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Transforming Education in Uttarakhand through Cloud Computing Model: An Explorative Study

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Abstract

The education system in Uttarakhand, India, faces significant challenges, including inadequate infrastructure, limited teacher availability, and difficulties in delivering quality education to remote areas. This study explores the potential of cloud computing to transform the education system in Uttarakhand, improving access, reducing costs, and enhancing collaboration. The study's implications suggest a 'TESU' model that cloud computing can play a critical role in bridging the digital divide and providing quality education to all in Uttarakhand. The findings of this study can inform education policy and practice in Uttarakhand, highlighting the need for additional investment in cloud computing infrastructure and educator training.

Keywords: *Education, Model, Cloud Computing, Learners, MOOCs.*

1. Introduction:

In recent years, the Indian government has emphasised the need to revamp the education system to make it more inclusive, accessible, and effective. In this context, technology has emerged as a powerful tool to bridge the gap between the haves and have-nots. Cloud computing, in particular, has the potential to transform the education landscape in Uttarakhand by providing scalable, cost-effective, and flexible solutions for storing and accessing educational resources. Uttarakhand Open University, the only State Open University in Uttarakhand, has established its Learning Support Centres (LSCs) in remote locations across the state. This initiative has significantly contributed to fulfilling its mission of bringing 'education to the doorsteps of learners. (Joshi, Fulara, Tamta, Chaudhury, & Paliwal, 2022). In Uttarakhand, higher education is offered by 36 institutions, with 97% operating through conventional modes and only 1 university (3%), Uttarakhand Open University (UOU), dedicated entirely to ODL (Open and Distance Learning).

Cloud computing can facilitate remote learning, enable collaborative learning environments, and provide students in even the most remote areas of Uttarakhand with access to high-quality educational content. Moreover, cloud-based solutions can help reduce the digital divide, increase access to education, and improve learning outcomes. This paper proposes a case model for transforming education in Uttarakhand through cloud computing, focusing on leveraging this technology to overcome challenges faced by the traditional education system. The proposed model aims to explore the potential of cloud computing in enhancing the quality, accessibility, and affordability of education in Uttarakhand. By examining the current challenges faced by the education system in the region and identifying the opportunities offered

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by cloud computing, this research paper aims to develop a comprehensive framework to harness the power of cloud technology and transform education in Uttarakhand.

2. Aim and objectives

Based on the abstract provided, the following two objectives can be derived for the study:

Objective 1: To evaluate the impact of cloud computing on improving access to quality education in Uttarakhand, particularly in remote and underserved areas, by addressing challenges such as inadequate infrastructure and limited teacher availability.

Objective-2: To develop and propose the 'TESU' model, demonstrating how cloud computing can reduce costs, enhance collaboration, and bridge the digital divide in Uttarakhand's education system, with implications for informing education policy and practice.

3. Literature Review

Cloud computing has emerged as a transformative technology in education, offering numerous benefits and challenges. It provides access to advanced infrastructure and software, enhancing teaching effectiveness and student learning ((Anand, 2015). Cloud computing enables inclusive and equitable quality education, aligning with the UN Sustainable Development Goals. (Haleem, Javaid, Qadri, & Suman, 2022). It facilitates better management of educational resources, including labs, research facilities, and libraries, while promoting collaborative work among students and teachers. (Ruzaina & Afshar, 2017). The technology's advantages include cost reduction, improved computing power, and increased accessibility. (González Martínez, Bote-Lorenzo, Gómez-Sánchez, & Cano-Parra, 2015). However, implementation challenges persist, such as security concerns and the need for careful service selection. Despite these challenges, cloud computing's potential to revolutionise education is significant, particularly in light of recent global events like the COVID-19 pandemic, which has accelerated the adoption of digital technologies in education. (Haleem, Javaid, Qadri, & Suman, 2022). The following papers are relevant and align well with the research topic, as mentioned in Table 1.

