on involvement to learners, promoting the acquisition of certain skills like time management and task organization, introducing laboratory techniques to students who wanted to pursue medicine, and last but not the latter is promoting real-world experiences with real frog specimens.

The sad point about frog dissection would be the emotional disturbance that causes students. Animals also experience pain like what human beings experience, which is why animal dissection and/ or vivisection promotes harm to animals as well as the environment. This process also gives students the idea that animals are just disposable organisms.

The cost of frog dissection is more expensive than virtual frog dissection. Another common concern of students in dissection experiments is exposure to formalin, which causes them to have different health problems. Among the 75 responses, 58 students complained about formalin's unpleasant smell.43 students had runny or congested nose, 38 students had redness of the eyes and 34 students had unusual tiredness or dizziness. Some of the symptoms among students who performed the dissection experiment include, excessive lacrimation, prolonged sleeping time, itching or sore eyes, disturbance of sight, unusual thirst, respiratory distress, dry or sore throat, nausea, headache, disturbed nocturnal sleep, dry or sore nose, low assimilation, gastrointestinal tract disturbance, syncope (fainting episode), skins eruption, as well as itching or sore skin on hands. This particular chemical would eventually cause health hazards for students (Blazer, 2015; Onyije & Avwioro, 2012).

### B. AR/ VR in 21st Century Science Education

Virtual reality and augmented reality in education provide a lot of benefits. Rosenberger (2011) and Walling (2014) defended the utilization of virtual dissection as an alternative and emphasized that virtual alternatives provide the best way in anatomy education. Merchant et al. (2014) emphasized that learning outcomes were enhanced through the use of virtual reality-based instruction. Concerning student engagement in dissection, it was reported by Paretti et al. (2008) that virtual frog dissection enhanced student engagement in engineering students.

Virtual reality could be beneficial not only to students but also to people who have suffered emotional trauma, specifically post-traumatic stress disorder. In connection to this, it has been proven by Juan et al. (2005) that this system would be an effective tool in treating psychological disorders, particularly phobia. They have exposed patients with a phobia of cockroaches and found out that the patient was able to conquer the phobia on cockroaches. Because of this, the AR/VR system might also be a cure for Ranidaphobia or students who have a fear of frogs. This particular system is also used in psychotherapy training and treatments, neurosurgical training, health education, and SPED education (Beutler & Harwood, 2004; Lányi et al.,2006; Lemole et al., 2007; Ershow et al., 2011).



**Fig. 1: Hume's 3 Rs to consider in animal experimentation.**

Debates with regards to the utilization of species dissection or the use of dissection alternatives have been presented since the early times. Some stands go with the utilization of the original dissection process and some go with the alternatives. Osenkowski et al. (2015) reported that among their respondents, 76% of students and 84% of teachers still utilize dissection of species in their classrooms to improve student performance. Unfortunately, there are certain ethical controversies concerning the utilization of the dissection method- slaying frogs for the sake of a science grade. These frogs also experience difficulties when they are captured and transported in the laboratory. These frogs also experience pain and stress, especially when they are slain without the use of anesthesia or any pain relief (Bishop & Nolen, 2001; Blache, et al., 2008; Kolar, 2006; Oakley, 2009; Rosenberger, 1998; Sapontzis, 1995; Webster, 2014). These are the reasons why Charles Hume's 3 Rs which are reduction, refinement, and replacement in the experimentation of animals or the alternative animal dissection method was proposed (Flecknell, 2002) as shown in Figure 1.

