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Virtual science lab for secondary schools: Teachers' Perceptions of its Usefulness

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Abstract:
The study aimed to examine the perceptions of secondary school science teachers regarding the usefulness of virtual labs in teaching science at the secondary level. The research targeted all secondary school science teachers from Bhagalpur district of Bihar, with a sample of 88 secondary school science teachers. A **descriptive survey research design** with a **quantitative approach** utilizing a five-point Likert scale perception tool to investigate the perceptions of secondary school science teachers regarding the usefulness of virtual labs in science education was adopted. Data were analyzed using descriptive statistics. The findings indicate that teachers generally hold a positive perception of virtual labs, recognizing their potential to enhance student engagement and improve learning outcomes. The study suggests the need for capacity-building programs and infrastructural support to promote the integration of virtual labs in science education.

Key words: Virtual Lab, Secondary schools, Science teachers, Teachers' perception.

I.INTRODUCTION

Science education has traditionally relied on laboratory activities to help students understand complex and abstract scientific concepts through experiential learning and the principle of "learning by doing." Research indicates that laboratory experiences enhance students' understanding of science and foster positive attitudes toward science learning (Gecer & Zengin, 2015; Aydogdu & Kesciroglu, 2005). Science laboratories also play a significant role in developing students' 21st-century skills, scientific attitudes and problem-solving abilities.

Despite their importance, traditional science laboratories face several practical and pedagogical challenges. These include inadequate physical space, lack of sufficient equipment for individual students, time constraints, safety concerns during hazardous experiments and limited opportunities for repeated practice and experimentation. Such limitations often restrict students' active participation and effective learning experiences in science education (Z. Tatli & A. Ayas, 2013; Jong, Linn, & Zacharia, 2013).

In response to these limitations, virtual laboratories have emerged as an innovative and effective alternative for conducting science experiments. Virtual science laboratories provide students with opportunities for experiential learning without the constraints of physical laboratory infrastructure. Studies have shown that virtual laboratories help create a conducive learning environment, improve conceptual understanding and stimulate students' interest in constructing knowledge (Alsharif, 2024; Benzamin Tatira, 2024; Asiksoy Gulsum, 2023; Rashid et al., 2021). Moreover, these advanced digital tools have been found to enhance students' curiosity, confidence, engagement and overall learning satisfaction (Makransky & Petersen, 2021; Liu et al., 2025). They offer accessible and cost-effective learning environments where students can perform experiments safely, repeatedly and interactively.

The successful integration of virtual laboratories in science education largely depends on teachers, who play a crucial role in adopting and implementing digital technologies in classroom practices. Teachers' attitudes and perceptions significantly influence the effectiveness of technology integration and students' learning experiences. Research suggests that virtual laboratories not only support students' academic learning but also empower teachers to integrate technology-enhanced pedagogical approaches in science classrooms (Shambare, Brian, & Jita, 2024; Navarro et al., 2024; Alneyadi, 2019). Positive perceptions toward virtual laboratories can encourage teachers to incorporate these innovative tools into their teaching practices more effectively.

Despite lots of potential of virtual labs in science education, little is known about how science teachers of Bhagalpur perceive these tools. This study aims to fill that gap by exploring their experiences,

challenges, and outlook regarding virtual labs. This study aims to investigate how secondary school science teachers perceive virtual science labs in terms of usability, educational effectiveness, accessibility and relevance to the existing curriculum of government secondary schools of Bhagalpur. By understanding these perspectives, the research intends to provide insights that can inform policymakers, curriculum developers and educational institutions. Ultimately, the study aspires to contribute to the broader goal of making science education more equitable, engaging, and effective for all learners.

In this context, this study aimed to investigate the perception of teachers towards virtual laboratory. For this purpose, the following research questions were examined:

Research Questions:

- What are the perceptions of secondary school teachers toward virtual labs?
- How do they perceive the impact of virtual labs in fostering conceptual clarity in secondary-level science education?
- How do they perceive the role of virtual labs in empowering students' learning?

Objectives:

1. To study the perception of secondary level Science teachers' concerning the use of virtual labs in science education.

1.1 To investigate teachers' views on the effectiveness of virtual labs in fostering conceptual clarity in secondary-level science education

1.2 To examine how secondary science teachers perceive the role of virtual labs in supporting science teachers and their teaching practices.

1.3 To examine how secondary science teachers, perceive the role of virtual labs in empowering students' learning.

II.METHODOLOGY

Research Design:

The present study employed a **descriptive survey research design** with a **quantitative approach** to investigate the perceptions of secondary school science teachers regarding the usefulness of virtual labs in science education.

Study Participants:

Data were collected from 88 science teachers from different secondary schools of Bhagalpur district who were participated in a virtual lab-related workshop held at DIET, Bhagalpur.

Data Collection Tools & Procedures

Data were collected using a **structured** Perception scale (**Google Form questionnaire** that included a **five-point Likert scale** ranging from *Strongly Disagree (1)* to *Strongly Agree (5).* This study used a Perception scale that consists of 18 items. These items were arranged in three sections. The first section consisted of seven items that aimed to assess teachers' views about use of virtual laboratories in promoting conceptual understanding in science. The second section comprised six items that were aimed to assess teachers' views about use of virtual laboratories in supporting teachers and teaching practices. The third section comprised five items that were designed to assess how teachers perceived virtual labs for empowering students' learning. The face and content validity of the questionnaire was validated through expert review. The final version was distributed to selected participants using Google Forms. Respondents were given clear instructions and confidentiality of responses was ensured.

