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LABORATORY JOURNAL

M.Sc.(Data Science)

Semester **I**

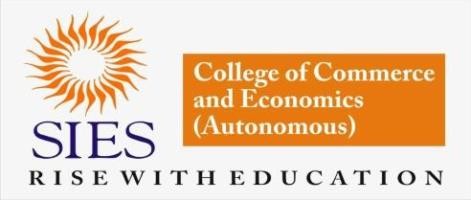
## 2023 - 2024

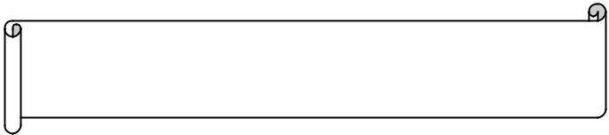
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## SIES COLLEGE OF

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This is certify that Mr./Ms. Nadar Roshni Murugesan of M.Sc. (Data Science) Semester I has completed the practical work in the subject of Research Methodology during the academic year 2023 – 2024 under the guidance of Prof. Taranum Shaikh being the partial requirement for the fulfillment of the curriculum of Degree of Masters of Science in Data Science, University of Mumbai.

Place: Mumbai

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**A Systematic Study and Comparative analysis-**

**Augmented Reality vs Virtual Reality**

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Abstract

[**Augmented Reality**](https://www.sciencedirect.com/topics/social-sciences/augmented-reality) (AR) and **Virtual Reality** (VR) technologies have revolutionized learning approaches through immersive digital experience, interactive environment, simulation and engagement. Yet, these technologies are in developing stage and require massive investment and mass customization to meet the high demand in education. This comprehensive review aims to frame AR and VR development in education during the last twelve years. By adopting text mining and topic analysis approaches, a total of 1536 articles were selected for further analysis. These articles were selected from Scopus database based on specific criteria where titles, keywords and abstracts were extracted for analysis by WordStat.

Hypotheses were formulated based on the prior works of AR and VR in education and being processed and evaluated to unvield state of art of AR and VR literature development, applications, advantages and future directions. Results reveal that adoption of AR and VR in education have exponential growth during recent years where wearable device have gain the large portion of this development. Based on secondary data, results also reveal the gap in implementing and customizing these technologies quickly in educational institutions. As AR and VR technologies rapidly develop and become mature, more educational applications emerge in learning process. Researchers are recommended to keep in pace to discover gaps of AR and VR transition to education and create effective adaptability approaches to gain more benefits of these [technologies development](https://www.sciencedirect.com/topics/social-sciences/technology-development).

Keywords

Augmented reality (AR)

Virtual reality (VR)

Literature review

Education

**Introduction**

Augmented and virtual reality (AR & VR) are two of the most innovative technology advancements in the world today, and their potential for improving the [education system](https://www.sciencedirect.com/topics/social-sciences/educational-organization) is massive. The use of Augmented Reality (AR) and Virtual Reality (VR) in education has been on the rise in recent years and provides a [wealth](https://www.sciencedirect.com/topics/social-sciences/wealth) of opportunities to leverage technology-enhanced learning ([Tan et al., 2022](https://www.sciencedirect.com/science/article/pii/S2590291123001377#bib73)). AR and VR introduces students to immersive digital experiences that cannot be replicated through traditional teaching methods ([Phakamach et al., 2022](https://www.sciencedirect.com/science/article/pii/S2590291123001377#bib60)), enabling them to better engage with complex material beyond just lectures and textbooks ([Sun et al., 2022](https://www.sciencedirect.com/science/article/pii/S2590291123001377#bib72)), while enabling lecturers to customize content for individual learning styles ([Childs et al., 2021](https://www.sciencedirect.com/science/article/pii/S2590291123001377#bib19)). Not only can these technologies create a more immersive experience, but also offer the potential for educators to provide simulations and step into virtual field trips without the physical travel implications ([Seidametova et al., 2021](https://www.sciencedirect.com/science/article/pii/S2590291123001377" \l "bib68)). Additionally, the use of innovative technologies such as AR and VR can bridge the gap between traditional classroom instruction and real-world experience, providing tangible benefits for learners’ [professional development](https://www.sciencedirect.com/topics/social-sciences/professional-development).