The path model framework as shown in Figure 2 emphasizes the needs assessment of Traditional Frog dissection (TFD) through students'perceptions (SP 01) which would be the main basis for the development and validation of AR/VR Frog

dissection software (AVFD ). The AVFD branches into module only (Mo), AR/VR group (AVg), and AR/VR individual (AVi).These concepts branch into academic achievement (AA), intrinsic motivation (IM) as well as students' perceptions (SP ).
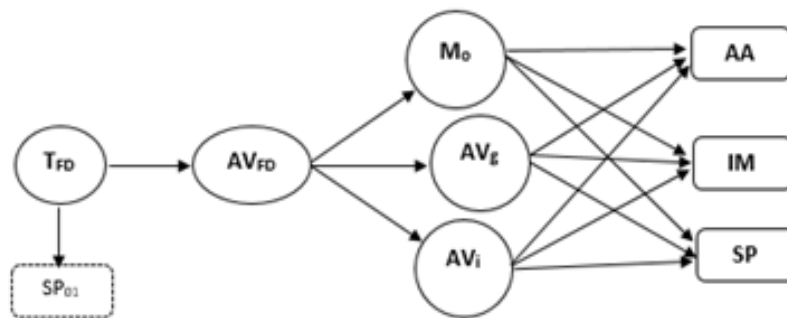


**Fig. 2. Path Model for AR/VR Development and Evaluation**

This research study aimed to identify the effect of utilizing the AR/VR frog dissection software in enhancing academic achievement as well as student engagement in the study of biology. Specifically, it seeks to address the following objectives:

1. Assess the needs to develop an AR/VR frog dissection software

2. Develop an AR/VR frog dissection software

3. Validate the newly developed AR/VR frog dissection software through the SNDAVS given to the content experts

4. Validate the MC exam before intervention through an item analysis

5. Determine the pretest scores of the student respondents

6. Determine the VARK scores of the student respondents

7. Determine the respondents' profile based on:

  7.1 Personal Features

    7.1.1 Biological Age

    7.1.2 Biological Gender

8. Determine the significant difference between the pretest and post-test scores obtained from:

  8.1 Module only

  8.2 AR/VR individual

  8.3 AR/VR group

9. Determine the significant difference between the obtained Post Test scores among the 3 groups (Mo, AVi, and AVg)

10. Determine the intrinsic motivation scores per category that were obtained from:

  10.1 Module only

  10.2 AR/VR individual

  10.3 AR/VR group

11. Determine the significant difference between the obtained intrinsic motivation (IM) scores among the 3 groups (Mo, AVi, and AVg)

12. Identify the student respondents' perceptions after they utilize the newly developed AR/VR frog dissection software.

## III. RESEARCH METHODOLOGY

The research conducted is a Developmental research which aims to develop a new digital tool that would meet the demands of 21st-century learners and enhance 21st-century skills towards global competitiveness.

### A. Sampling and Participants

The student respondents who participated in the study were randomly picked. Respondents were grade 12 STEM (Science, Technology, Engineering, and Mathematics) students only from the University of the East, Manila. Respondents were heterogeneous having distinct pacing and individual differences. There were 75 student respondents in the study, which were divided into 3 groups. This indicates that there were 25 student respondents in each group.

### B. Instruments Used

There were different instruments that were used in the study. The first one was a reflective journal paper that was intended to identify the lived experiences of grade 12 STEM students after conducting their frog dissection experiment. Then, you have the Survey on the Newly Developed Software (SNDAVS) for the verification of the Talapang software content. There is the MC Tier test which was administered after the intervention process. The intrinsic motivation inventory (IMI) questionnaire, VARK questionnaire, and Reflective Journal were administered to the student respondents.

### C. Procedure

Before the development of the AR/VR software, the researcher conducted the traditional dissection method to 122 grade 12 STEM (Science, Technology, Engineering, and Mathematics) students, which consisted of 57 male and 65 female student respondents which are all heterogeneous. This was done per batch (3 batches) to identify the students' perception with regard to conducting the traditional dissection experiment in Philippine schools. The students were asked to write a reflective journal that would seek answers to the following questions:

1. What did you feel after you conducted the frog dissection experiment?

2. What did you like about the frog dissection?

3. What did you dislike about the frog dissection?

4. What are the difficulties that you encountered after conducting the frog dissection experiment?

5. What can you suggest so that other students like you would better learn the concept of frog anatomy?

There was careful planning before the software content writing. The researcher conducted further research so that the word content of the software was considered correct and valid. The contents of the particular software were patterned and organized properly from the introduction, anatomical position, external parts, internal parts- coelom and viscera as well as the functions of each part. The researcher asked help from different professionals such as biology professors as well as IT experts so that the script content of the module as well as the software was verified properly.

