International Journal of Multidisciplinary Education and Research
www.multidisciplinaryjournals.in
ISSN: 2455-4588
Received: 25-02-2023, Accepted: 11-03-2023, Published: 27-03-2023
Volume 8, Issue 1, 2023, Page No. 66-72

Augmented reality in contextualized field-based instruction on students' engagement and academic performance in biology

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Abstract
Augmented reality in contextualized field-based instruction is a teaching strategy that incorporates promising approaches to enhance and develop students' interest and conceptual understanding of biological concepts. This study focused on the use of augmented reality in contextualized field-based instruction as an instructional tool. The study aims to describe the engagement of students in Biology who are exposed to ARCoFBI and those exposed to non-ARCoFBI in terms of cognitive, affective, and behavioral; assess the students' academic performance in Biology who are exposed to ARCoFBI and those exposed to non-ARCoFBI; find out the significant difference in the students' engagement in Biology who exposed to ARCoFBI and those exposed to non-ARCoFBI in terms of cognitive, affective, and behavioral; and ascertain the significant difference in the students' academic performance in Biology who are exposed to ARCoFBI and those exposed to non-ARCoFBI. The study was participated by the Grade 9 students of San Isidro Integrated School, San Isidro, Valencia City, Bukidnon utilizing quasi-experimental research design. The results were analyzed using descriptive statistics and Analysis of Covariance (ANCOVA).
The results revealed a "highly engaged" indication of students' engagement in Biology when exposed to ARCoFBI in terms of cognitive, affective, and behavioral domains, with affective domain having the highest mean among the engagement domains, followed by behavioral and cognitive domains. Students' academic performance when exposed to ARCoFBI was in high level on their posttest from a very low level on their pretest. A significant difference was observed on both engagement and academic performance which indicates that there is significant difference in the level of students' engagement and academic performance in Biology when exposed to ARCoFBI and those exposed to non-ARCoFBI. The null hypothesis of this study was all rejected, which implies a positive indication. By the results shown, it is observed that as engagement of the students increases, their academic performance also progresses. With this, it is recommended to utilize an augmented reality as an instructional tool in a contextualized field-based instruction to broaden students' understanding of biology concepts.

Keywords: augmented reality, contextualization, field-based instruction, engagement, academic performance, biology

Introduction
The science education curriculum in the Philippines has been reviewed to address the trend and impacts of globalization in response to the country's many concerns. As a result, the K–12 Basic Education Curriculum was implemented to meet the ongoing vicissitudes in the many educational disciplines. Consequently, the program was changed from fixed to spiral curriculum progression to improve the students' performances.
However, the Filipino learners' performance in the 2019 Trends in International Mathematics and Scientific Studies (TIMSS) [45] and the 2018 Programme for International Student Assessment (PISA) [34, 42] exhibited low student performance in sciences and mathematics. The Inquirer.net (2019) [23] reported that the assessment results coincide with the previous National Achievement Test (NAT), with scores showing "low mastery" of the concepts. In addition, the recently conducted Division Achievement Test (DAT) of the Division of Valencia City revealed that San Isidro Integrated School had obtained an overall mean percentage score (MPS) of 67.57, which interprets "nearly proficiency" in the concepts. The results seemed alarming since DepEd has set its standards to 75 percent to achieve its goal of quality education. This problem may relate to several issues encountered in the country's educational system, such as the quality of education, lesser educational budget, poverty, brain drain, and lack of school facilities which are kept unaddressed [7] and is worsening due to the Covid-19 pandemic. [46]
The global pandemic has influenced the educational process, which has required the use of alternative learning modalities. As a result, students have been more likely to have challenges and stress while dealing with the subjects, impacting their physical and psychological well-being. These stressors significantly affect students' concentration, motivation, and engagement during online classes [25]. In this sense, they actively involve the students in any teaching and learning interaction with the aid of technology, creating a positive engagement among students [26] and an improvement in their academic performance [4, 19, 30].
Contextualization is one of the trends in education which helps students understand basic and complex science concepts. It enhances students' conceptual understanding and interest with the aid of localized instructional materials and engages students to apply different science concepts in a more straightforward and realistic illustration [13].
On the other hand, field-based instruction allows the students to discover and realize how important the field environment is in learning different science concepts. This instruction will put them into a situation where they will learn the concepts in an exciting and motivating condition. Moreover, field-based instruction allows students to