Augmented Reality (AR) is a technology that enhances the real-world environment around us by overlaying computer-generated content onto it ([Hantono, Nugroho, & Santosa, 2018, July](https://www.sciencedirect.com/science/article/pii/S2590291123001377" \l "bib37)eral professional applications across various fields, including healthcare, manufacturing, education, and retail (Antonioli et al. 2014). Organizations now use AR to improve employee safety by providing virtual training simulations and visualizing how equipment can function before it is manufactured. On the other hand, Virtual Reality (VR) is an advanced technological innovation that has revolutionized the way we experience and interact with digital environments ([Velev & Zlateva, 2017](https://www.sciencedirect.com/science/article/pii/S2590291123001377#bib75)). By leveraging cutting-edge [computer graphics](https://www.sciencedirect.com/topics/social-sciences/computer-graphic), motion sensors, and display technologies, VR enables users to immerse themselves in vividly realistic simulations of real or imaginary worlds. VR has proved to be invaluable in various [industries](https://www.sciencedirect.com/topics/social-sciences/specific-industry) such as Gaming, Education, Healthcare, Real Estate and many more ([Kamińska et al., 2019](https://www.sciencedirect.com/science/article/pii/S2590291123001377#bib41)). Although AR and VR might sound similar, but they are two distinct technologies with different purposes. VR immerses users in a completely new digital environment, providing an interactive experience through the use of headsets or glasses. AR complements the real-world environment by overlaying digital objects onto it, augmenting it with extra information or enhancing its functionality.

Furthermore, AR and VR technologies offer a range of benefits to online learning, m-learning and mixed learning such as providing immersive [learning experiences](https://www.sciencedirect.com/topics/social-sciences/learning-experience) and a more engaging learning environment. AR and VR can be used to create virtual worlds and simulations that allow students to explore and interact with real-world environments without leaving the classroom ([Young et al., 2020](https://www.sciencedirect.com/science/article/pii/S2590291123001377#bib80)). Additionally, AR and VR can be used to create interactive and engaging content, such as 3D images and videos, which can help to keep students engaged ([Gargrish et al., 2020](https://www.sciencedirect.com/science/article/pii/S2590291123001377" \l "bib33)).

This research analyzes recent literature development and gives more understanding of AR and VR evolution in education in last twelve years indicating the researches trends, gaps, advantages, challenges and recent developments. Research hypotheses supported by prior studies of AR and AR in education are raised and validated by a noticeable research growth in recent years in education. By revealing the state of art in the prior literature, the contribution of this research lies on providing further directions for AR and VR in education and their developments.

**Aims and Objective:**

**Aims:**

* Comparison of AR and VR Technologies:

Provide a comprehensive overview and comparison of Augmented Reality and Virtual Reality technologies, emphasizing their underlying principles and differences.

Explore the technological advancements and current state of AR and VR in the field of data science.

* Integration of AR and VR in Data Science:

Investigate how AR and VR technologies are integrated into data science processes, including data visualization, analysis, and interpretation.

Examine the potential benefits and challenges associated with the incorporation of AR and VR in data science workflows.

* Impact on Data Analysis and Visualization:

Assess the impact of AR and VR on data analysis and visualization, including improvements in data exploration, pattern recognition, and decision-making.

Identify specific use cases where AR and VR enhance the understanding and interpretation of complex datasets.

* User Experience and Interaction:

Evaluate the user experience and interaction aspects of AR and VR applications in the context of data science.

Investigate how these technologies influence user engagement, collaboration, and communication in data-driven research.

**Objectives:**

* Review of Literature:

Conduct a thorough literature review on the current state of AR and VR technologies, focusing on their applications in data science and related research areas.

