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Perception of agriculture students about virtual reality in learning: Empirical evidence from students' exposure to VR module on downy mildew of grapes

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Abstract

The study examines the perception of agricultural students at Tamil Nadu Agricultural University towards a Virtual Reality (VR) module on Downy Mildew of Grapes. The aim of the study is to assess agriculture students' perception and learning outcomes using a VR module on downy mildew of grapes. The research design was ex post facto. Students who have undertaken the VR module-downy mildew of grapes session were taken purposefully, because large number of students attended this VR module. In this research, 150 students were selected by simple random sampling method. The information was gathered from students by both telephonic and direct interviews using well-organised questionnaire. The research findings showed that students had a favourable and positive opinion towards the VR module. Also, it insists that previous experience among the students in VR and confidence in the students improve their understanding and opinion towards VR module, whereas prior experience in VR and self-confidence had significant positive association with students' perception towards VR module. This result also contains some challenges faced by the students during VR classes, like discomfort, fear, less knowledge and technical issues. It also recommended some suggestions to improve the VR classes. This concluded that the students felt VR module was effective and efficient for their education and VR helped them in order to improve their knowledge, understanding and skills.

Keywords: agriculture education; immersive nature; student perception; virtual reality

Introduction

Virtual Reality (VR) is a technological advancement that has changed how people view and interact with digital worlds (1). VR gives the brain enough sensory input to create a version of reality that it considers adequate (2). VR is able to accommodate a wide range of learning preferences. Kinesthetic learners can participate in hands-on activities in the virtual environment, while visual learners capitalize on the visual and spatial representations in virtual reality (3). Additionally beneficial to auditory learners are virtual reality experiences that include audio instructions and narratives (4). VR technology offers a simulated experimental education platform that integrates crops, growth patterns, ecological scenarios and related content to address the shortcomings of traditional experimental instruction (5).

The predominant focus of VR technology research in agricultural applications has been on training programs for farmers and simulations of agricultural machinery; however, there is a paucity of studies implemented in practical environments (6). VR technology improves the efficiency of agricultural production by simulating market transactions and production management, thereby enhancing the comprehensive utilization of agricultural resources and facilitating agricultural education, training and research (7). By supplementing or replacing traditional media, VR has the ability to guarantee that agricultural information reaches the public in a relevant way. Through immersive and interactive virtual experiences that provide verified scenarios for opinion formation, it can establish a strong relationship with the general audience (8). Using the VR module, students receive instruction on how to operate and maintain farm equipment (9).

VR technology promotes the development of high-level thinking among agricultural talents. Higher-order thinking is a type of psychological activity or cognitive capacity that takes place at a higher cognitive level. It exhibits a critical mindset, innovative performance and self-learning ability. It is the ability to make a realistic assessment of items or happenings (10). Instead of creating distinct courses that foster higher-order thinking separately, the best approach to build higher-order thinking is to incorporate higher-

order thinking skills into the teaching activities of certain subjects. Thus, using VR technology to build learning scenarios depending on the students' initial cognitive level and to implement problem-solving and case-based learning is essential to helping agricultural students develop higher-order thinking skills (11). VR technology can enhance the effectiveness of hands-on learning or lab simulations and foster the development of agricultural students' critical thinking, creative thinking and practical exploratory skills (12).

VR training can significantly improve information retention. Undergraduate students can efficiently get the curriculum content from the training. Moderately rigorous immersion training is recommended (13, 14). VR in agricultural education possesses significant potential to enhance classroom instruction. Encapsulating facilitation, application, reflection and assessment paves the way for a more systematic, effective and efficient utilisation of VR technology in agricultural education. The VR teaching and learning environment can be enhanced for the advantage of both educators and learners by instructors who understand the intricate nature of these elements (15).