understand a real-world perspective on a subject matter [26]. Augmented reality notably impacts teaching and learning science courses through the integrative process between real, virtual, and technology environments. Further, AR technology might enhance the students' interest, where they can actively interact with the real environment and technology [28].

With this new normal mode of learning delivery, there is also a need to modify different strategies to address issues concerning students' interests and how they will perform to improve their learning. For example, it has been observed that field-based learning is declining in academic institutions. This study anticipates integrating several methods to augment students' conceptual understanding of biology to avoid misconceptions. In addition, this study assessed the extent of augmented reality in contextualized field-based instruction (ARCoFBI) on students' engagement and academic performance in biology. Lastly, this study provides additional input to the educational system in improving and developing students' interest and performance in science education.

Methodology

This study utilized a quasi-experimental research design involving pretest-posttest to determine the effects of augmented reality in contextualized field-based instruction on engagement and academic performance of Grade 9 biology students in San Isidro Integrated School, San Isidro, Valencia City, Bukidnon, Philippines. Two (2) intact Grade 9 sections from the first quarter of 2022-2023 participated in the study. One group was exposed to ARCoFBI (experimental) integrating AR applications and contextualized field-based instructions, while the other was exposed to non-ARCoFBI (control group) utilizing conventional approach. Both groups utilized the 7E learning cycle. This study used academic assessment that consist of fifty (50) item multiple-choice test and non-academic assessment that consist of thirty (30) item students' engagement statements adapted from Hart, Stewart, and Jimerson (2011) [21]. Both instruments were content validated by three biology experts, pilot tested, and showed reliability of 0.787 (academic assessment) and 0.853 (non-academic assessment). The participants were given an orientation and accomplished the informed consent prior to the study. Statistical tools that were used includes descriptive statistics and ANCOVA.

Results and discussion

This presents the analysis and interpretation of data gathered in the study. The order of the presentation follows the arrangement of the problems and objectives identified in the study.

Levels of Students' Engagement in Biology

Table 1: Summary of Students' Engagement in Biology

Indicators	ARCoFBI				Non-ARCoFBI			
	Pretest		Posttest		Pretest		Posttest	
	Mean	QI	Mean	QI	Mean	QI	Mean	QI
Cognitive Engagement	3.61	HE	4.01	HE	3.71	HE	3.76	HE
Affective Engagement	3.95	HE	4.21	HE	4.01	HE	4.07	HE
Behavioral Engagement	3.56	HE	4.02	HE	3.55	HE	3.68	HE
GRAND WEIGHTED MEAN	3.71	HE	4.08	HE	3.76	HE	3.84	HE

Table 1 summarizes students' engagement in biology between ARCoFBI and non-ARCoFBI before and after the intervention. The overall means of both groups in terms of pretest and posttest indicates "high engagement," which implies that students are interested to learn in biology. The overall students' engagement during the pretest was 3.71 in ARCoFBI, while 3.76 in non-ARCoFBI. The affective domain obtained the highest mean, followed by the cognitive and behavioral domains. These results relate to the emotion of the students, wherein it facilitates a more significant role in improving students' abilities. When students are happy, positive outcomes may recuperate. Hence, prior engagement may seem to be a basis for their performance.

Moreover, this finding implies that students are emotionally prepared to learn biology. It can also be associated with an increased level of student performance. This result is similar to the study of Polestico (2020) [38], which found that the affective domain (3.95) obtained the highest mean, followed by the cognitive (3.61) and behavioral domains (3.56). Cavilla (2017) [5] iterated that developing self-reflection creates positive self-esteem and increases cognitive levels and academic performance.