Table 1: Cloud Computing and Education

Scope of Cloud Computing in the Education Sector: A Review *(Anand, H.S., & India, P. (2015). Scope of Cloud Computing in Education Sector: A Review.)*	- Cloud computing can help deliver quality education by providing access to the latest hardware and software infrastructure. - There are certain issues that need to be addressed when implementing cloud computing in the education sector.
Understanding the Role of Digital Technologies in Education: A Review *(Haleem, P.A., Javaid, D.M., Qadri, P.M., & Suman, D.R., 2022). Understanding the Role of Digital Technologies in Education: A review. Sustainable Operations and Computers.)*	- Digital technologies are essential tools for achieving quality education and have various applications in areas like emissions detection, energy efficiency, and greenhouse gas removal. - The COVID-19 pandemic has accelerated the adoption of digital technologies in education, leading to a paradigm shift where

	they serve as knowledge providers, co-creators of information, mentors, and assessors. - Technological improvements in education have made it more convenient for students, allowing them to use digital tools and devices instead of traditional methods, which increases their research interest.
Role of cloud computing technology in the education sector *(*Thavi, R.R., Jhaveri, R.H., Narwane, V.S., Gardas, B.B., & Jafari Navimipour, N. (2021). Role of cloud computing technology in the education sector. *Journal of Engineering, Design and Technology*.)	- The paper identifies various factors that influence the adoption of cloud computing in the education sector. - Cloud computing could enhance educational systems, especially in developing countries, and improve the scope for remote/distance learning.
Cloud-Based Architecture for Smart Educational System Using Modern Technology *(Vistro, D.M., Rehman, A.U., Abid, A., Farooq, M.S., & Idrees, M.S. (2020). Cloud-Based Architecture for Smart Educational System Using Modern Technology.)*	- Cloud computing is a revolutionary technology that is transforming the traditional IT system. - Cloud computing can change the way teaching is done, as students are moving towards modern technology, and educational institutions need to educate students and teachers about cloud computing and data storage. - Implementing cloud-based systems in educational institutions, especially in backward areas, is a challenge due to a lack of awareness about cloud computing.
Understanding the Status of Computer Education in the State of Uttarakhand: A Case Study of Roorkee *(Aggarwal, U. (2020). Understanding the Status of Computer Education in the State of Uttarakhand: A Case Study of Roorkee.* International Conference on Research in Management & Technovation*.)*	- The study aimed to analyse the impacts of e-initiatives in the education sector in the state of Uttarakhand. - The study specifically looked at the issues with e-initiatives in school education in Uttarakhand, with a case study of the city of Roorkee. - The study also examined the computer literacy and skills of school-going children in the region.
Selecting a suitable Cloud Computing technology deployment model for an academic institute.	- Selecting a suitable cloud computing deployment model is an important decision for academic institutes, as it can impact the

(N., R., P., S., G., T., & G. A. (2014). Selecting a suitable Cloud Computing technology deployment model for an academic institute. Campus-wide Information Systems, 31*, 319-345.)*	requirements of various stakeholders. - The implementation of cloud computing in the educational sector is more common in Western countries compared to developing countries like India.

Based on the recent research reviewed (Table 1), the following common findings and gaps have been identified:

a) **Common Benefits and Challenges:** Most studies highlight the numerous benefits of cloud computing in education, such as providing a reliable, scalable, and cost-effective on-demand computing infrastructure. However, these studies also identify challenges in their implementation, particularly in educational systems.

b) **Lack of Centralised Monitoring: A significant gap identified is the absence of a centralised** monitoring system for educational institutions in India. This is seen as a major factor contributing to the country's low literacy rates and poor-quality education.

c) **Geographical Disparities in Implementation:** The adoption of cloud computing in education is more prevalent in Western countries compared to developing nations like India. This indicates a disparity in the implementation and utilisation of cloud technologies across different regions in the educational sector.

d) **Focused but Limited Scope:** Aggarwal, U. (2020) conducted a study focusing on a single state (Uttarakhand) and city (Roorkee), offering a "general review" and recommendations for improvement. However, this study lacks a detailed analysis of current e-initiatives, limiting its applicability to broader contexts.

e) **Absence of a Suitable Model for Learners:** None of the reviewed research papers has proposed or implemented a suitable cloud computing model tailored specifically for learners. This represents a significant gap in the literature, indicating the need for further research in this area.