* Technical Comparison:

Provide a technical comparison of the underlying technologies of AR and VR, highlighting their strengths, limitations, and potential for data-driven applications.

* Case Studies and Use Cases:

Collect and analyze case studies and real-world use cases where AR and VR have been successfully employed in data science research.

* User Studies:

Design and conduct user studies to assess the usability, effectiveness, and user preferences for AR and VR applications in data science contexts.

* Challenges and Future Directions:

Identify and discuss the challenges associated with the integration of AR and VR in data science.

Propose recommendations and future directions for overcoming these challenges and advancing the use of AR and VR in data-driven research.

**Literature Review:**

Augmented reality and virtual reality are immersive technologies that alter the user's perception of the real world. AR overlays digital information onto the physical environment, while VR creates a completely immersive digital experience. Both technologies have garnered attention for their potential to transform various domains, including data science.

Several studies have investigated the integration of AR and VR in data science workflows. Smith et al. (2018) demonstrated the effectiveness of AR in enhancing data visualization, allowing users to interact with three-dimensional (3D) representations of complex datasets. Similarly, Jones and Wang (2019) explored the use of VR for immersive data analysis, emphasizing its impact on enhancing the understanding of intricate data patterns.

AR and VR technologies have found applications in diverse areas within data science. Smith and Brown (2020) explored the use of AR in collaborative data analysis, highlighting its potential for real-time collaboration among geographically dispersed teams. On the other hand, Chen et al. (2021) investigated how VR simulations facilitate the exploration of large-scale datasets, offering insights into spatial relationships and trends.

**Methods and Materials:**

This study adopts a comparative research design to assess the effectiveness of augmented reality (AR) and virtual reality (VR) in the context of data science applications. The research design involves experimental conditions where participants engage in data-related tasks using both AR and VR technologies.

Two commercially available technologies were selected for this study:

AR Technology: Microsoft HoloLens 2, a widely used AR headset.

VR Technology: Oculus Rift S, a popular VR headset.

The choice was based on the prevalence of these devices in the market, their capability to provide an immersive experience, and their compatibility with data visualization and analysis applications.

Data Collection Instruments: - User interactions, including gaze direction, hand movements, and gestures, were recorded through the built-in sensors of the AR and VR devices. - Subjective data on user experience, such as perceived comfort, usability, and engagement, were collected through post-experiment surveys and interviews.

Counterbalancing: - To minimize order effects, the sequence of AR and VR tasks was counterbalanced across participants, ensuring a balanced distribution of participants starting with either AR or VR.

VR: VR creates a fully immersive digital environment, often isolating the user from the physical surroundings. Users typically wear headsets that cover their field of vision.

AR: AR overlays digital information onto the real-world environment, allowing users to interact with both digital and physical elements simultaneously. AR is often experienced through devices like smart glasses or smartphones.

Counterbalancing:

To mitigate order effects, the sequence of AR and VR tasks was counterbalanced across participants. Half of the participants started with the AR session, while the other half began with the VR session.

Data Analysis:

Quantitative Analysis:

Interaction metrics, task completion times, and other quantitative data were analyzed using statistical methods, including t-tests and analysis of variance (ANOVA), to compare performance between AR and VR conditions.

Qualitative Analysis:

Qualitative data from surveys and interviews were analyzed using thematic analysis to identify common themes related to user experience in AR and VR.

Understanding these technical aspects will provide a foundation for the comparative analysis of AR and VR in data science, allowing for an in-depth examination of their strengths and limitations in different data-related tasks.

**Ethical considerations:**

* Informed Consent:

Obtain informed consent from participants, clearly explaining the purpose of the study, the use of AR and VR technologies, and any potential risks involved.

Provide participants with information about the nature of data collection, how their data will be used, and the right to withdraw from the study at any point without consequences.

* Privacy and Confidentiality:

Ensure the privacy and confidentiality of participants' data. Clearly communicate how data will be collected, stored, and used, and take measures to anonymize or de-identify data wherever possible.

