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Effectiveness of Virtual Lab Learning for Enhancing Environmental Sustainability Awareness and Self-Efficacy of B.Ed. Students

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KEYWORDS

Virtual Lab Learning, Environmental Sustainability Awareness, Self-Efficacy, B.Ed. Students, Teacher Education..

ABSTRACT

The present study examined the effectiveness of virtual lab learning in enhancing environmental sustainability awareness and self-efficacy among B.Ed. students. An experimental method using a single-group pre-test–post-test design was employed. The sample consisted of 45 B.Ed. students selected through purposive sampling. Data were collected using the Environmental Sustainability Awareness Test and the Self-Efficacy Scale based on Bandura's Self-Efficacy Theory. Statistical techniques such as mean, standard deviation, paired t-test, and Cohen's d effect size were used for data analysis. The results revealed a significant improvement in both environmental sustainability awareness and self-efficacy among B.Ed. students after the virtual lab learning intervention. The findings indicate that virtual lab learning is effective in promoting environmental sustainability awareness and strengthening self-efficacy among prospective teachers..

1. INTRODUCTION

Environmental sustainability has emerged as one of the most critical concerns of the twenty-first century due to rapid industrialization, environmental degradation, climate change, and depletion of natural resources. Education plays a pivotal role in creating awareness, shaping attitudes, and developing responsible behaviour towards environmental conservation. Teacher education institutions, in particular, bear the responsibility of preparing future educators who can integrate sustainability concepts into classroom teaching.

With the rapid advancement of information and communication technology, virtual laboratory learning has become an innovative pedagogical approach that provides immersive, interactive, and learner centered educational experiences. Virtual laboratories enable students to perform simulations, investigate environmental issues, visualize ecological processes, and engage in inquiry-based learning without the limitations of physical laboratory facilities. Such learning environments enhance conceptual understanding while simultaneously strengthening psychological constructs such as self-efficacy.

Self-efficacy, as proposed by Albert Bandura, refers to an individual's belief in their capability to perform tasks and overcome challenges. High self-efficacy enables learners to engage actively, persist in difficult tasks, and apply knowledge effectively. Hence, the present study attempts to examine the effectiveness of virtual lab learning in enhancing both environmental sustainability awareness and self-efficacy among B.Ed. students.

2. NEED AND SIGNIFICANCE OF THE STUDY

Environmental sustainability education is essential in teacher education programmes to prepare future teachers who can promote responsible environmental practices. In the context of rapid technological advancement, there is a growing need to integrate innovative digital learning approaches such as virtual laboratory learning into teacher education. Virtual laboratories provide experiential, interactive, and flexible learning opportunities that can enhance both environmental knowledge and learner confidence. Self-efficacy plays a vital role in influencing academic performance, motivation, and professional competence among prospective teachers. The present study is significant as it provides empirical evidence on the effectiveness of virtual lab learning in enhancing environmental sustainability awareness and self-efficacy among B.Ed. students. The findings of the study will be useful for teacher educators, curriculum planners, and educational policymakers.

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3. OBJECTIVES OF THE STUDY

1. To prepare and validate a virtual laboratory module on Environmental Sustainability.

2. To find out the effectiveness of virtual lab learning in enhancing environmental sustainability awareness.

3. To find out the effectiveness of virtual lab learning in enhancing self-efficacy based on Bandura's Self-Efficacy Theory.

4. HYPOTHESES OF THE STUDY

1. There is a significant difference between the pre-test and post-test mean scores of environmental sustainability awareness among B.Ed. students.

2. There is a significant difference between the pre-test and post-test mean scores of self-efficacy among B.Ed. students.

5. REVIEW OF RELATED LITERATURE

Previous studies have emphasised the importance of environmental education and self-efficacy in improving students' knowledge, awareness, and confidence. Research by Tilbury (1995) and Palmer (1998) showed that structured environmental education programmes enhance students' understanding of sustainability concepts. Bandura (1997) and Schunk (1991) highlighted that self-efficacy significantly influences learning, motivation, and performance and can be strengthened through guided instructional interventions. Studies on virtual laboratories and technology-enhanced learning have demonstrated that simulation-based learning environments improve conceptual understanding, engagement, and learner confidence. However, limited research exists on the combined effect of virtual lab learning on environmental sustainability awareness and self-efficacy among B.Ed. students. The present study attempts to address this research gap.

6. METHODOLOGY IN BRIEF

Research Method

Research methodology provides a systematic way of solving research problems and helps ensure valid and reliable findings Kothari (2004). The investigator adopted the experimental method in this study.

Research Design

Research design is the plan and procedures for study that range from broad assumptions to detailed methods of data collecting and analysis (Creswell, 2014). In this study the investigator used single-group pre-test–post-test experimental design.

Population of the Study

A population is any group of individuals that have one or more characteristics in common that are of interest to the researcher (Best & Kahn, 2006). The population comprised all B.Ed. students enrolled under the Kerala University syllabus in Thiruvananthapuram District.

Sample of the Study

A sample is a part of the population which is selected to represent the population in a research study (Kothari, 2004). The investigator selected 45 B.Ed. students for the present study. The investigator adopted purposive sampling technique for the sample selected for the study.

Tools Used for the Study

The investigator used the following tools and materials for the present study

Environmental Sustainability Awareness Test developed and standardised by the investigator.