The overall students' engagement after the intervention revealed a higher mean in both groups. The ARCoFBI group obtained a mean of 4.08, while the non-ARCoFBI group obtained a mean of 3.84, interpreted as "high engagement". The affective domain obtained the highest mean of 4.21, followed by behavioral engagement with a mean of 4.02 and cognitive engagement with 4.01, implying that the students are happy when they acquiesced to interactive strategy. This discovery substantiates a positive interaction of students toward the subject. This implies that biology subjects interest students, which further improve their engagement and performance. The use of an interactive approach intricately incorporated with valuable technologies, enhanced and improved their interest and engagement in biology.

These findings are similar to the study of Akcayir and Akcayir (2016) [3], which states that supporting AR application to student-to-content interaction occurs in learning which enhances and develops the students' interest in the lessons. Results also agree with Davidsson and Granklint-Enochson (2021) [9] and Reyes *et al*. (2019) [40] that students are more active and participate well when lessons are more contextualized, which can support students in relating content to experience. In addition, Chapple *et al*. (2022) [6] suggest that utilizing convenient and authentic approaches improves students' attitudes, behavior, and emotional well-being. Lastly, Eunice and Michael (2016) [15] said that the more teaching extends outside the classroom to a real-world setting, the more meaningful the understanding of the lesson will be. Accordingly, outdoor learning experiences integrated with technology can significantly

enhance motivation and interest, supporting more meaningful knowledge and understanding [14]. Thus, exposing students to ARCoFBI positively impact their engagement with the subject, and when they are highly engaged, their academic performance also increases.

Level of Students' Academic Performance in Biology

Table 2: Level of Students' Academic Performance in Biology

Performance	ARCoFBI				Non-ARCoFBI				QI
	Pretest		Posttest		Pretest		Posttest		
Percentage Score	N	%	N	%	N	%	N	%	
90% – 100%	0	0	13	39.39	0	0	8	28.57	VH
85% – 89%	0	0	12	36.36	0	0	7	25.00	H
80% – 84%	0	0	4	12.12	0	0	6	21.43	A
75% – 79%	3	9.09	4	12.12	2	7.14	7	25.00	L
74% Below	30	90.91	0	0	26	92.86	0	0	VL
TOTAL	33	100	33	100	28	100	28	100	
Weighted Mean	18.85 (VL)		43.12 (H)		18.11 (VL)		40.04 (A)		

As shown in Table 2, the pretest mean of the ARCoFBI group was 18.85, interpreted as "very low." There were 3 (9.09%) students who belonged to "developing" students, interpreted as low performance, and 30 (90.91%) students who were beginning, interpreted as "very low" performance. On the other hand, there were 2 (7.14%) students belonging to a developing and 26 (92.86) who were beginning students, with an overall mean of 18.11, interpreted as "very low" academic performance. The results suggest an alarming condition as it reflects the lower performance of the students in biology. This means that an interactive teaching approach to improve the students' performance needs to be developed. As discussed, the results imply that students in the ARCoFBI group and non-ARCoFBI had little to no background knowledge about the subject since most had very low scores in their pretest.

The results took congruency with the studies of Asparin and Tan (2018), Pagtulun-an and Tan (2018), Segumpan (2018), and Yonzon (2017), which indicate that students got low scores during pretests because they did not have enough prior knowledge on the given test. Correspondingly, students also still need to meet the learning competencies of the lesson.

Moreover, as shown in Table 2, the students' academic performance in posttest was revealed. A "high proficiency" performance in the ARCoFBI group corresponds to an obtained mean of 43.12. There were 13 (39.39%) very proficient students, 12 (36.36%) proficient students, and 4 (12.12%) approaching proficient and developing students. On the other hand, the non-ARCoFBI group has a mean of 40.04, interpreted as average.