Tamil Nadu Agricultural University (TNAU) has made tremendous progress in integrating technology into agricultural education by developing 15 VR modules covering seven core agricultural domains. These modules are intended with the primary purpose of boosting the learning experience of students, researchers and agricultural scientists by offering immersive, interactive and practical exposure to complex agricultural ideas. Among these, the VR module titled "Downy Mildew of Grapes" stands out as a specific educational tool designed to demonstrate the identification, life cycle and symptoms of downy mildew disease in grapes. There existed a perceptible research gap on what the agricultural students perceive about the VR module and its influence on learning. This study assesses agriculture students' perceptions and learning outcomes from a VR module on Downy Mildew of Grapes, developed at TNAU.

Materials and Methods

TNAU, Coimbatore, developed a VR/AR module for improving learning and providing training to students and scientists. There are 15 modules in 7 domains of agriculture. Among these modules, the VR module on Downy Mildew of Grapes was purposively selected for the study, as it had the highest student participation. The undergraduate students of agriculture who have attended the training session with VR module of Downy Mildew in Grapes were the population considered for the study, from which 150 UG students were chosen using simple random sampling method. The perception of students towards VR was analysed using statements related to perception about VR. The statements were initially evaluated by subject matter experts for appropriateness on a three-point scale: very relevant (3), relevant (2) and not relevant (1). The reliability and validity of the statements were assessed and the statements possessing reliability coefficient of more than 0.7 and validity coefficient of 0.6 were selected. Thus, thirty statements were shortlisted to be administered among students.

The student respondents were asked to give their opinions about individual perception statements using a five-point continuum, namely strongly agree, agree, neutral, disagree and strongly disagree, which were given scores of 5, 4, 3, 2 and 1, respectively (16).

In order to quantify the perception of students about VR, a perception index was worked out with the following formula (17, 18).

$$\text{Perception Index} = \frac{(SA(n) + A(n) + N(n) + D(n) + SD(n))}{N \times \text{Maximum Score}} \times 100 \quad \text{(Eqn. 1)}$$

SA = Strongly agree, A = Agree, N = Neutral, D = Disagree, SD = Strongly Disagree

n = Number of responses for each scale category, N= Sample size

For finding association between the independent variables and perception index, correlation analysis was chosen. Hence, the assumptions were met and Pearson's correlation analysis was performed in this study.

Results and Discussion

The results of this study have been categorised into four sections. The first section dealt with the profile of learners and in the second section, the perception index of students towards VR module is discussed. The third section presents the correlation between students' profile and their perception of VR module. The fourth section highlights the results of constraints and suggestions of students in VR module, respectively.

Profile of the students

Among the students who attended the VR module on Downy Mildew of grapes, 56.76 % of the students were female, followed by males (43.43 %). The majority of the students came from rural areas (62.76 %) and only 37.4 % were from urban areas.

With respect to academic performance, (64.7 %) of the students had high level of academic performance, followed by (32.00 %) had medium level and (3.43 %) had low level of academic performance. Prior experience in VR was experienced by majority of the students (54.67 %), where (45.43 %) of the students had no experience with VR before. Majority of the students had high level of self-confidence (38.00 %), followed by 32.00 % had low level and 30.00 % had medium level, respectively.

Students' perception towards VR module

The study was conducted to find out the perception of agriculture students towards VR module on downy mildew of grapes. As shown in Table 1, students' opinions after using the VR module demonstrated both the advantages and certain difficulties of using this technology for education.

Knowledge retention and conceptual understanding

The statement that VR is an innovative learning tool received the highest score (Perception Index = 81.74), indicating that students enjoyed using new technology for their studies and followed by statements regarding recalling the disease's lifecycle stages (PI = 80.27), identifying its symptoms (PI = 80.80) and remembering the infestations of Downy mildew of grapes (PI = 79.6). These findings suggest that the VR module's interactive and visual elements enhanced the students' understanding and ability to remember information about the disease. The VR system enhanced the overall learning experience by making complex ideas easier to visualize and understand. Overall, the VR module improved students' knowledge and gave them an improved understanding of complicated agricultural processes.