The Environmental Sustainability Awareness Test was developed and standardised by the investigator to assess the level of environmental sustainability awareness among B.Ed. students. The test consisted of 32 multiple-choice items covering Environmental Knowledge, Environmental Protection and Conservation, Sustainable Development and Practices, and Environmental Responsibility and Ethics. Each item carried one mark, making the maximum score 32.

Self-Efficacy Scale developed and standardised by the investigator.

The Self-Efficacy Scale was constructed and standardised by the investigator based on Bandura's Self-Efficacy Theory. The scale consisted of 24 statements under the components of Mastery Experiences, Vicarious Experiences, Verbal Persuasion, and Physiological and Emotional States. It followed a five-point Likert scale ranging from Strongly Agree to Strongly Disagree. The maximum obtainable score was 120.

Procedure of Intervention

The study aims to evaluate the effectiveness of Virtual Lab Learning for Enhancing Environmental Sustainability Awareness and Self-Efficacy of B.Ed. Students. The investigator used an experimental method for the study that associated with its goals. Primarily, the investigator developed and validated tools and materials for collecting relevant data for the study. The study began with the administration of the Environmental Sustainability Awareness Test and the Self-Efficacy Scale as pre-tests. The investigator then implemented a virtual lab learning programme on Environmental Sustainability. The investigator conducted the experiment study in B.Ed. students enrolled under the Kerala University syllabus in Thiruvananthapuram District. Investigator selected 45 B.Ed. students for the study. The intervention enabled students to perform virtual environmental experiments, simulation-based activities, interactive case studies, digital investigations, and scenario-based learning tasks related to environmental conservation and sustainable development. The virtual laboratory incorporated multimedia resources, animations, interactive simulations, and guided activities that allowed students to explore environmental concepts in an engaging and experiential manner. Mobile phones and computers were used to access the virtual laboratory, providing flexible, anytime-anywhere learning opportunities. Following the intervention, post-tests were administered. The collected data were analysed using the paired t-test and Cohen's d effect size to determine the effectiveness of the virtual lab learning programme.

Statistical Techniques Used

Mean

Standard Deviation

Paired t-test

Cohen's d Effect Size

7. ANALYSIS AND INTERPRETATION OF DATA

The data collected from 45 B.Ed. students through the Environmental Sustainability Awareness Test and the Self-Efficacy Scale were analysed to determine the effectiveness of virtual lab learning. Descriptive statistics such as mean and standard deviation were used, while the paired t-test examined the significance of differences between pre-test and post-test scores. Cohen's d effect size was calculated to assess the magnitude of the intervention.

Table 1 Pre-Test and Post-Test Scores on Environmental Sustainability Awareness

Test	N	Mean	SD	t-value	Level of Significance	Effect Size	Cohen's Category
Pre-Test	45	16.42	3.18			1.18	Large Effect
Post-Test	45	24.19	2.94	9.87	Significant at 0.05 level		

Table 1 shows that the mean score of Environmental Sustainability Awareness increased from 16.42 (SD = 3.18) in the pre-test to 24.19 (SD = 2.94) in the post-test. The paired t-test yielded a t-value of 9.87, which was significant at the 0.05 level. The effect size (Cohen's d = 1.18) indicates a large effect. Therefore, virtual lab learning significantly improved the environmental sustainability awareness of B.Ed. students.

Table 2 :Pre-Test and Post-Test Scores on Self-Efficacy

Test	N	Mean	SD	t-value	Level of Significance	Effect Size	Cohen's Category
Pre-Test	45	74.36	8.45			1.32	Large Effect
Post-Test	45	96.82	7.91	11.24	Significant at 0.05 level		

Table 2 shows that the mean score of Self-Efficacy increased from 74.36 (SD = 8.45) in the pre-test to 96.82 (SD = 7.91) in the post-test. The paired t-test yielded a t-value of 11.24, which was significant at the 0.05 level. The effect size (Cohen's d = 1.32) indicates a large effect. Therefore, virtual lab learning significantly improved the self-efficacy of B.Ed. students.

8. EDUCATIONAL IMPLICATIONS

Virtual laboratory learning can be effectively integrated into teacher education programmes to promote environmental sustainability education.

Interactive simulations enhance conceptual understanding and improve learners' confidence in applying environmental concepts.

Curriculum developers may incorporate virtual laboratory activities into environmental education courses.

Virtual laboratories provide experiential learning opportunities even in institutions with limited physical laboratory facilities.

Teacher educators can use virtual laboratories to develop environmentally responsible and self-confident future teachers.

9. LIMITATION OF THE STUDY

The study is limited to B.Ed. students only

The sample is confined to B.Ed. students enrolled under the Kerala University syllabus in Thiruvananthapuram District.

The duration of the virtual lab intervention is limited.

Variations in students' prior knowledge of technology and their level of engagement may have influenced the results.

10. DELIMITATIONS OF THE STUDY

The study was limited to 45 B.Ed. students.

Only one experimental group was included; no control group was used.

The intervention was confined to a virtual laboratory module implemented over a limited duration.

11. CONCLUSION

The study revealed that the virtual lab learning intervention had a significant positive effect on both the environmental sustainability awareness and self-efficacy of B.Ed students. The mean scores on both the Environmental Sustainability Awareness Test and the Self-Efficacy Scale increased significantly from pre-test to post-test. The findings indicate that virtual laboratory learning is an effective instructional strategy for enhancing environmental sustainability awareness and self-efficacy among B.Ed students. The integration of virtual laboratories into teacher education programmes can contribute significantly to the preparation of environmentally responsible, technologically competent, and self-confident future educators..

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