The software development process was done by an IT developer through Unity. The contents of the said software were rechecked by content experts in different fields. The Talapang software was utilized as an augmented reality application using a cellular phone or utilized as a virtual reality application through a cell phone placed on VR glasses. The phones that can only be utilized using this application are android phones.

The particular software was validated and evaluated by 3 STEM Biology professors and 5 IT professionals. Revisions were done after the given software was viewed and reviewed by content experts through their comments and suggestions. Also, analysis and interpretation of the SNDAVS responses of the content experts were made with the help of the SPSS software and with the guidance of a professional statistician. Once the researcher had assurance that the newly developed software was ready to be utilized on the learners as instructional material, there was the administration of a pilot test before the real assessment of the effect of Talapang software in enhancing academic achievement as well as Intrinsic Motivation among STEM Senior High School Filipino students.

After the pilot testing, the researcher gathered data from the three groups after the intervention process. During the intervention, a pretest was first given in order to the knowledge of the students in biology prior to immersion in Talapang. The intervention was done after the pretest. The students were asked to read the module for the Mo group , individually use the AR/VR software for the AVi group, and use the software per group for the AVg group. After which, the posttest was given followed by the IMI, VARK, and reflective journal.

IBM SPSS (Statistical Package for the Social Sciences) was utilized as a statistical tool for the statistical treatment of data. The study involved descriptive statistics as well as inferential statistics. Measurement of the significant difference between the pretest and post-test scores of the students for each experimental group was measured using a parametric paired samples t-test. The significant difference between the 3 experimental groups was measured using one-way ANOVA. Finally, students' perceptions were analyzed using the thematic approach.

## IV. FINDINGS OF THE STUDY

### A. Pretest and Post-test Results

#### 1. Module Only (Mo)

In order to identify the level of increase from the pretest to the post-test after utilizing the module for learning frog anatomy in a classroom setting, the researcher made a graph between the pretest and post-test group as shown in Figure 3. The scores of the students who took the pre-test and it is indicated that the students who got the highest score for the pretest were student numbers 5 and 11, who both got 27 points.
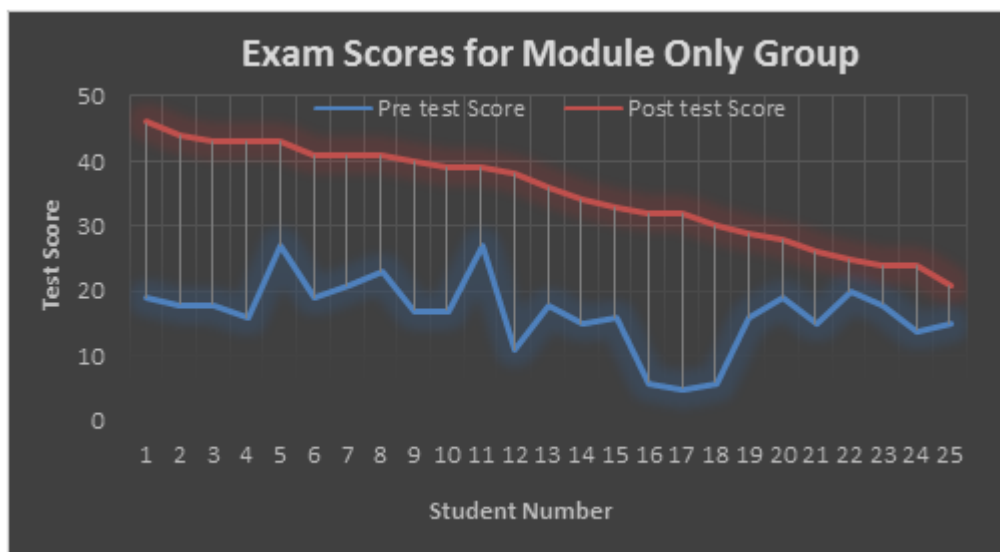