Table 1. Perception index of perception of students towards VR module

S.No	Statements	PI
1	I think VR is an innovative learning tool for students	81.74
2	VR module improved my understanding of the disease downy mildew of grapes	80.94
3	I know the symptoms of downy mildew of grapes	80.80
4	I can clearly remember lifecycle stages of the downy mildew disease of grapes	80.27
5	I am able to recall the infestations of downy mildew diseases of grapes easily	79.60
6	The VR module increased my enthusiasm for the topic of Downy mildew of grapes	78.40
7	The VR module helped me to understand concepts better than traditional methods of learning	77.47
8	VR made my learning environment more fun and enjoyable	77.06
9	VR will become vital component for future education	75.47
10	The VR experience kept my full focus during the session	75.34
11	I could more effectively link concept with practical applications using VR	74.94
12	I will use VR module for regular usage	74.40
13	I would recommend VR modules for learning agriculture to others	74.14
14	I developed better problem-solving skills through the VR agricultural module	73.20
15	I considered the VR module helpful in envisioning complicated concepts	71.87
16	Immersive nature of VR module made my learning experience engaging	71.60
17	VR allowed me to explore scenarios that would be difficult in real life	71.47
18	I can understand spore formation of the disease	71.47
19	I recalled additional knowledge after using the VR module	69.20
20	I am open to using more technology, like VR, in the classroom	68.67
21	VR enhanced my interest in all the subjects	67.20
22	I believe VR can significantly improve academic performance	62.14
23	I did not require much assistance in handling the VR system,	59.87
24	The virtual reality (VR) equipment was easy to wear and operate	56.00
25	The Operating functions were simple to follow	55.07
26	I faced no technical issues during the VR session	53.34
27	I felt discomfort during the VR session	52.67
28	I can differentiate various VR tools and features in VR stimulation	49.74
29	The VR module was easy to navigate and control	45.20
30	I think VR module always not meet with academic curriculum	42.94

Students were able to explore scenarios that are typically difficult to visualize in traditional classroom settings. Many students felt that the VR experience was more effective than typical classroom teaching (PI = 77.47) and that it improved their understanding of the disease (PI = 80.94). Students found it easier to visualize and understand complex concepts (PI = 71.87) and explain spore formation (71.47) and use such concepts practically (PI = 74.94). This demonstrated how students were able to understand not only the theory but also how to use that information in practical application with the help of 3D experience in virtual reality. Students were able to know scenarios that are difficult to visualize in a traditional classroom, like advanced stages of disease. The response to the statement that the students can understand additional knowledge after using the VR module (PI = 69.20) indicates that VR's immersive and interactive elements helped with conceptual reinforcement and memory retention. Thus, the understanding of the downy mildew of grapes disease was enhanced by these kinds of experiences, demonstrating that VR can be an effective teaching tool for complex agricultural concepts.

Student engagement and skill development

Throughout the VR learning session, the students showed a high level of enthusiasm and curiosity. Statements like "VR kept my full focus" (PI =75.34), "It made learning fun and enjoyable, "Learning experience was engaging due to the VR module's immersive nature (PI = 71.6), “Virtual reality is a vital part of education in the future” (PI = 75.47) and "VR increased my enthusiasm" (78.40) were all supported by a large number of students. This indicated how the virtual reality environment actually kept them engaged and how VR was important for future education. Since VR environment and the way the content was delivered, students felt more engaged and enthusiastic about the topic when using VR than in a traditional classroom. The immersive environment and audio aids encouraged the students to use the VR module again (PI = 74.4) and also made them recommend the VR module learning experience to others (PI = 74.14). The adoption of new digital technologies in education is also positively reflected by the large number of students who said they were open to using more technology, such as VR in the classroom (PI = 68.67) and that VR can greatly increase academic performance (PI = 62.14). This indicates that VR provided motivation in learning and enhanced the students' learning experience by making it more interesting and engaging.