Data Analysis:

- Quantitative data were analyzed using descriptive statistics

Objective-wise data analysis:

1. To study the perception of secondary level Science teachers' concerning the use of virtual labs in science education.

1.1 To investigate teachers' views on the effectiveness of virtual labs in fostering conceptual clarity in secondary-level science education

1.2 To examine how secondary science teachers perceive the role of virtual labs in supporting science teachers and their teaching practices.

1.3 To examine how secondary science teachers, perceive the role of virtual labs in empowering students' learning.

Objective 1.1: To investigate teachers' views on the effectiveness of virtual labs in fostering conceptual clarity in science.

Result and discussion: For **above objective** which focused on assessing teachers' views on the effectiveness of virtual labs in enhancing conceptual clarity in science, **seven relevant items** were included in the instrument. Result showed that teachers demonstrate strong acknowledgement regarding the effectiveness of virtual science labs in enhancing conceptual understanding in secondary-level science education.

Question-wise detailed descriptions are as follows:

Q.1. Virtual labs are helpful in exploring the subject matter and lab experiences in science.

Fig 4.1

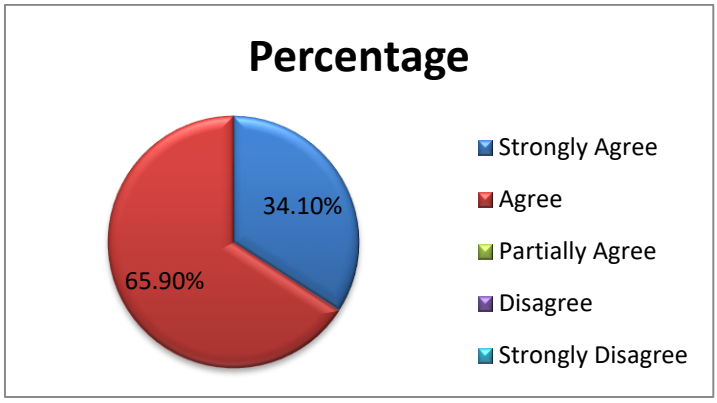

Figure 4.1 indicates that teachers show a high level of agreement with 34.1 % of strongly agree and rest 65.9 % of teachers agree with the idea that virtual labs are effective tools for enhancing understanding of subject content and providing valuable science lab experiences.

The data strongly suggests that **teachers overwhelmingly recognize the educational value of virtual labs.** Their consistent agreement highlights a **positive perception** of virtual labs as powerful tools that enrich students' learning experiences and deepen their understanding of scientific concepts.

Q.2 Virtual lab is not an essential tool for our student especially in Science.

Fig 4.2

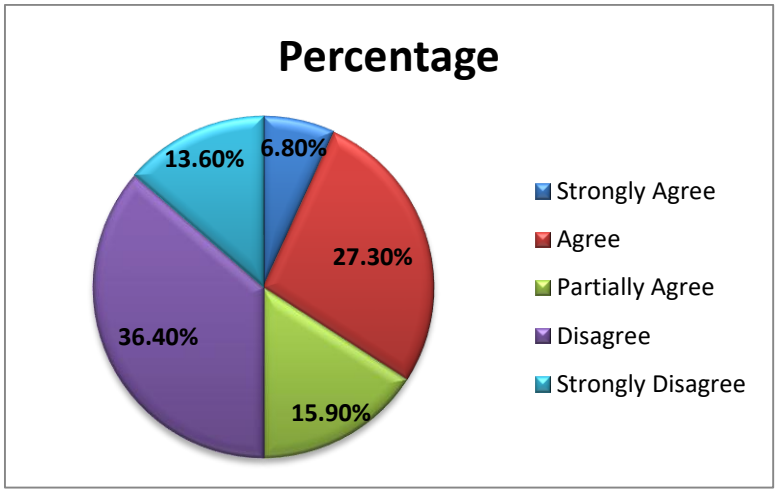

Figure 4.2 reveals that a significant portion of teachers as **13.6 % strongly disagree** and **36.4 % disagree**, collectively making up **50%, disagree with the negative statement** that *"Virtual lab is not an essential tool for our students, especially in Science."* This indicates that more than half of the teachers **reject the notion** that virtual labs lack importance. Conversely, **6.8 % strongly agree, 27.3 %**

agree, totaling **34.1%** of teachers who align with the negative statement to varying degrees and **15.9 % of them partially agree with the statement.**
This suggests that **most teachers recognize the importance of virtual labs as essential tools** in supporting science education. Despite some differing views, the overall trend highlights a **favorable perception of virtual labs**, underscoring their perceived value in enhancing scientific understanding and engagement among students.
Q.3.Virtual Science Lab facilitates interactive learning experiences.
Fig 4.3

