International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Effect of Learning Biology Through Virtual Reality by Ninth Standard Students

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Abstract
The continual evolution of ICTs has profoundly reshaped educational processes, fostering the development of new collaborative and individual learning environments that promote the acquisition of both disciplinary and transversal competencies. Virtual Reality is the creation of simulation of a real-world experience that a person can enter and leave at any time using technology. Virtual reality can also increase students' motivation to learn and make learning interesting. Thus, virtual reality in this study have enhanced student learning in biology subject. For the present study the experimental study method is adopted. Both the control and experimental group were tested. Nearly 80 ninth standard students from Chennai district, Tamil Nadu state was taken from the Government school. In each group 40 students were selected. For both the groups pretest and posttest were give and the score were analyzed using the SPSS. In biology the circulatory and skeletal system class was taken through virtual reality in the online learning environment. Results of the study indicated that there is significant mean difference in experimental study in post-test score, which proves that virtual reality has more effect on the experimental group students where they have learnt through VR technology,

Keywords: Virtual reality, Experimental, Control group and Biology

INTRODUCTION

The increasing diversity in academic abilities, prior preparation levels, and learning styles has compelled education institutions to flexible their teaching and learning methodologies, seeking adaptive strategies that promote academic success without compromising quality standards (Noui, 2020). In this context, the incorporation of ICTs has emerged as a fundamental pillar for addressing these challenges, facilitating the personalization of learning and broadening access to innovative educational experiences (Keshavarz and Mirmoghtadaie, 2023).

The continual evolution of ICTs has profoundly reshaped educational processes, fostering the development of new collaborative and individual learning environments that promote the acquisition of both disciplinary and transversal competencies (Mariaca Garron et al., 2022; García-Sánchez et al., 2018). This phenomenon has encouraged the proliferation of active learning approaches, wherein students assume

a central and participatory role in constructing their own knowledge through interactive and reflective activities.

Virtual Reality is the creation of simulation of a real-world experience that a person can enter and leave at any time using technology. According to Jackson (2015), Virtual Reality (VR) is the use of computer technology to create a simulated environment. Unlike traditional user interfaces, VR places the user inside an experience. Instead of viewing a screen in front of them, users are immersed and able to interact with 3D worlds. By simulating as many senses as possible, such as vision, hearing, touch, even smell, the computer is transformed into a gatekeeper to this artificial world. Virtual reality does not only allow learners to construct and manipulate screen "objects" for exploring underlying concepts, but they also provide learners with the observation and manipulation tools necessary for exploring and testing hypotheses in the simulated world. According to Umur, and Xing (2017), virtual reality allows learners to visualize abstract concepts and link them to prior knowledge thereby fostering conceptual learning. Students interacting with an instructional simulation gain a better understanding of a real system. This interactivity provides opportunities for students to modify their mental models by comparing the outputs of the model with their expectations. In this study the students use VR for learning circulatory system from the biology subject.

REVIEW OF RELATED LITERATURE

Incorporating virtual reality (VR) tools into the pedagogical instructions has been found to facilitate abstract conceptualization, thereby enhancing learners' understanding of complex concepts. However, the use of VR tools in biology instruction have not been extensively explored, primarily due to its accessibility and the perception that VR devices are perceived as gaming tools rather than learning mediums. The study investigated by Analyn Tolentino, Beatrice Varela (2025), on the effect of VR tools on students' conceptual understanding, performance, and perceived usefulness. To gauge the effect of VRI approach on the students' conceptual understanding, data from pre-and post-diagnostic tests were collected and analyzed using the Wilcoxon signed- rank test in SPSS, the effect size and item analysis was also performed. The effect of the VRI approach on students' performance was evaluated through the summative assessments (SA), and descriptive analysis of the SA scores was conducted using SPSS. Regarding the students perceived usefulness of VR, selected students were interviewed, and their responses were analyzed using thematic analysis. The findings revealed that VRI approach improved student's conceptual understanding and performance. Additionally, students perceived that VR tools enhance their visualization of concepts and created an immersive experience. However, the complex features of the controllers and their limited availability hindered students' learning. Overall, the study suggests that integrating VR tools into pedagogical instruction fosters an engaging, interactive learning environment and improve students' performance.

The integration of virtual reality (VR) and augmented reality (AR) technologies into biology education represents a transformative approach to addressing the complexities inherent in biological concepts. The comprehensive review synthesised by Wazim Rafeek Sharif, Lydia Narain and Abraham Abiodun Ogowewo (2025), on the efficacy of VR and AR in enhancing student engagement, conceptual understanding, and spatial awareness in biology education. While evidence suggests that these immersive technologies can foster deeper learning and motivation, findings regarding their overall effectiveness compared to traditional teaching methods are mixed. Factors such as cognitive load, individual learner differences, and technical challenges significantly influence outcomes. The review examines applications

across various biology subdisciplines, including anatomy, cellular biology, ecology, and genetics, highlighting successes and limitations. Furthermore, it explores the potential of VR and AR to facilitate collaborative and personalised learning experiences while acknowledging the inherent challenges of cost, content development, and integration into existing curricula. Critical analysis revealed that while these technologies offer unique visualisation and interaction opportunities, their educational value is contingent upon thoughtful implementation and alignment with pedagogical objectives. Future research directions emphasise the need for adaptive technologies, innovative assessment methods, and long-term studies to fully leverage the educational benefits of VR and AR in biology education. This review underscores the importance of a balanced approach that considers both the potential and limitations of immersive technologies in enhancing biology education.