Students also reported that their problem-solving skills improved after using the VR module (PI = 73.20). They agreed that VR gave them a chance to explore situations that are hard to experience in real life (PI = 71.47). The VR module allows them to practice making decisions in simulated activities, such as managing a crop disease outbreak. This kind of learning helps students think critically and apply what they learn to real-world challenges. VR module, through its active and interactive way of learning, equipped the students to develop their practical skills.

Limitations and technical challenges

Some students expressed the limitations in their responses while answering the statements. The VR material did not always align with the course content, which was one of the main issues brought up by the students (PI = 42.94). This indicates that some students thought the VR did not provide adequate knowledge related to the material they were expected to learn for their course. Physical pain during the VR sessions was another problem (PI = 52.67). After using the headset for an extended period of time, some students complained of issues like fatigue, eye strain and dizziness. These results imply that VR has physical limitations, even if it is an interesting and captivating learning tool. It was crucial to consider student comfort during extended learning sessions and ensure that the content related to the course topic.

Problems in the technical aspect of using VR were also raised by students. When asked how simple it was to utilise the VR system, students scored lower. They struggled to navigate the module (PI = 45.20), identify various tools (PI = 49.74) and had difficulty operating the equipment (PI = 55.07). However, the VR equipment was easy to wear and operate (PI=56.00). During the session, a large number of students experienced technical difficulties (PI = 53.34) and others required assistance using the system (PI = 59.87). These answers demonstrated that a large number of students lacked VR experience, which limited their ability to get what they needed from the learning experience. Although the topic itself was engaging, the mix of technological difficulties and physical discomfort added to the irritation. These issues show that before students use VR for learning, they need improved training and assistance.

Overall, the findings showed that most students considered the VR program helpful, engaging and informative. Things that were hard for them to understand could be seen and touched. What they did in VR helped them learn more, think more deeply and remember things better. It was fun to learn as well. They said they had trouble with the system and that the VR material didn't fully align with what they were learning in class. Some people found it tougher to learn because of these issues. People think that the system should be easier to use, the content should be more related to the curriculum and students should get some basic training before they use the program. This will help VR work better in the future. VR could become a good way to teach hard things like farming now that these changes have been made.

Association between profile of the students and perception of students towards VR module

Table 2 reported that Pearson's correlation analysis was conducted to find association and relationship between the profile of the students and the perception of students towards VR module on Downy Mildew of Grapes. Hence, prior experience (0.267781) and self confidence (0.807317) were positively correlated with the perception of students towards the VR module on Downy Mildew of Grapes and significant at 5 percent level. Majority of the students had previous experience in the VR module for entertainment purposes and also for some other purposes, which made them aware of the VR module. Hence, prior experience was positively correlated with the perception of students towards VR module. The majority of the students have self-confidence in using various technologies for learning and they were confident about their understanding capacity and their ability to do something new and innovative, so self-confidence was positively correlated with the perception of students towards the VR module.

Table 2. Correlation analysis between profile of the students and perception of student towards VR module

Variables no	Variables	r value
X1	Gender	0.027774^{NS}
X2	Rural-Urban background	-0.10033^{NS}
X3	Academic performance	0.072178^{NS}
X4	**Prior experience**	**0.267781^{*}**
X5	**Self confidence**	**0.807317^{*}**

(NS- Not significant,* -Significant at 0.05 level)

Constraints faced by the students during VR module session

This study reported some challenges faced by students during the VR session. The constraints identified are summarized in Table 3 & Fig. 1. The majority of the students felt that insufficient equipment (inadequate - VR headsets, VR controllers) was one of the main challenges and ranked I (76.67 %). Nearly two-thirds reported experiencing fear when entering the VR environment, resulting in a rank II (63.00 %). This could be because the VR world was unfamiliar and unpredictable to the students. Students with rank III (54.00 %) indicated a lack of technical personnel support and training for VR learning, which was attributed to insufficient trainers and inadequate training resources. The next challenge