This implies that when students were exposed to ARCoFBI, their ability to contextualize biology concepts through a field-based approach was enhanced. Likewise, students' knowledge has improved as more students had higher performance scores on their posttest. Furthermore, the overall students' performance in both groups also increased.

The use of the interactive approach has significantly impacted students' performance, as it was observed in the ARCoFBI group that 39.39% of the students were very proficient, from initially 90.91% considered beginners. The findings were similar to the descriptive results of the studies of Aguanta and Tan (2018) [2] and Galarosa and Tan (2022) [19], wherein students' performance was "low" before exposure to an intervention, and an increase in students' performance revealed after exposure to the intervention. In addition, results also revealed that using interactive and active learning approaches positively impacts students' performance [1, 33, 44].

The students' engagement also powers up the students' academic performance. An increase in the level of students' academic performance can be related to their gladness, interest, and intrinsic motivation [8] [36], goal drive, persistence, enthusiasm, efforts, and attitudes [17] [18], and their cognitive constructs toward the subject [37].

Utilizing technology, contextualizing the lesson, sending the students to a real-world setting, and giving them activities enhance their broad perspective and influence students' academic performance in biology. This claim means that the students' performance depends on the intervention employed, in which the more active the intervention, the better the students will perform. This is consistent with Juniati and Budayasa (2021) [24] and Whitmeyer *et al*. (2020) [47] that the variety of teaching approaches enhances students' performance and ability to connect concepts to real-life experience.

Moreover, the students' performance is also dependent on the school environment they are interacting with, such that an excellent atmospheric condition in the teaching and learning process positively affects the students' academic performance [20, 22]. This proves that learning in a field setting is a powerful tool for developing students' knowledge and environmental literacy, which is essential for stimulating a better understanding of biological concepts [16] [41].

Additionally, allowing students to perform outdoor fieldwork or learning exercise allows them to acquire knowledge from the material under study [15]. This helps them to view biological concepts in their local context, such as in learning competencies taught during the implementation of the study. The more contextualized the lesson is, the more the students can connect their experiences from the lesson content to their context of understanding [9, 12, 13, 31, 40].

However, the current findings of the study do not conform with the results of Yapici and Karakoyun's (2021) [48] study. Instead, they claim that poor performance and interest of the students may prevail due to unaddressed technological problems. Further, Sharma (2016) [43] contradicts with the study's results, concluding that teaching through field-based instruction is not as beneficial as a traditional approach in improving students' attitudes and performance. Therefore, it is with consideration to concisely adopt Eunice and Michael's (2016) [15] disposition that traditional teaching

should be discouraged because they possess an exclusive monopoly of knowledge that may affect students' academic performance. Thus, using augmented reality in contextualized field-based instruction is as effective as a tool for active learning mechanisms.

Comparison of Students' Engagement in Biology

Table 3: Comparison of Students' Engagement in Biology

Group	N		Mean	SD	
ARCoFBI	33		4.08	.30	
Non-ARCoFBI	28		3.84	.38	
Total	61		3.96	.36	
Source	**Sum of Squares**	**df**	**Mean Squares**	**F-Value**	**Sig.**
Corrected Model	1.098[a]	2	.549	4.862	0.11
Pretest (Covariate)	.230	1	.230	2.036	.159
Group	.898	1	.898	7.958	0.007*
Error	6.435	57			
Total	947.637	61			

Table 3 summarizes the ANCOVA of the overall students' engagement in biology for both groups. A higher mean was observed in the ARCoFBI group, with a mean of 4.08 at 0.30 SD, compared to the non-ARCoFBI group, with a mean of 3.83 at 0.38 SD. The results displayed a low SD, implying that the data huddled near the mean. The mean values showed a less diverse distribution, indicating a corresponding equilibrium within the group.