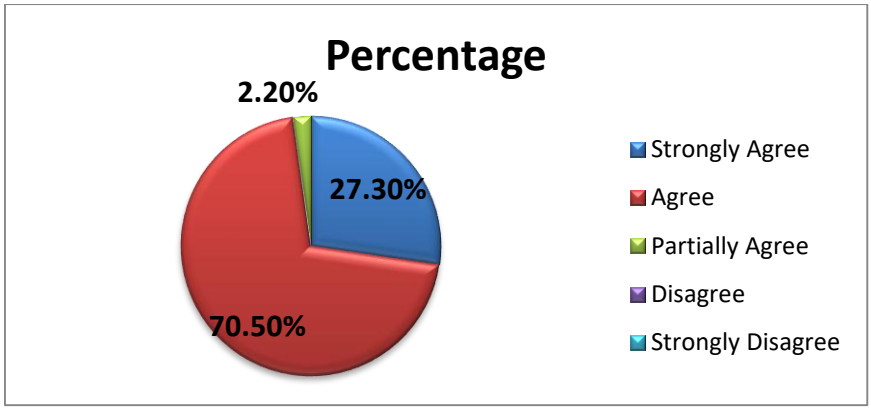

Fig 4.3 shows that all the teachers **exhibit a high level of agreement** with the idea that **virtual labs facilitate interactive experiences** with **27.3% strongly agreeing** and **70.5% agreeing.** The majority (70.5%) agree, while a notable portion (27.3%) strongly agrees. 2.2% partially agree with the statement.
The findings suggest that **teachers unanimously acknowledge the interactive nature of virtual labs** emphasizing their potential to actively engage students in learning.
Q.4 I can use the virtual lab to make science learning easier**.**
Fig 4.4

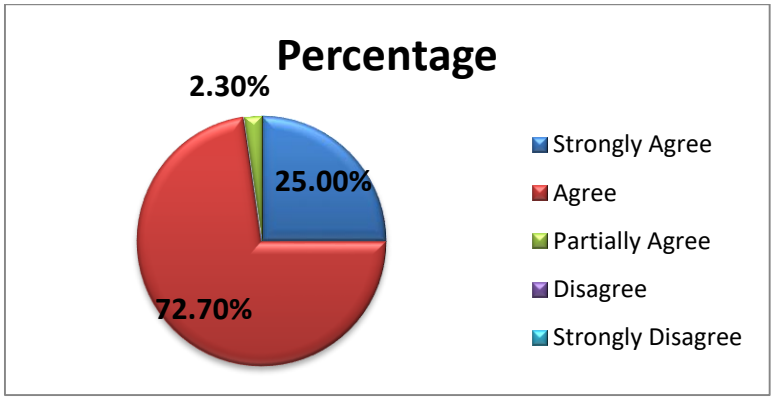

Fig 4.4 shows that all the teachers **exhibit a high level of agreement** with the idea that they can make science learning easier with the help of virtual lab with **25 % strongly agreeing, 72.7 % agreeing and 2.3 % partially agreeing with the statement.** The majority (72.7%) agree, while a notable portion (25%) strongly agrees.
The findings suggest that **teachers strongly acknowledge the use of virtual lab for making science learning easier.**
Q.5. **Virtual labs help teachers in preparing science teaching related activities.**
Fig 4.5

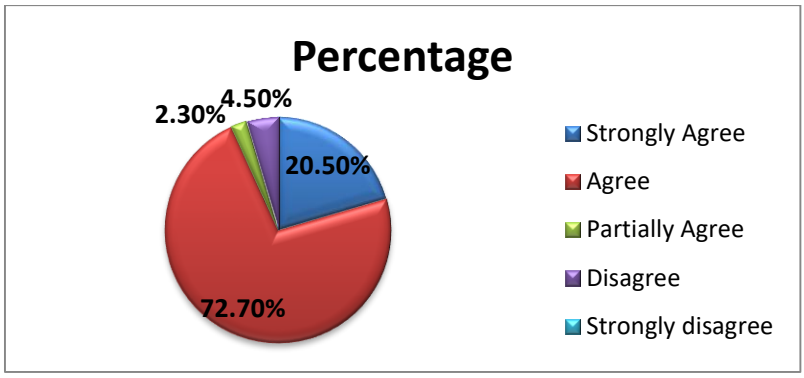

Figure 4.5 shows that 20.5% of teachers strongly agree, 72.7% agree, 2.3 % partially agree and 4.5% disagree with the statement that virtual labs help teachers in preparing science teaching-related activities. The data indicates that a large majority of teachers (**93.2 % in total**) hold a positive view regarding the usefulness of virtual labs in supporting the preparation of science-related teaching activities.
The findings suggest that **virtual labs are widely perceived by teachers as valuable tools** for planning and enhancing science instruction including lesson preparation and activity design.