**Fig. 3: Graph showing the difference between the exam scores of student   respondents for module only group**

The lowest score for the pretest was also noted and it was student number 17, who got only 5 points. On the other hand, there is progress seen on all posttest scores after immersion in the modular approach to frog anatomy and physiology. The highest score for the post-test was attained by student number 1, who got 46 points out of 50 points. The lowest score noted was the score of student number 25, who got only 21 points. Students who displayed significant progress in their scores from pretest to post-test were student numbers 1, 4,12, and 17, who were able to have 27-points of increase in their scores from pretest to post-test. The mean value for the pretest was 16.64 having a standard deviation of 5.476, while the mean for the post-test is 34.88 having a standard deviation of 7.418.

#### 2. AR/VR Individual (AVi)

The researcher also noted the difference between the scores of the students who were immersed in the AVi frog dissection process. This shows that there is an increase in the students' scores, knowing that the software is new to the students. As shown in Figure 4, among the student respondents for AVi, it was noted that the person who got the highest score for the pretest was student number 12, who got 30 points. Meanwhile, the lowest scorer for the pretest was student number 24, who got only 8 points. The graph also shows the student who got the highest when they took their posttest. They were students 1 and 2, who both got 42 points. The lowest recorded score was obtained from student number 25, who only got 20 points. The highest increase in the score was obtained from student number 8, who got an increase of 24 points from his pretest score up to his post-test score.
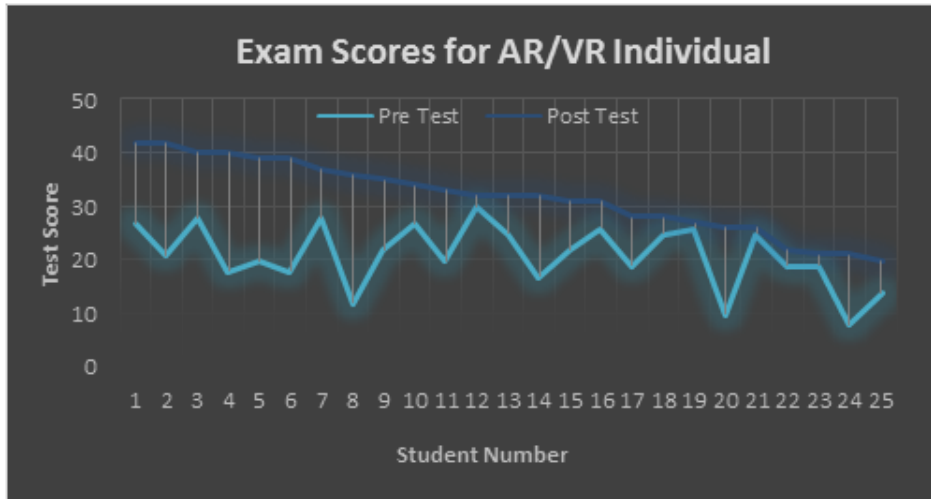
**Fig. 4: Graph showing the difference between the exam scores of student respondents for AR/VR- individual**

*3. AR/VR Group (AVg)*

Last but not the least, there is a need to tackle the graphical comparison between the pretest and post-test results for students under AVg. As shown in Figure 5, among all the student respondents under AVg, the highest score obtained when they had their pretest was 23, which was the score of student number 13. Meanwhile, student numbers 3 and 24 got the lowest scores of 5.
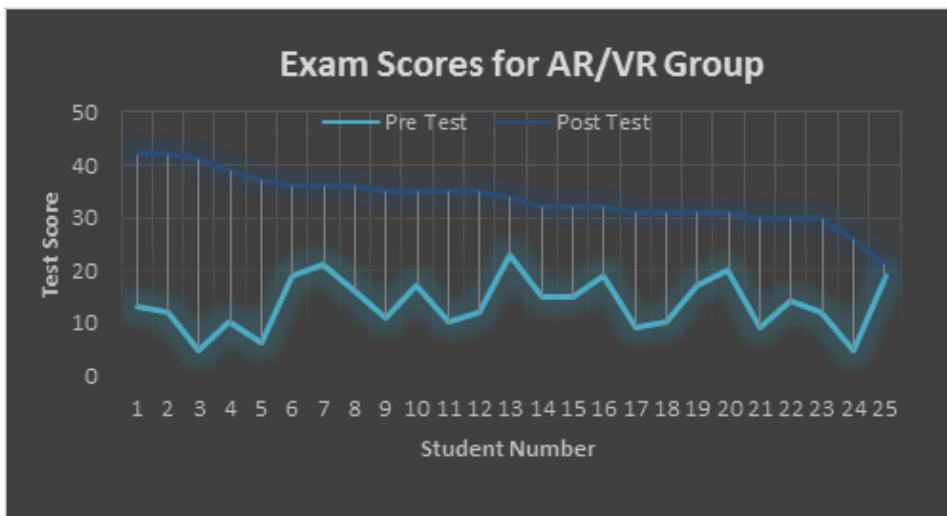