Virtual reality (VR) has emerged as a promising tool for enhancing practical skills of students in science and engineering education. However, the effectiveness of VR in this context remains unclear due to inconsistent findings across studies. The meta-analysis aimed by Chuanwen et al (2024), to synthesize the existing literature and investigate the overall impact of VR on practical skills among science and engineering students. A comprehensive literature search was conducted, yielding 37 empirical studies published between 2000 and 2022 that met the inclusion criteria. The analysis included 72 effect sizes, and the random-effects model was employed to account for heterogeneity among studies. The results revealed a significant moderate positive effect of VR on practical skills ($g = 0.477$). Moderator analyses indicated that the disciplinary category significantly influenced the effect size, with medical students demonstrating the largest improvement in practical skills. Additionally, using the practice approach combining with traditional methods yielded the highest effect size among the instructional approaches. The study also considered potential reasons behind the observed results and acknowledged certain constraints.

The growing number of students in higher education has raised challenges in inclusion and equity due to the diversity of students' backgrounds and entry level skills. Educational institutions must adapt teaching-learning strategies to ensure the achievement of learning outcomes. In this context, the study explored by Carrasco (2025) on Information and Communication Technologies (ICTs), combined with gamification, offer tools like Labster TM, which enable interactive scientific simulations and promote active learning. The study used a quasi-experimental design with self-selected participation to evaluate the impact of Labster in a "Biological Foundations of Psychology" course across nine nationwide sections. The sample consisted of 315 first-year Psychology students, 237 in the experimental group and 78 in the control group. Given the non-normal distribution of academic data (Shapiro- Wilk test, $p < 0.05$), non-parametric tests were applied. A Kruskal-Wallis test on learnng gain (final minus initial grade) showed that students using Labster achieved significantly greater academic improvement than the control group ($H = 12.347$, $p = 0.00004$). A multiple linear regression, controlling for baseline performance (cat_1, ej_1, ta_1), confirmed that participation in the intervention predicted higher final grades (_ = 0.3891, $p = 0.0053$; adjusted $R2 = 0.216$). No significant differences were found between the two types of simulations used (Kruskal-Wallis, $p = 0.2814$). A perception survey was administered to 237 Labster users, of whom 87 responded (response rate: 36.7%). The results revealed positive evaluations regarding usability, academic relevance, and motivational impact. In summary, Labster-based virtual simulations enhance academic performance and individual progress in scientific learning among psychology students, especially in diverse and non-science-oriented populations.

The study investigated by Nsimeneabasi Michael Udoh and Esther Etop Ekon (2018), investigate the influence of virtual reality and flow chart on biology students' academic achievement on circulatory system. Non- randomized pre-test, post-test control group design was used for the study. Study sample was 121 SS3 biology students drawn from Uyo Municipality of Akwa lbom State, Nigeria. Simple random sampling technique was used for the study. Two research questions and two hypotheses were tested. The instrument for data collection was Biology Achievement Test (BAT). A reliability index of 0.87 was determined
using test-retest approach. The results showed that gender was not a strong determinant of students' achievement in biology. It was recommended among others that, parents and biology teachers should encourage both male and female students towards excellence in biology.

NEED AND IMPORTANCE OF THE STUDY

Virtual laboratories represent a tangible manifestation of these technological innovations, enabling students to engage with scientific concepts and procedures within controlled digital environments (Akinola and Oladejo, 2020). Such tools transcend the physical limitations of traditional laboratories by eliminating barriers associated with cost, specialized equipment, and the inherent risks of certain experimental practices (Byukusenge et al., 2022; Kennepohl, 2021; Potkonjak et al., 2016). Empirical studies have demonstrated that virtual laboratories not only bolster students' motivation and autonomy but also reinforce conceptual understanding and facilitate the transfer of knowledge to practical contexts, provided that they are grounded in robust pedagogical frameworks (de Vries and May, 2019). Nonetheless, there is widespread consensus that virtual laboratories should be conceived as complementary rather than as absolute substitutes for real experimental experiences, particularly in disciplines that necessitate the development of fine procedural skills (Navarro et al., 2024).

Virtual reality helps students to understand invisible conceptual worlds of science through animation which can lead to more concrete understanding of scientific concepts. Virtual reality as an instructional material also encourage the development of the mental capability of the students, and it best suited where mastery is required of subjects that students perceive as difficult, abstract or interesting (Jackson, 2015).