This review highlights the need for more comprehensive studies that address these gaps, particularly the development of tailored cloud.

4. Why ‘TESU’ model for Learners?

The market for online project preparation and training for students in India, specifically targeting BCA, BBA, MCA, and MBA programs, is significant and growing rapidly due to increasing demand for skill-based education, remote learning, and the widespread use of online platforms. Here’s an approximate estimate of the market size in terms of money and learners:

(a) **Market Size in Terms of Revenue:** The Indian EdTech market is expected to reach around

$10.4 billion by 2025, growing at a compound annual growth rate (CAGR) of 39% from 2020 to 2025. **(Bain Company, 2020)**

(b) **Market Size in Terms of Learners:** India has a large student base in higher education, with over 38 million students enrolled in various undergraduate and postgraduate programs. As a result, a significant portion is enrolled in courses such as BCA, BBA, MCA, and MBA. With the rise of online learning, many students are now using online platforms for project preparation and training. It is estimated that around 20% to 30% of these students (approximately 800,000 to 1.2 million learners) are actively using online services for their academic projects and training needs. **(KPMG & GOOGLE, 2021)**

(c)**Growth Factors**

- **COVID-19 Impact**: The pandemic accelerated the shift to online learning, significantly boosting the market for online education and training.

- **Government Initiatives**: Programs like SWAYAM and Digital India have further fueled the adoption of online education (Ministry of Education, 2023)**.**

- **Increased Internet Penetration**: With the rise in internet accessibility and smartphone usage in India, even students from remote areas are now able to access online training and project preparation resources (Nasscom, 2024).

5. Description of Proposed 'TESU' Model

In Figure 1 of a cloud service architecture, several components are depicted. This diagram is based on three layers:

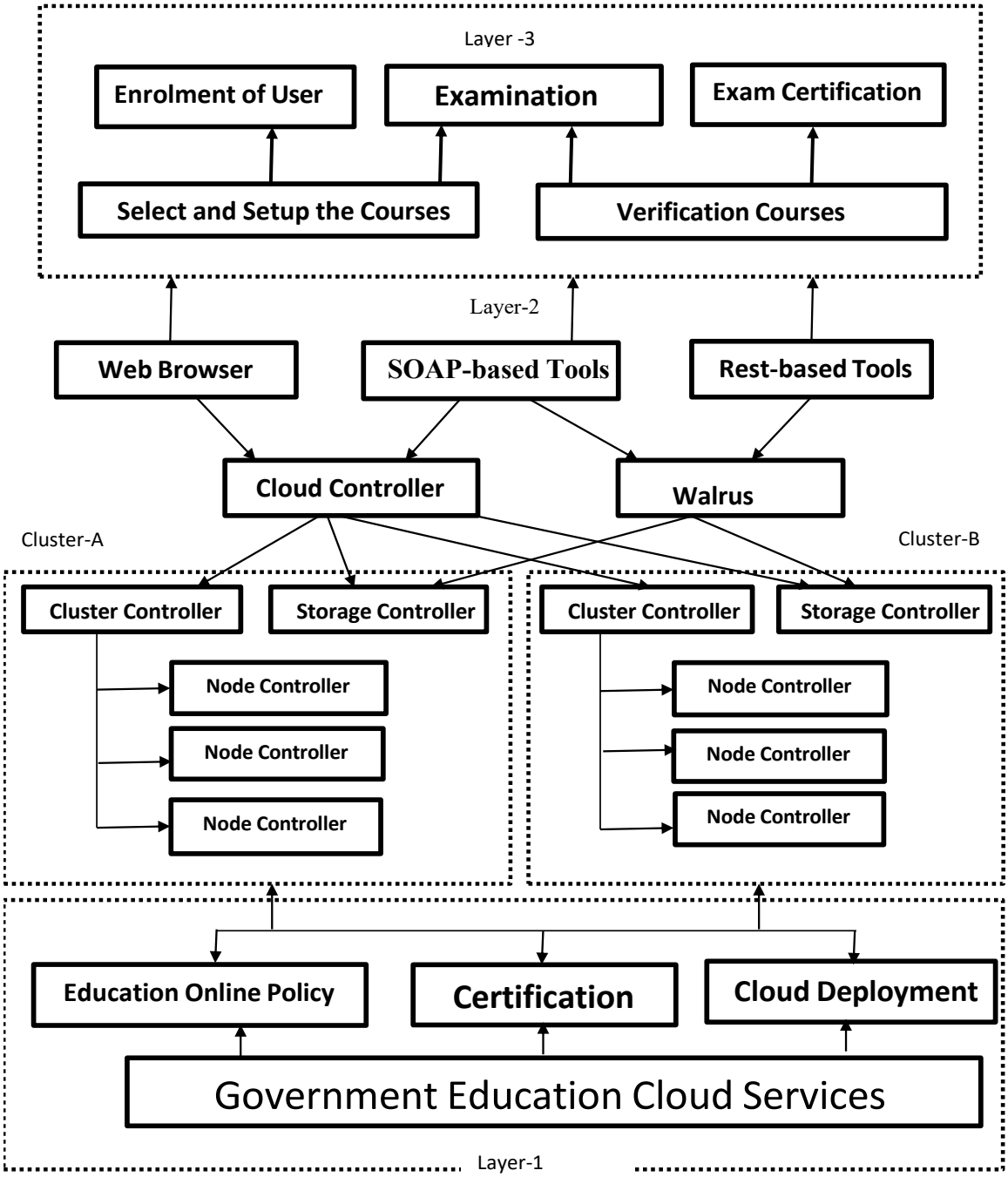
Layer 1 and the innermost core of the system**.** This can also be called the Government Education Cloud Services Layer (GECS Layer). This Layer suggests the presence of cloud services specifically tailored for government education purposes, highlighting a specialized use case within the cloud environment. This layer has three components:

(a)Education Online Policy: The role of an Education Online Policy at the state level is crucial for shaping the future of digital learning. Such a policy typically encompasses several key functions:

i. **Accessibility and Inclusion**: Ensures that all students, regardless of location, socioeconomic status, or physical ability, have access to quality online education. It promotes digital literacy and provides the necessary infrastructure, such as internet connectivity and digital devices, to underserved areas.
ii. **Curriculum and Content Development**: Guides the creation and curation of online educational content that aligns with state educational standards. It ensures that digital resources are relevant, up-to-date, and cater to diverse learning needs.
iii. **Teacher Training and Support**: Establishes guidelines for training educators in effective online teaching methods. It supports professional development to help teachers integrate technology into their classrooms and adapt to new online teaching platforms.

iv. **Quality Assurance and Evaluation**: Sets standards for the quality of online education, including content delivery, student engagement, and assessment methods. It also includes mechanisms for continuous evaluation and improvement of online educational programs.
v. **Data Privacy and Security**: Provides regulations to protect student data and ensure privacy in the online learning environment. It addresses cybersecurity and the ethical use of student information.
vi. **Equity in Funding**: Ensures equitable allocation of resources to schools for implementing online education, particularly in rural or economically disadvantaged areas. It may also involve partnerships with private sector companies or non-profits to fund digital education initiatives.
vii. **Policy Advocacy and Public Awareness**: Advocates for the importance of online education and its role in modern learning. It helps increase public awareness of the benefits and challenges of digital learning, fostering a culture of acceptance and support.
viii. **Innovation and Research**: Encourages innovation in educational technology and pedagogy. It supports research initiatives to explore new online learning methods, tools, and their impact on educational outcomes.