Q.6. Virtual labs facilitate my understanding of scientific concepts more clearly.
Fig 4.6

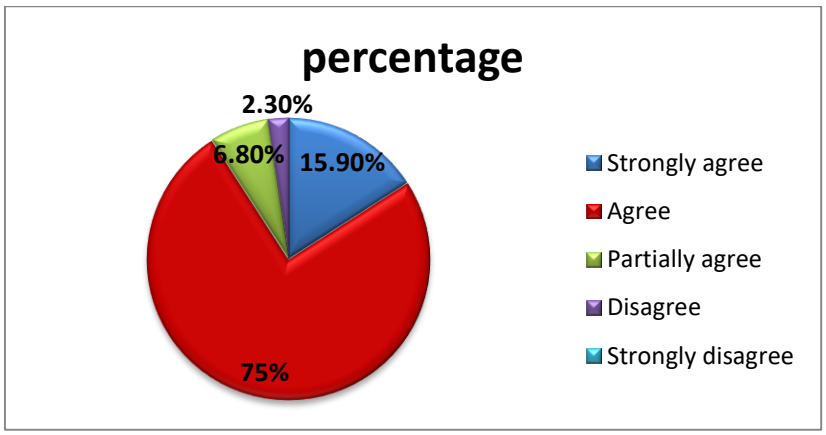

Figure 4.6 illustrates that **15.9 % of teachers strongly agree, 75 % agree 6.8 % partial agree** and 2.3% disagree with the statement that *virtual labs facilitate their understanding of scientific concepts more clearly.* The data shows that a significant majority of teachers (90.9%) perceive virtual labs as effective tools for enhancing their understanding of scientific concepts. Only a small portion (6.8%) expressed partial agreement and 2.3 % i.e. only 1 teacher shows disagreement with the statement.
These findings indicate that virtual labs are widely regarded by teachers as helpful in deepening conceptual understanding in science. The overwhelming agreement reflects strong support for the use of virtual labs as a means to improve clarity and comprehension of scientific topics.

Q.7. In science education, the virtual lab should be used in conjunction with the traditional lab.
Fig 4.7

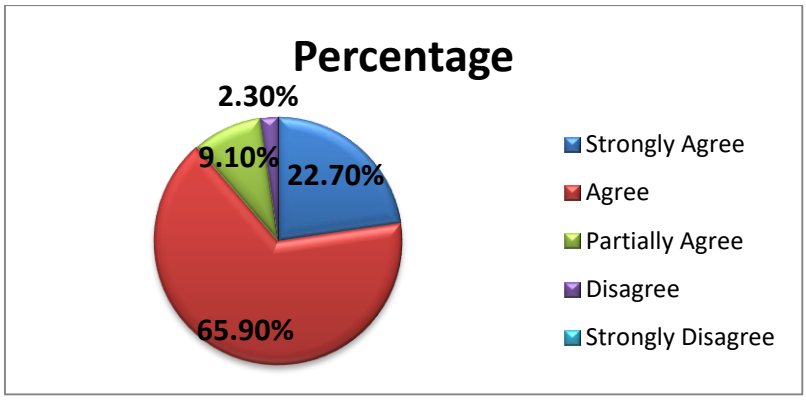

Figure 4.7 illustrates that **22.7 % of teachers strongly agree, 65.9 % agree,** 9.1 **% partial agree and 2.3 % disagree** with the statement that *in* science, the virtual lab should be used in conjunction with the traditional lab. The data shows that a significant majority of teachers (88.6%) perceive virtual labs experiences should be used with the traditional lab. Only a small portion (2.3%) i.e. only 1 teacher expressed disagreement. These findings indicate that virtual labs are widely regarded by teachers to be used in conjunction with the traditional lab**.** The overwhelming agreement reflects strong support for the use of virtual labs with traditional lab for better experiences in lab.
Based on the discussions outlined in points 1 to 7 and the data presented in Figures 4.1 to 4.7, it can be concluded that teachers demonstrate strong consensus regarding the effectiveness of virtual science labs in enhancing conceptual understanding in secondary-level science.

Objective1.2: To examine how secondary science teachers perceive the role of virtual labs in supporting science teachers and their teaching practices.
Result and discussion: For **above objective** which focused on assessing teachers' views on the role of virtual labs in supporting science teachers and their teaching practices. **To achieve this objective six questions (Q.No.8-13) were included in the perception scale.** Result showed that teachers demonstrate strong consensus regarding the effectiveness of virtual science labs in supporting science teachers and their teaching practices.
Question-wise detailed descriptions are as follows:
Q.8. Virtual labs are not beneficial for secondary school science teachers.