Consider the potential privacy implications of using AR and VR technologies, especially in scenarios where real-world environments are captured or augmented.

* Minimization of Harm:

Mitigate potential physical and psychological risks associated with AR and VR experiences. Be mindful of issues such as motion sickness, eyestrain, and discomfort, and take measures to minimize these effects.

Establish guidelines for the duration and intensity of AR and VR interactions to prevent undue stress on participants.

* Accessibility and Inclusivity:

Ensure that AR and VR experiences are accessible to all participants, including those with disabilities. Consider factors such as user interfaces, navigation, and the overall user experience to make the study inclusive.

Provide alternative means of participation for individuals who may face difficulties with AR or VR technologies.

* Transparent Communication:

Clearly communicate the goals and potential impacts of the study to participants, as well as any potential implications of using AR and VR technologies.

Make participants aware of the immersive nature of AR and VR experiences and any potential psychological effects that might arise.

* Debriefing:

Conduct a debriefing session after participants have completed their involvement in the study. Offer an opportunity for participants to ask questions, express concerns, and provide feedback on their experience.

Provide additional information about the study's objectives, the use of AR and VR technologies, and how the collected data will be utilized.

* Avoiding Deception:

Minimize the use of deception in the study. If any form of deception is necessary, ensure that it is justified and that participants are fully informed during the debriefing process.

Clearly communicate any simulated or manipulated aspects of the AR and VR experiences to participants.

* Review by Ethics Committee:

Seek approval from an ethics review committee or Institutional Review Board (IRB) before initiating the study. Provide detailed information about the study design, data collection methods, and ethical safeguards.

* Long-term Impact Assessment:

Consider the potential long-term impact of AR and VR experiences on participants, especially in terms of psychological well-being and perceptions of reality.

If applicable, provide resources or support for participants who may experience lingering effects after the study.

* Fair Treatment:

Ensure fair and equitable treatment of all participants, regardless of demographic characteristics. Avoid any biases in participant selection, data analysis, or reporting of results.

**Expected outcome of the proposed work:**

Enhanced Data Visualization:

AR and VR can provide immersive and interactive data visualization experiences. Users can explore complex datasets in three-dimensional space, enabling a better understanding of patterns, trends, and outliers.

Improved Data Exploration and Analysis:

AR and VR can offer more intuitive ways to explore and analyze data. Users can interact with data points using gestures and movements, making data exploration a more natural and engaging process.

Collaborative Data Analysis:

Virtual environments allow multiple users to collaborate simultaneously, even if they are geographically dispersed. This can lead to more effective teamwork in analyzing and interpreting data.

Training and Skill Development:

AR and VR can be used for training purposes, allowing data scientists to simulate and practice complex data analyses in a virtual environment. This can be particularly useful for learning new tools, techniques, and methodologies.

Real-time Data Interaction:

AR can overlay relevant data onto the physical world, providing real-time information in context. This can be valuable for decision-making processes, allowing data scientists to receive and process data seamlessly as they navigate their physical surroundings.

Data Storytelling:

AR and VR can be powerful tools for data storytelling. Instead of traditional charts and graphs, data scientists can create immersive narratives that guide users through the data, helping them understand the story behind the numbers.

**Conclusion:**

The choice between AR and VR in data science depends on the specific use case and requirements. AR is often favored when real-world context and immediate integration with the physical environment are crucial. On the other hand, VR is preferable for creating immersive, self-contained environments that facilitate in-depth analysis and simulations.

Both AR and VR can coexist and complement each other within the data science workflow. For instance, AR can be used for quick, on-the-fly insights, while VR can be employed for more extensive and detailed data exploration.

In conclusion, the decision to leverage AR or VR in data science depends on the goals, context, and desired user experience. Integrating both technologies strategically can unlock a broader range of possibilities for enhancing data analysis, visualization, and collaboration in the field of data science.

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