**Fig. 5: Graph showing the difference between the exam scores of student respondents for AR/VR- group**

In terms of the post-test scores of the students, student numbers 1 and 2 got the highest score of 42 and student number 25 got the lowest having the score of 21. In terms of the difference between the pretest as well as post-test scores, student number 3 got the highest improvement of a score. There was a 36-point difference between the pretest score and post-test scores of student number 3. This is higher than the Mo cluster as well as the AVi cluster. The mean value for the pretest results for the AVg was 13.56 and the mean value for the posttest was 33.60.

*B. Paired samples t-test for the pretest and post-test results*

**Table 1: Summary of the paired samples t-test results among the 3 experimental groups**

| Group | n | Mean (Pre-test) | Mean (Posttest) | Std. Deviation | Std. Error Mean | t value | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|
| Mo | 25 | 16.64 | 34.88 | 7.40090 | 1.48018 | -12.323 | .000 |
| AVi | 25 | 21.04 | 31.76 | 7.12110 | 1.42422 | -7.527 | .000 |
| AVg | 25 | 13.56 | 33.60 | 7.48042 | 1.49608 | -13.395 | .000 |

To address the dilemma if there is a significant difference between the pretest as well as post-test scores of the students, there is a need to utilize the paired samples t-test for the statistical treatment of data. Will the alternative hypothesis be accepted or rejected? Will the intelligent guess done by the researcher correct or not? In Table 1, the analysis done through SPSS indicates that the t value is -12.323 with a df value of 24. Since the p-value or significance value "0.000" is lower than "0.050", the null hypothesis must be rejected and the alternative hypothesis must be accepted. This indicates that there is a significant difference between the pretest and post-test scores in the module only group.

To identify if there is a significant difference between the pretest as well as the post-test results for the AVi cluster, there is a need to utilize again the paired-samples t-test with SPSS. Focusing on the results, Table 1 shows a value of -7.527 and df of 24. The p-value is "0.000" which indicates that there is a need to reject the null hypothesis and a strong acceptance of the alternative hypothesis. This reiterates that there is a significant difference between the pretest and the post-test scores among students who utilized AR/VR as part of their intervention individually.

The last group to be analyzed using the paired-samples t-test through SPSS would be the respondents who utilized AVg. As shown in Table 1, the t value is -13.395 and the df is 24. The p-value is "0.000" which is below "0.050", which denotes the acceptance of the alternative hypothesis, which emphasizes that there is a significant difference between the pretest scores and the post-test scores of student respondents who utilized the AVg.

*C. The significant difference between the obtained post-test scores among the 3 groups (Mo, AVi, and AVg)*

**Table 2: ANOVA for AA of the 3 experimental groups (Mo, AVi, AVg)**

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---|---|---|---|---|---|---|
| Between groups | 122.9867 | 2 | 61.49333 | 1.491149 | 0.231982 | 3.123907449 |
| Within Groups | 2969.2 | 72 | 41.23889 | | | |
| Total | 3092.187 | 74 | | | | |

A one-way analysis of the test scores among the 3 experimental groups was noted using one-way Analysis of Variance (ANOVA). As shown in Table 2, the p-value is approximately "0.23" which is higher than "0.05". This indicates that there is a need to accept the null hypothesis and reject the alternative hypothesis. Another factor is that the F value of 1.49 is less than the Fcrit value, which is 3.12. As an assumption, there was no significant difference between the mean values of the 3 groups that were utilized in the study (Mo, AVi, and AVg).