Fig 4.8

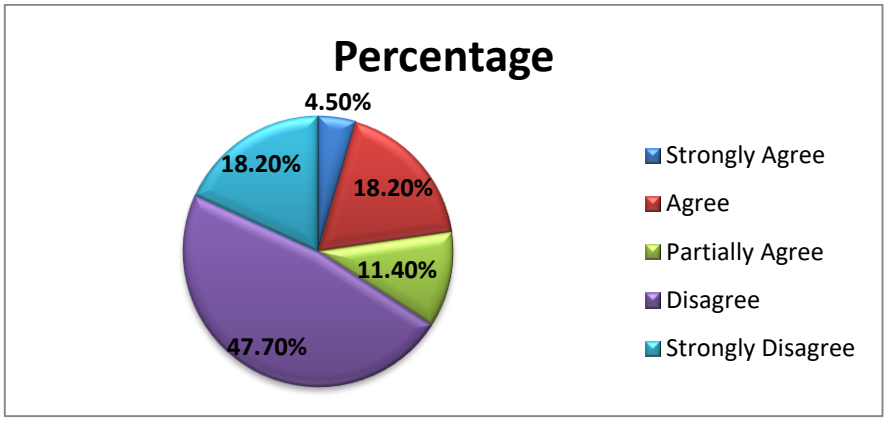

Figure 4.8 reveals that a significant portion of teachers as **18.2 % strongly disagree** and **47.7 % disagree**, collectively making up **65.9 %, disagree with the negative statement** that "Virtual labs are not beneficial for secondary school science teachers." This indicates that more than half of the teachers **reject the notion** that virtual labs lack importance for secondary school teachers. Conversely, **4.5% strongly agree, 18.2% agree** and **11.4% partially agree,** totaling **34.1%** of teachers who align with the negative statement to varying degrees.
This indicates that more than half of the teachers **reject the notion** that virtual labs lack importance for secondary school teachers. Despite some differing views, the overall trend highlights a **favorable perception of virtual labs.**

Q.9. I would recommend the Virtual Science Lab to other science educators for use in their teaching.

Fig 4.9

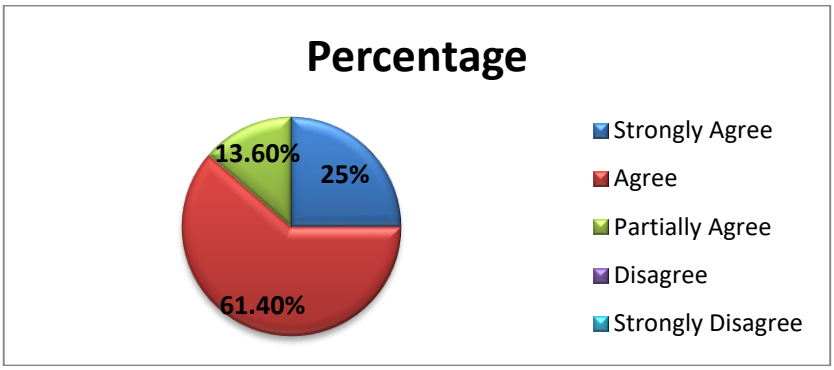

Figure 4.9 illustrates that **25 % of teachers strongly agree, 61.4 % agree** and **13.6 % of teachers are partially agree** with the statement that they would recommend the Virtual Science Lab to other science educators for use in their teaching

The data shows that all the teachers with a significant majority of teachers (86.4%) perceive virtual labs experiences should be recommend to the other educators. These findings suggest that teachers widely endorse the use of virtual labs as a valuable resource for all educators involved in science teaching.

Q.10. I am ready to initiate the laboratory work in science classrooms with more ease.

Fig 4.10

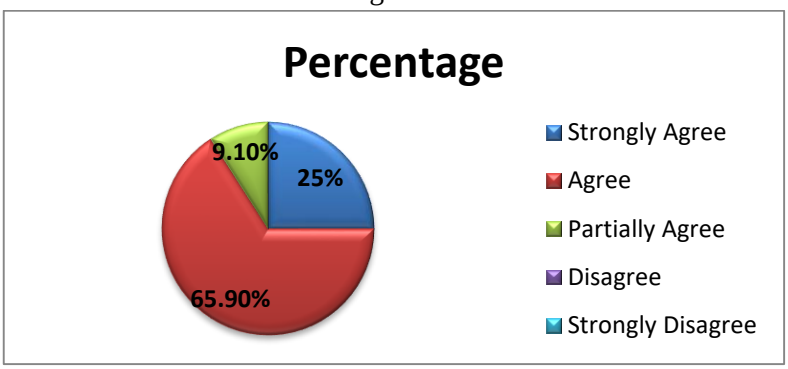

Figure 4.10 illustrates that **25 % of teachers strongly agree, 65.9 % agree** and **9.1% partially agree** with the statement that *they* are ready to initiate the laboratory work in science classrooms with more ease. The data shows that a significant majority of teachers (90.9%) perceive that they can easily use virtual lab in their respective science classrooms. Only a small portion (9.1%) expressed partial agreement.

These findings indicate positive reflection towards initiation of laboratory work with more ease.

Q.11. I can teach specific concept using virtual lab experiments with the help of virtual Science lab.

Fig 4.11

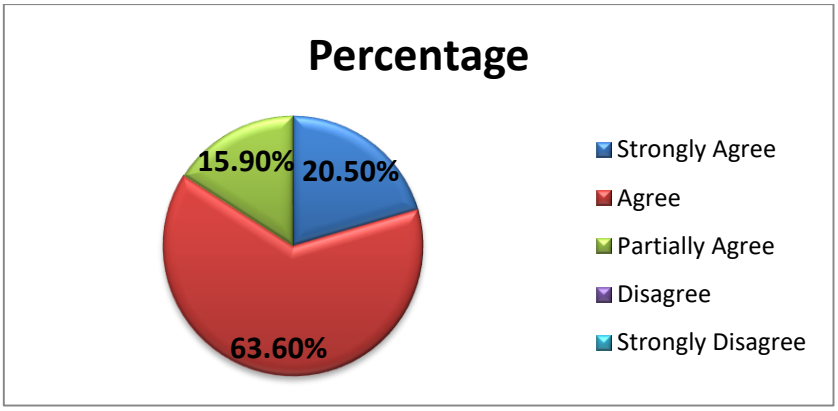

Figure 4.11 illustrates that **20.5 %, 63.6 %** and **15.9% of teachers are strongly agree, agree and partially agree** respectively with the statement that they can teach specific concept using virtual lab experiments with the help of virtual Science lab.