Biology is one of the basic science subjects in secondary school education system and it is core subject for science students. It is therefore a stepping stone for millions of secondary school students for successful career in any area of science. The knowledge of biology thus promotes acquisition of knowledge, prevent and cure diseases, gives us ideas about our genetic make-up, all geared toward improving the quality of life and conceptual review has shown that virtual reality as instructional resources are indispensable instructional components for the teaching and learning of biology. Virtual reality can make teaching more effective with accurate and sufficient information that supports the curricula content as well as more efficient by reducing the time to deliver instruction. In addition, they can increase instructional appeal so that students are more likely to devote time and energy to the learning task and review what they learned later. Virtual reality can also increase students' motivation to learn and make learning interesting. Thus, virtual reality in this study have enhanced student learning in biology subject

METHODOLOGY

Experimental study method is adopted. Both the control and experimental group were tested. Nearly 80 ninth standard students from Chennai district, Tamil Nadu state was taken from the Government school. In each group 40 students were selected. For both the groups pretest and posttest were give and the score

were analyzed using the SPSS. In biology the circulatory and skeletal system class was taken through virtual reality in the online learning environment. The pre-test and post-test were conducted for both the control and experimental group. The score obtained from the test has been calculated using the SPSS analysis.

RESEARCH QUESTIONS

1. Is there is any significant difference between the control and experimental group students in the pre-test scores of Virtual Reality in Biology and Online learning environment?
2. Is there is any significant difference between the control and experimental group students in the post-test scores of Virtual Reality in Biology and Online learning environment?
3. Is there is any significant difference between the pre-test, pro-test and gain score of the control group in the Virtual Reality in Biology and Online learning environment?
4. Is there is any significant difference among the pre-test, post-test and gain score in the Virtual Reality in Biology and Online learning environment?

FINDINGS AND DISCUSSION TO THE RESEARCH QUESTIONS

Answer -Question No:1

Significance of Mean difference between the Control and Experimental group students in the pre-test scores of Virtual Reality in Biology and Online learning environment

Variable		Control (N = 40)	Experimental (N = 40)	t value	Level of Significance
Virtual Reality in Biology	Mean	12.10	12.05	0.087	NS
	S.D	2.540	2.591		
Online learning environment	Mean	87.80	87.93	0.068	NS
	S.D	9.238	7.145		

Note: NS – Not significant

It is evident that there is no significant mean difference between the control and experimental group in the pretest scores of virtual realities in Biology and online learning environment. Hence it is found to be same score in pre-test for both control and experimental group.

Answer -Question No:2

Significance of Mean difference between the Control and Experimental group students in the post-test scores of Virtual Reality in Biology and Online Learning Environment

Variable		Control (N = 04)	Experimental (N = 40)	t value	Level of Significance
Virtual Reality in Biology	Mean	12.78	17.53	7.590	P<0.001** S
	S.D	2.833	2.764		
Online learning environment	Mean	88.90	103.73	6.804	P<0.001** S
	S.D	9.470	10.010		

Note: S- Significant; ** - Significant at 1% level

It is evident that there is a significant mean difference between the control and experimental group in the post-test score. It is found that the experimental group students have better virtual reality in biology and online learning environment than the counter parts. Moreover, it is also evident that it is positively significant at 1% level.

Answer -Question No:3

Significance of Mean difference among the pre-test, post-test and gain score of the Control group students in the Virtual Reality in Biology and Online Learning Environment

(N = 80)

Variable		Pre- test	Post-test	Gain Score	t value	Level of Significance
Virtual Reality in Biology	Mean	12.10	12.78	0.78	0.246	NS
	S.D	2.540	2.833	.577		
Online learning environment	Mean	87.80	88.90	1.10	0.079	NS
	S.D	9.238	9.470	.810		

Note: NS – Not significant

From the above table it is found that among the pre-test, post-test and gain score there is no significant difference in the control group students. It means that the score is more or less similar among the pre-test, post-test and gain score of the control group students.

Answer -Question No:4

Significance of Mean difference between the pre-test, post-test and gain score of the Experimental group students in the Virtual Reality in Biology and Online Learning Environment

(N = 80)

Variable		Pre-test	Post- test	Gain Score	t value	Level of Significance
Virtual Reality in Biology	Mean	12.05	17.53	5.48	7.293	P<0.001 S
	S.D	2.591	2.764	4.064		
Online learning environment	Mean	87.93	103.73	15.80	8.401	P<0.001 S
	S.D	7.145	10.010	7.244		

Note: S- Significant; ** - Significant at 1% level

From the above it is proved that there is significant mean difference among the pre-test, post-test and gain scores in the virtual reality in biology and online learning environment. It is found that in the post-test score have better virtual reality in biology and online learning environment in the experimental group students than the pre-test score, it is evident in the gain score also it is noted that it is significant at 1% level.

CONCLUSION

Virtual reality technology has demonstrated significant potential to enhance biology education by providing immersive, interactive learning experiences that can improve conceptual understanding, spatial awareness, and student engagement. Thus, in the present study Virtual reality offers unique opportunities to visualise complex biological structures and processes, conduct virtual field trips and laboratory

experiments, and explore otherwise inaccessible environments. As such, VR technology represents powerful tools with the potential to transform biology education, offering new ways to engage students and enhance their understanding of complex biological concepts. As educators and researchers continue to explore and refine the use of these technologies, the future of biology education may be transformed.

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