*D. Intrinsic Motivation*
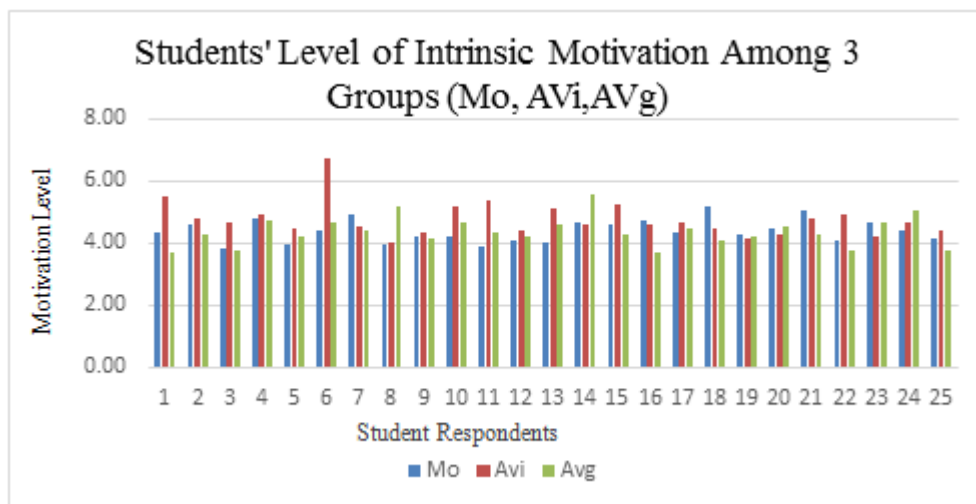


**Fig. 6: Students' level of intrinsic motivation among Mo, AVi, and AVg**

As shown in Figure 6, there is a variation in terms of the mean value for the average responses for the students in the 3 given groups: Mo, AVi, and AVg. It was also found out that there was a significant difference between the average motivation level of each student from the 3 different groups (Mo, AVi, and AVg).

## V. DISCISSION

Stated below are summary of the results of the study based on the given objectives:

**Objective 1:** Assess the needs to develop an AR/VR frog dissection software

The student respondents were asked to immerse in the traditional frog dissection experiment. Subsequently, their opinions about traditional frog dissection were gathered. Based on the statement of student number 75, *"Knowing that frogs have their own lives, they should not be captured and cut their body parts for educational purposes. Many frogs are killed for dissection. Also, formalin that is used for the preservation of the frog's body is uncomfortable to our eyes and nose."* The statement of student number 99 should also be emphasized, *"I did not like anything about having to dissect a frog. It made me realize that I do not like anything related to medicine."* Also, many students are complaining about the formalin like that of student number 17, *"I actually felt light headed and a bit rugged because of the diffusion of formalin into the air. It's quite nice that I got to experience dissecting a frog but its difficult and I just wanted to experience that once in my lifetime."* Because of these reasons, there is really a need to develop and AR/VR frog dissection software as stated by student 97, *"Maybe modern technology can be used as an alternative for actual frog dissection."*

**Objective 2:** Develop an AR/VR frog dissection software

The software was developed by Mr. Jermel Barrientos , an IT developer from Bataan. The software was subjected to revisions if there was erroneous information present.