The data shows that all the teachers with a significant majority of teachers (84.1%) perceive that they can easily teach specific topics with the help of virtual science lab. These findings suggest that teachers widely endorse the use of virtual labs as a valuable resource for conducting experiments.

Q.12. I can adopt and use particular experiments in virtual labs to meet my different learner's capabilities.

Fig 4.12

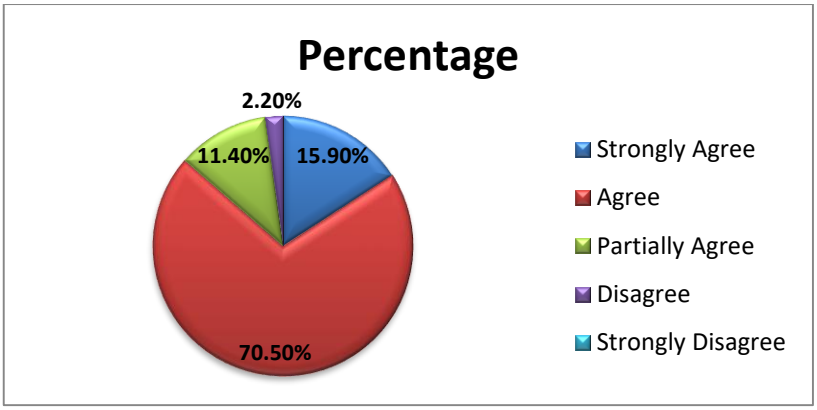

Fig 4.12 shows that all the teachers **exhibit a high level of agreement** with the idea that they can adopt and use particular experiments in virtual labs to meet my different learner's capabilities with **15.9 % strongly agreeing, 70.5 % agreeing and 11.4% partial agreeing and 2.2% with disagreement**. A notable portion (86.4 %) agrees with the statement.

The findings suggest that **teachers strongly acknowledge the use of virtual lab** to meet different learner's capabilities.

Q.13. Virtual Science Lab contributes to my professional development by offering new teaching tools and techniques.

Fig 4.13

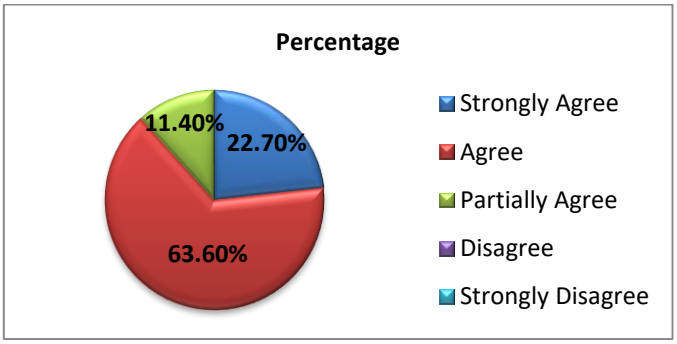

Fig 4.13 shows that all the teachers **exhibit a high level of agreement** with the idea that The Virtual Science Lab contributes to my professional development by offering new teaching tools and techniques with **22.7 % strongly agreeing, 63.6 % agreeing and 11.4% partial agreeing.** All the teachers (100%) agree, while a notable portion (22.7%) strongly agrees. The findings suggest that **teachers strongly acknowledge the use of virtual lab** to contribute to my professional development by offering new teaching tools and techniques.

Based on the discussions outlined in points 8 to 13 and the data presented in Figures 4.8 to 4.13, it can be revealed that all the teachers (100%) agree, while a notable portion (22.7%) strongly agrees.

Objective 1.3: To examine how secondary science teachers perceive the role of virtual labs in empowering students' learning.

Result and discussion: For **above objective** which focused on assessing teachers' views on the effectiveness of virtual labs in empowering students' learning, **five relevant items** were included in the

instrument. Result showed that teachers demonstrate strong acknowledgement regarding the effectiveness of virtual science labs in empowering students' learning in secondary-level science.
Question-wise detailed descriptions are as follows:
Q.14 Virtual labs are beneficial for secondary school students.

Fig 4.14

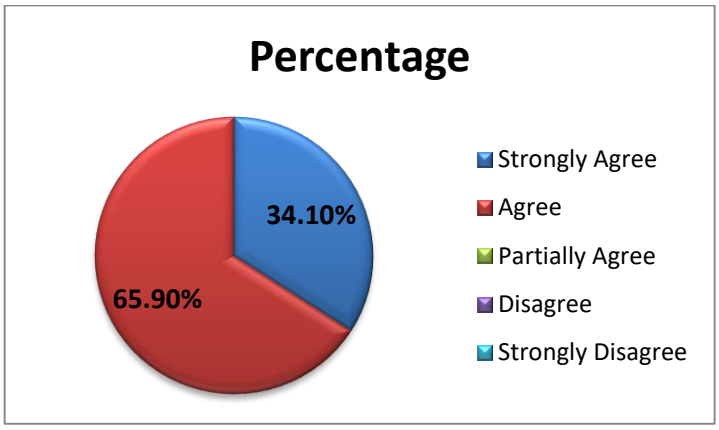

Fig 4.14 shows that science teachers **exhibit a high level of agreement** with the idea that virtual labs are beneficial for secondary school students with **34.1% strongly agreeing** and **65.9% agreeing**. The majority 100% agree, while a notable portion (34.1%) strongly agrees.
The findings suggest that **teachers unanimously acknowledge the use of virtual lab for science students.**
Q.15.The virtual lab provides students with new dimensions for self-learning, allowing them to enhance their scientific attitude and creativity.