Table 3. Constraints faced by the students during VR module session

S.No	Constraints	Frequency	Percentage	Ranking
1.	Insufficient VR equipment	115	76.67 %	I
2.	Fear Feeling while in the VR environment	93	63.00 %	II
3.	Lack of Technical personnel to support and train VR learning	81	54.00 %	III
4.	Having limited knowledge of how to access VR device	63	42.00 %	IV
5.	More theory than practical	54	36.00 %	V
6.	Students who wear spectacles face difficulty in visualisation	45	30.00 %	VI
7.	Interaction in VR classroom is lower than typical classroom	42	28.00 %	VII

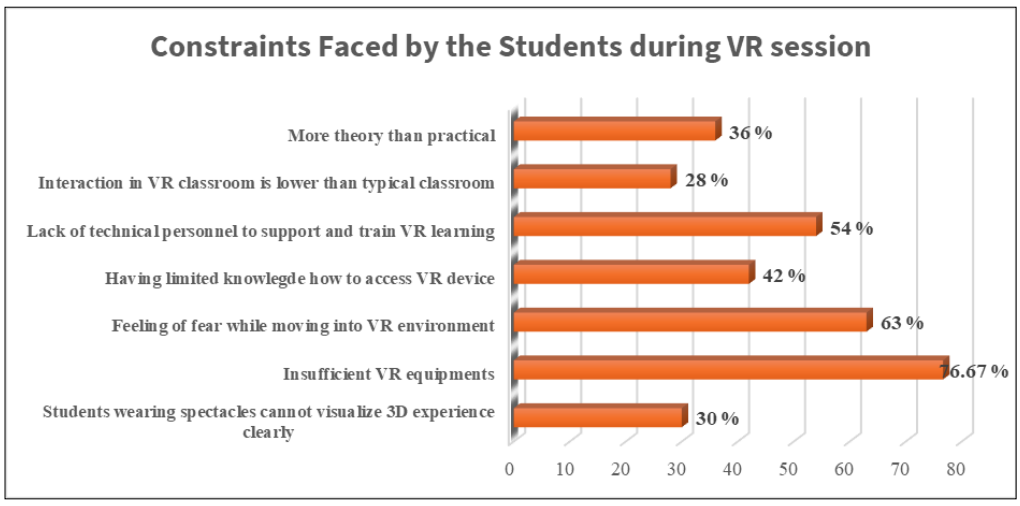

Fig. 1. Constraints faced by the students during VR module session.

was having limited knowledge to access the VR device, which ranked IV (42.00 %). Students may not know how to use the VR device due to less exposure and training. The reason for the rank V (36.00 %) was that the VR session consists of more theoretical content than practical content. Students who wear spectacles faced difficulties in visualization, ranking this challenge as VI (30.00 %) because some students using spectacles due to eyesight issues felt difficulty in visualizing 3D experiences. Interaction in the VR classroom is lower than in a typical classroom and was ranked VII (28.00 %) because the immersive nature made students have less connection and collaboration with peer members.

Suggestions to improve VR module session

This study provided some suggestions to improve the VR module sessions by resolving the challenges and developing the efficiency of the VR sessions among students. The suggestions to improve the VR module session are listed in Table 4 & Fig. 2.

The majority of the students suggested developing interactive and interesting content for the sessions and ranking it as I (80.00 %). This indicates that developing interactive sessions like question and answer sessions and group discussions could improve students' interest in learning and develop engagement among the peer students. Increasing the availability of VR equipment was ranked II (77.43 %) because by increasing the availability of equipment like VR headsets and VR controllers, many students can attend the same session. The next suggestion was to strengthen the training facilitators, which ranked III (68.00 %). This could be because by increasing the trainers, students can be well trained to access the VR device. Collecting feedback after the session was ranked IV (65.43 %). This indicates that knowing the negative and positive reviews can help improve the VR learning in their upcoming sessions. Conducting seminars and workshops was ranked V (63.43 %). The reason is to increase the awareness of VR among students and to develop their technical skills.