**Objective 3:** Validate the newly developed AR/VR frog dissection software through the SNDAVS given to content experts

The software was validated by 5 IT experts and 3 Biology professors. The mean rating given by the IT expert to the said AR/VR frog software was 4.39 which is rounded off to "4". They gave the software the assessment of *"Very Good"*. Meanwhile, the Biology professors gave a lower score. When you calculate the mean score that they gave to the software, it is 3.77 but when you round it off, it is equivalent to "4" or *"Very Good"* as well. There are also comments given by the experts on the said software, such as, *"It is unique to the students. I never encountered this kind of educational yet exciting game",* and *"that through this software, users can dissect and learn the anatomy of the frog without needing to kill one. Another good point is that the users with no experience in VR will be exposed to this kind of technology. I think that it will be very fun for them and this may broaden their interest in the new technology."*

**Objective 4:** Validate the MC exam prior to intervention through item analysis

Based on the item analysis made, the diff value for the MC Exam was 49.40, which indicates an average exam. Through this, you can identify that the exam is not that hard and not that easy. Also, each exam question does not fall below the 30 points diff value, which is good. Based from the item analysis done, the entire exam is considered as *"Very Good"* which can be administered already to the student respondents.

**Objective 5:** Determine the pretest scores of student respondents

The mean pretest scores of the student respondents for each group will only be emphasized. With regard to the Mo group, the mean pretest score of the student respondents was 16.64. For the AVi group, the mean pretest score was 21.04, while the mean pretest score for the AVg group was 13.56.

**Objective 6:** Determine the VARK scores of student respondents.

There are diverse learning styles of the students and through VARK, they will be able to identify if they are visual, auditory, read/write, or kinesthetic learners. For the Mo group, there are 4 visual, 8 aural, 8 read/write, and 10 kinesthetic learners. For the AVi group, there were 6 visual, 8 aural, 8 read/write, and 8 kinesthetic learners. Lastly, for AVg, there 3 visual, 10 aural, 13 read/write, and 13 kinesthetic learners. Note that the total value exceeds the sample size. This is due to an overlap of the VARK because many students have multimodal learning styles.

**Objective 7:** Determine the respondents' profile based on:

a. Personal Features

   i. Biological Age

The respondents' age who participated in the study ranges from 17 up to 19 years old. There are 36 respondents who were 17 years old, which comprises 48% of the total sample size while there are 38 samples (51%) who are 18 years old and only 1 person (1%) was 19 years old.

ii. Biological Gender

There were 39 (52%) male and 36 (48%) female respondents who participated in the study.

**Objective 8:** Determine the significant difference between the pretest and post-test scores obtained from:

a. Module only

Based on the results obtained from the paired samples t-test results, having a p-value of "0.000", indicates acceptance of the alternative hypothesis, which indicates that there is no significant difference between the pretest and post-test scores for the Mo.

b. AR/VR individual

A p-value result of "0.000" for the AVi cluster shows that we need to accept the alternative hypothesis. Because of this, we can say that there is no significant difference between the pretest and post-test scores for the AVi cluster.

c. AR/VR group

Lastly, a p-value of "0.000" for the AVg was obtained. This shows the need to reject the null hypothesis and accept the alternative hypothesis. Thus, there was a significant difference between the pretest and post-test scores in the AVg.

**Objective 9:** Determine the significant difference between the obtained Post Test scores among the 3 groups (Mo, AVi, and AVg)

Using one-way ANOVA, it was found out that the p value is "0.232", which indicates that there is a need to reject the alternative hypothesis and accept the null hypothesis. Therefore, there was no significant difference between the obtained pos-ttest scores among the 3 groups (Mo,AVi, and AVg). Take note as well the F value of "1.491" is lower than the Fcrit value of "3.123".

**Objective 10:** Determine the intrinsic motivation scores per category which was obtained from:

a. Module only

The intrinsic motivation level of students was divided into specific categories. The mean score for each category was identified for the module group only. For the Interest or enjoyment, a mean score of 5 signifies that the students "Somewhat Agree" that they enjoyed the given activity. A mean score of 5 ("Somewhat Agree") for perceived competence, 5 ("Somewhat Agree") for effort/ importance, 3 ("Somewhat Disagree") for pressure/ tension, 4 ("Neither Agree/Disagree") for perceived choice, and 6 ("Mostly Agree") for value/usefulness.