Fig 4.15

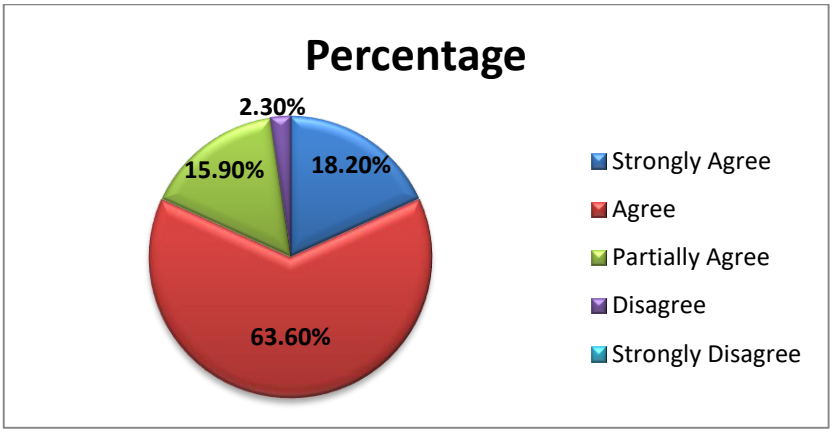

Figure 4.15 illustrates that **18.2 % of teachers strongly agree, 63.6 % agree** and **15.9 % partially agree and 2.3% disagree** with the statement that the virtual lab provides students with new dimensions for self-learning, allowing them to enhance their scientific attitude and creativity. The data shows that a significant majority of teachers (79.5%) perceive that virtual lab is beneficial for self-learning, making scientific attitude and creativity. Only a small portion (2.3% i.e. 1 teacher only) expressed disagreement. These findings reflect a positive outlook on the use of virtual labs, highlighting their role in promoting self-directed learning while fostering students' scientific attitudes and creativity.
The data indicates that most teachers view virtual labs as highly beneficial for promoting self-learning, scientific attitude, and creativity among students. With nearly 80% agreeing or strongly agreeing, and only one teacher disagreeing, the findings reveal an overall positive perception of virtual labs in enhancing self-directed and creative learning.
Q.16. With the help of VSLA module students will be able to learn higher order skills like analyzing, evaluating, creating in scientific way.

Fig 4.16

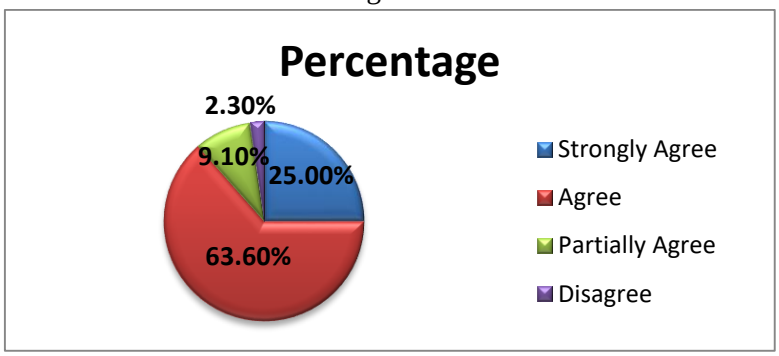

Fig 4.16 shows that all the teachers **exhibit a high level of agreement** with the idea that The Virtual Science Lab contributes to my professional development by offering new teaching tools and techniques with **25 % strongly agreeing, 63.6 % agreeing and 9.1% partial agreeing, 2.3 disagree with the statement**. Out of 88 teachers 86 teachers shows agreement, while a notable portion (25%) strongly agrees. The findings suggest that **teachers strongly acknowledge the use of virtual lab for students** to contribute to learn higher order skills like analyzing, evaluating, creating in scientific way.

Q.17. With the help of the virtual lab, our students will be able to create various projects related to the subject of Science in the future.