Further, it revealed a statistically significant difference between both groups with a computed F-value of 7.958 ($P<0.50$), which means that there is enough evidence to prove that there is a difference in the engagement levels of students who are exposed to ARCoFBI and those exposed to non-ARCoFBI. This means there is enough evidence to distinguish the extent of ARCoFBI toward students' behavioral engagement. The ARCoFBI intervention facilitates the active participation of students and helps them acquire essential skills necessary to understand biology concepts better.

This value implies that students' engagement in biology when exposed to ARCoFBI and those in non-ARCoFBI has a significant difference with the computed *p*-value 0.007 ($p<0.050$), indicating a highly significant difference in the student engagement level of both groups. Therefore, it rejects the null hypothesis that there will be no significant difference between the students' engagement level of students in biology who are exposed to ARCoFBI and non-ARCoFBI. Hence, ARCoFBI as an intervention facilitates students' active participation and interest in learning biology, implying that the significant difference allows a distinguishing and valuable relevance as to their extent of enhancing students' engagement and performance. Furthermore, it further enhances their attitude, cognition, and emotions, as observed in the increase in all engagement domains.

This finding coincides with Piryani *et al*. (2019) [37], which concluded that when students are actively involved in the learning process with an engaging learning environment, it resembles higher engagement and academic performance. Further, the results support Lei *et al*. (2018) [27], which determined a moderately strong and positive correlation between student engagement and academic performance. Devito (2016) [11] further argued that highly engaged students were frequently active participants in a variety of in-class activities and eager to answer teacher's inquiries, while those who were less engaged had a lower performance which is observable in the non-ARCoFBI group's performance.

In contrast, it is inconsistent with Marpa's (2016) [32] findings, which revealed that students' behavioral and cognitive engagement was high while affective engagement was average. In addition, Madernach (2015) [29] stated that student engagement should promote higher levels of engagement in schools. Thus, promoting interactive strategies such as augmented reality in contextualized field-based instruction is recommended.

Comparison of Students' Academic Performance in Biology

Table 4: Comparison of Students' Academic Performance in Biology

Group	N		Mean	SD	
ARCoFBI	33		43.12	3.97	
Non-ARCoFBI	28		40.04	5.86	
Total	61		41.83	5.19	
Source	**Sum of Squares**	**df**	**Mean Squares**	**F-Value**	**Sig.**
Corrected Model	395.566[a]	2	197.783	9.468	.000
Pretest (Covariate)	225.916	1	225.916	10.814	0.002*
Group	129.286	1	129.286	6.189	0.016*
Error	1190.767	57			
Total	106588.000	61			

Table 4 presents the Analysis of Covariance (ANCOVA) of the posttest results for both groups using the pretest as a covariate. Based on the data, the ARCoFBI and non-ARCoFBI group obtained a mean of 43.12 (SD=3.97) and 40.04 (SD=5.86), respectively. In addition, the computed F-value within the pretest (covariate) was 10.814, and the p-value was 0.002 ($p<0.050$), while between groups was 6.189 at a p-value of 0.016 ($p<0.050$), indicating a highly significant difference. The scores of the students are highly varied and distributed, implying that the performance is not contained in the maximum or minimum score. The students' performance was trenched towards average to a high level of performance. Thus, students performed well in biology.

The results revealed a significant difference implicating that there is enough reasonable evidence in assessing and evaluating the extent of ARCoFBI, which facilitates students' academic performance. This further implies that the effective implementation of ARCoFBI significantly improves students' performance, as observed in the increase in their posttests scores. Thus, intricately involving the students in this kind of intervention may develop them academically.

The findings implied that students' academic performance in biology improved when exposed to ARCoFBI. Therefore, it rejects the null hypothesis that there is no significant difference in the students' academic performance in biology between the ARCoFBI and the non-ARCoFBI groups.