b. AR/VR individual

For AR/VR individual, the Interest/ enjoyment is 5 ("Somewhat Agree"), the perceived competence is 5("Somewhat Agree"), the effort/ importance is 5("Somewhat Agree"), the pressure/tension is 4("Neither Agree/Disagree"), the perceived choice is 4 ("Neither Agree/Disagree"), and the value/usefulness is 6 ("Mostly Agree").

c. AR/VR group

The students who were grouped while utilizing AR/VR had varied motivation levels per category. In terms of interest or enjoyment, they show a mean value of 5 ("Somewhat Agree"), 4 ("Neither Agree/Disagree") for perceived competence, 5 ("Somewhat Agree") for effort/ importance, 4 ("Neither Agree/Disagree") for pressure/ tension, 4 ("Neither Agree/Disagree") for perceived choice, and 5 ("Somewhat Agree") for value/usefulness.

**Objective 11:** Determine the significant difference between the obtained intrinsic motivation (IM) scores among the 3 groups (Mo, AVi, and AVg)

In identifying the significant difference between IM scores, one-way ANOVA was used. The p value obtained was "0.0076" which is below "0.05". Therefore, there is a need to reject the null hypothesis and accept the alternative hypothesis. The data show that there is a significant difference between the obtained IM scores among the 3 groups (Mo, AVi, and AVg). Note that the Fcrit value of 3.12 falls below the F value of 5.22.

**Objective 12:** Identify student respondents' perceptions after they utilize the newly developed AR/VR frog dissection software

Thematically, the perceptions of the students were analyzed and presented on this part of the results of the study. The response of student 11 indicates, *"I feel that I have learned something new about frogs. The newly gained knowledge can be beneficial."* In terms of the AR/VR frog software, student 4 said, *"I find it cool, and I felt excited while doing the activity, because I'm not really sure if I can hold a frog."* According to student number 21, *"I feel so great to use such advanced technology. I feel happy to experience the AR/VR software."*

# VI. RECOMMENDATIONS

In terms of the salient results of this research study, the researcher presents the following recommendations for the improvement of the said research study:

1. Recommendation for the Improvement of the AR/VR Frog Dissection Software

   a. The developed AR/VR software should be improved in terms of its contents as well as ease of usage.

   b. VR glasses should be utilized in a computer laboratory with one VR glass per student.

   c. The AR/VR software should be modified so that any kind of cellular phone can view it.

   d. Include other organ systems of the said software and make it more detailed.

   e. Make the frog software more realistic.

2. If similar studies should be conducted, future researchers must:

   a. Use sufficient time to gather data.

   b. Collect data from different schools and compare the results of the study.

   c. Try to request other teachers to be the one who will demonstrate the usage of the given software to the class, the researcher will just observe.

   d. Measure other variables like extrinsic motivation, test anxiety, persistence level, biology readiness and the like

3. The results of the study prove that AR/VR enhances the students' academic achievement and enables them to be motivated to learn the different concepts in biology, specifically Anatomy and Physiology. Utilization of the AR/VR frog dissection software along with its module is highly recommended to be utilized in a classroom setting as an alternative tool for the traditional frog dissection experiment.

# VII. CONCLUSIONS

Looking back on the results and discussion part of this research study, the conclusions below were made:

1. There was a significant difference between the pretest and post-test scores for the students who utilized the module only. Using the frog module inside the classroom can enhance students' exam scores.

2. There was a significant difference between the pretest and post-test scores for the students who utilized AVi. Using AR/VR individually inside the classroom can significantly increase students' test scores.

3. There was a significant difference between the pretest and post-test scores for the students who utilized AVg. Using AR/VR by a group inside the classroom can also significantly increase students' test scores.

4. There was no significant difference in the post-test scores between Mo, AVi, and AVg. Meanwhile, the mean result of the post-test scores among the 3 experimental groups were almost the same.

5. There was a significant difference between the intrinsic motivation of students among the 3 experimental groups (Mo, AVi, and AVg). This means that the students had varied levels of motivation per group.

6. It was surprising that the student who had an aural learning style got the highest result for the post-test on the module only group, while most of the kinesthetic learners got the highest score for the posttest after they utilized the AR/VR frog dissection software.

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