Recommendation from the study

This study provides several recommendations for integrating VR into agricultural education. The VR module on Downy Mildew of Grapes has made the students visualise the disease and learn about it. Similarly, VR modules for various other crops and their diseases, which are complex to understand, may be developed. The faculty are to be trained in VR module preparedness, so that they can come up with a very impressive VR module. VR should be integrated into classroom teaching, rather than keeping it isolated. VR modules can be developed based on region-specific content, such as regional crops, seasonal variations and region-specific challenges in a particular region, which can be explained in the VR classrooms.

Conclusion

This study concluded that VR module on Downy Mildew of Grapes aimed to improve students' learning. Students expressed a positive opinion about the VR module. The VR module increased their knowledge about the Downy Mildew disease and improved their understanding. VR made the students improve their memory retention. VR made the students not only know about theory but also made them apply the theory practically. This VR connects students to theory and practice effectively through its visuals and concept delivery. The immersive nature of the VR module allowed the students to visualize complicated concepts in a realistic way and kept their full attention during the session. They developed students' interest in education and also engaged them in the classroom environment. It made the students engage through their interests and made the way of learning easy. Through this VR module, students developed their skills and they were motivated to use technologies for their education. After this session, students gained confidence that they can handle and use various educational technologies for their education. Students' previous experience in VR and their self confidence were positively influencing their perception towards the VR module. This research also highlights some of the limitations in the VR module and suggestions to develop VR learning, such as discomfort, lack of technical knowledge, accessibility and visualization issues. They recommended some thoughts to improve the VR classes by conducting workshops, group discussions and involving technical

Table 4. Suggestions to improve VR module session

S.No	Suggestions	Frequency	Percentage	Ranking
1.	Developing interactive and interesting content in the sessions	120	80.00 %	I
2.	Increasing availability of VR equipment	116	77.43 %	II
3.	Strengthening the training facilitators	102	68.00 %	III
4.	Collecting feedback after the sessions	98	65.43 %	IV
5.	Seminars and workshops for improving students' skill in VR	95	63.43 %	V

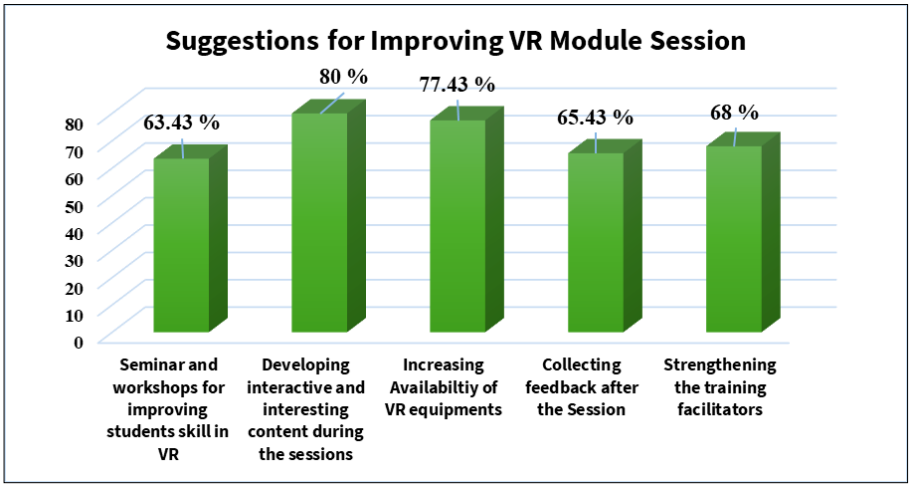

Fig. 2. Suggestions to Improve VR module session.

trainers. This study underscores the importance of VR learning among students and how it motivates them and how they contribute to the students' educational development in the agriculture sector.

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Authors' contributions

CSGP conceptualized, formulated the manuscript and analysed the data. BP guided the research by formulating the research concept and approved the final manuscript. AN helped in summarizing and statistical analysis of data. KLD helped in editing and reviewing the original draft. SKM helped in collecting the data. All authors have carefully read and approved the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare

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