This finding conforms with the studies of Aque *et al*. (2021) [4], Degracia (2022) [10], Galarosa and Tan (2022) [19], Inocencio (2018) [22], Montecillo (2019) [33], Pangcoga (2018) [35], and Rajabalee *et al.* (2019) [39], that students' academic performance improved after given an interactive intervention compared to the traditional way of teaching. The increase in the students' academic performance is a result of their improved engagement in class.

The results coincide with D'Errico *et al.* (2016) [8] and Pilotti *et al*. (2017) [36] that students perform better when emotionally engaged and intrinsically and extrinsically motivated. In addition, their persistence, goal drive, effort, interest, and good time attitude help them perform and finish their task in a given time frame [17, 18]. This means that when students actively engage in the learning process, their cognitive process may be enhanced, resulting in improved academic performance [37].

The findings showed a positive association and relationship between the given intervention, engagement, and academic performance, seen through the students' engagement and academic performance when employed with ARCoFBI. In addition, the results consistently agree with Eunice and Michael's (2016) [15] findings that field-based experiences improved students' understanding of the subject and significantly influenced their performance. Thus, science secondary high school teachers may apply the field-based teaching method to promote students' learning performance and engagement and to broaden their perspective.

The result contradicts Sharma's (2016) [43] findings that teaching through field-based instruction is less beneficial than traditional instruction in improving students' attitudes. Thus, incorporating several methods to make field-based instruction valuable is recommended to attain its objectives

Conclusions and recommendations

Based on the findings of the study, the following conclusions were drawn:

The level of students' engagement in biology when exposed to ARCoFBI and non-ARCoFBI in the following domains were: "highly engaged" in both groups, affective engagement showed the highest level in both groups, and cognitive engagement showed the lowest level in ARCoFBI. The overall engagement indicates a high level of engagement both in the pretest and posttest of ARCoFBI and non-ARCoFBI. The students' academic performance in biology when exposed to ARCoFBI was high, while when exposed to non-ARCoFBI was average. There is a significant difference between students' engagement in biology when exposed to ARCoFBI and non-ARCoFBI, rejecting the null hypothesis. Furthermore, the three (3) different engagement subscales significantly impacted the students' learning outcomes. A significant difference exists in students' academic performance when exposed to ARCoFBI and non-ARCoFBI, rejecting the null hypothesis. Hence, augmented reality in contextualized field-based instruction positively impacts students' learning process, resulting in higher posttest scores.

The results and findings of the study led to some recommendations that could help further research. Augmented reality in contextualized field-based instruction may be utilized as a supplementary aid during discussions and activities since it has been observed that it allows the understanding of complex concepts in biology and improves academic performance.

1. In students' engagement, the study revealed that only two sub-scales significantly differed between groups. Thus, the researcher recommends developing students in their mental and physical aspects, especially emotionally, as it will affect their performance. Further, additional sub-scales could also be considered in future research to cater to different variables that would help students be more engaged in the subject.
2. The study's findings showed a significant difference considering its sample size; this could be a basis for future research to broaden the variables to explore other learning areas and to ensure the significance of augmented reality in contextualized field-based instruction.
3. School administrators and curriculum developers may conduct training and workshops for teachers on making contextualized field-based instruction with the aid of augmented reality technology, which would help learners in their learning process and increase their engagement towards biology.
4. Teachers may also use contextualized field-based instructions in a collaborative way of learning to interact during activities to acquire diverse perspectives from their peers. With that, there will be an exciting outcome in terms of their learning performances.

Lastly, future researchers may look for other variables to show and replicate the positive results of employing augmented reality in contextualized field-based instruction, not only in the field of biology. In addition, future researchers may also consider other technologies to develop better the context of contextualized field-based instruction for better student engagement and academic performance.

Acknowledgment

Many people and organizations contributed to the success of this study. In particular, the researchers are very grateful to

Central Mindanao University, San Isidro Integrated School, and the Department of Science and Technology Science Education Institute (DOST-SEI) for all the support they have provided throughout the conduct of the study.

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