Fig 4.17

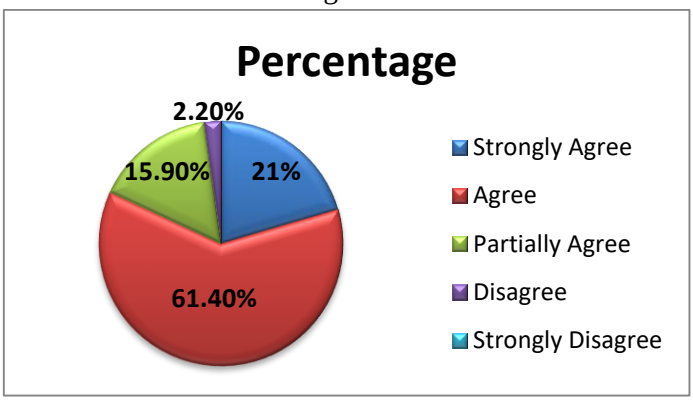

Fig 4.17 shows that all the teachers **exhibit a high level of agreement** with the idea that The Virtual Science Lab contributes to my professional development by offering new teaching tools and techniques with **20.5 % strongly agreeing, 61.4 % agreeing and 15.9% partial agreeing**. All the teachers 97.8% agree, while a notable portion (20.5%) strongly agrees. The findings suggest that **teachers strongly acknowledge that with** the help of the virtual lab students will be able to create various projects related to the subject of Science in the future

Q.18. Virtual science lab facilitates students with meaningful hands-on learning experiences.

Fig 4.18

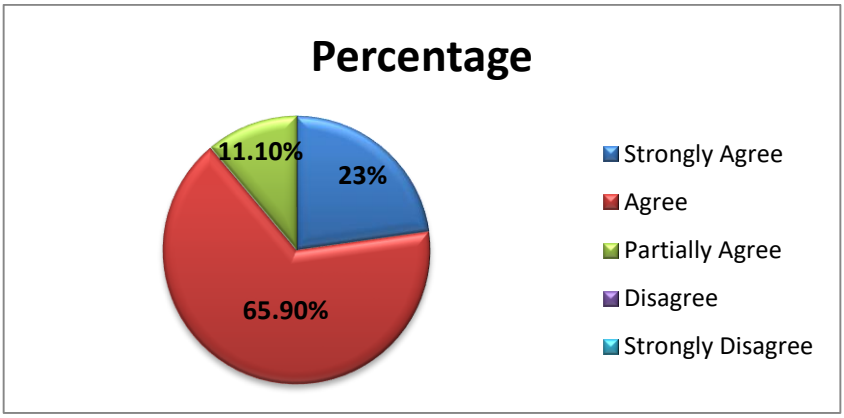

Fig 4.18 shows that all the teachers **exhibit a high level of agreement** with the idea that Virtual science lab facilitates students with meaningful hands-on learning experiences. Teachers show **23 % strong**

agreement, 65.9 % agreement and 11.10% partial agreement in this regard. All the teachers (100%) agree, while a notable portion (23%) strongly agrees with this statement. The findings suggest that **teachers strongly support** that virtual science lab facilitate students with meaningful hands-on learning experiences.

Based on the discussions outlined for question no. 14 to 18 and the data presented in Figures 4.14 to 4.18, it can be concluded that teachers demonstrate strong acknowledgement regarding the role of virtual labs in empowering students' learning.

V. RESULTS

Quantitative Findings:

- Over 80% of teachers strongly recognize the effectiveness of virtual science labs in improving conceptual understanding in secondary science.
- Majority of participating teachers agreed that virtual science labs effectively support science teachers and their teaching practices in secondary-level science.
- A significant majority i.e. more than 80% of teachers affirm the role of virtual science labs in empowering students' learning strengthening students' grasp of scientific concepts at the secondary level.

Discussion

The findings of this study reveal that secondary school science teachers in Bihar hold a generally positive perception toward the usefulness of virtual labs in teaching science. The majority of teachers agreed that virtual labs provide a valuable supplement to traditional laboratories by enhancing students' conceptual understanding, improving engagement, and offering safe, cost-effective alternatives to physical experiments. These perceptions are consistent with previous research that highlights the role of virtual labs in enriching science learning through interactivity and visualization of complex concepts (e.g., De Jong et al., 2013; Zacharia & Olympiou, 2011).

A key insight from the study is that while teachers appreciate the pedagogical potential of virtual labs, they also acknowledged certain barriers to their widespread adoption. Infrastructural challenges, such as lack of internet connectivity, inadequate access to digital devices, and electricity shortages, were identified as major hindrances. Additionally, teachers reported limited training opportunities in handling virtual simulations, which restricted their confidence and readiness to integrate these tools into classroom practice. These findings are aligned with studies conducted in other developing regions, where resource constraints and insufficient professional development have been cited as obstacles in implementing digital learning tools (Rana et al., 2020).

This study revealed that secondary school science teachers in Bihar hold a largely positive perception of virtual labs, acknowledging their role in enhancing students' conceptual clarity, engagement, and providing safe, cost-effective alternatives to traditional laboratories. Teachers emphasized that virtual labs enrich science learning through interactivity and visualization of complex concepts, though they cannot fully replace hands-on experiments that develop manipulative skills. Hence, teachers suggested a blended model where both traditional and virtual labs complement each other for more effective science education.

At the same time, the study highlighted several barriers that limit the adoption of virtual labs, including infrastructural challenges such as poor internet connectivity, lack of devices, electricity shortages, and insufficient training. Teachers with prior ICT exposure reported higher confidence and more positive attitudes, underscoring the need for professional development and hands-on workshops. Overall, while virtual labs have strong potential to improve science teaching, successful implementation will require addressing infrastructural gaps, expanding teacher training, and conducting future studies that include student perspectives and measure long-term impacts on learning outcomes.

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