Figure 1: Proposed Model (TESU) Based on Eucalyptus



By effectively implementing these roles, an Education Online Policy can help bridge the digital divide, enhance learning outcomes, and prepare students for the demands of the modern workforce.

(b) Certification

The Certification Layer in an online education model plays a crucial role in validating and recognizing the knowledge, skills, and competencies that students acquire through digital learning platforms. Here's how it functions within the context of a state's online education system:

1. **Standardization of Credentials:** Ensures Consistency: The Certification Layer establishes a standardized system for awarding certifications across various online courses and programs, ensuring that credentials are consistent, reliable, and recognized across the state. Alignment with State Standards: Certifications align with state educational standards, ensuring that online learning outcomes meet or exceed expectations set for traditional education models.

2. **Accreditation and Quality Assurance:** Validates Program Quality: This layer plays a critical role in accrediting online courses and programs, ensuring that they meet the required quality standards. Accredited programs are more likely to be trusted by employers, educational institutions, and other stakeholders. Monitoring and Evaluation: It involves regularly assessing online education providers to maintain the credibility and integrity of the certification process.

3. **Recognition and Transferability:** Facilitates Recognition: Certifications awarded through this layer are designed to be recognized by employers, higher education institutions, and professional bodies both within and outside the state. This helps students transition smoothly into the workforce or further studies. Enables Credit Transfer: It allows the transfer of credits and certifications between institutions, both online and traditional, facilitating lifelong learning and mobility for students.

4. **Validation of Learning Outcomes:** Assesses Competency: The Certification Layer ensures that certifications accurately reflect the learner's competency in a subject area, through assessments, practical exams, or project-based evaluations. Supports Personalized Learning: It may also recognize micro-credentials or modular learning, where students can earn certifications for specific skills or knowledge areas, supporting personalized and flexible learning pathways.

5. **Enhancing Employability:** Bridges Education and Employment: Certifications serve as a bridge between education and the labor market by validating skills that are directly relevant to industry needs. This layer can work closely with employers to ensure certifications align with current job-market demands. Supports Career Advancement: For working professionals, the Certification Layer offers opportunities for upskilling and reskilling, helping them to advance in their careers through recognized and relevant credentials.

6. **Equity and Accessibility:** Broadens Access to Credentials: By providing accessible certification options, this layer ensures that learners from diverse backgrounds, including those in remote or underserved areas, can earn recognized credentials that enhance their educational and employment opportunities. Supports Non-Traditional Learners: It recognizes and certifies informal and non-traditional learning experiences, making education more inclusive for those who may not follow conventional educational pathways.

7. **Innovation and Adaptability:** Adapts to Technological Advances: The Certification Layer keeps pace with technological and educational innovations, incorporating new assessment methods, such as AI-driven evaluations or blockchain for secure credentialing. Encourages

Continuous Improvement: It fosters an environment where online education providers continually update and improve their offerings to meet evolving standards and learner needs.

8. **Policy and Governance:** Guides State Policy: The Certification Layer provides a framework for state policies related to online education, ensuring that certifications are integrated into the broader educational and workforce development strategies. Ensures Accountability: It holds online education providers accountable for the quality of their programs and the validity of the certifications they issue, thereby protecting students and maintaining public trust.

By fulfilling these roles, the Certification Layer enhances the credibility, recognition, and impact of online education in the state, contributing to a robust and flexible education system that meets the needs of a diverse learner population.

(c) Cloud Deployment

Cloud deployment in online education not only enhances the efficiency and effectiveness of educational delivery but also makes it more accessible, scalable, and adaptable to the evolving needs of learners and educators.

Second Layer (Technical Controlling Layer): The second layer has the following layers

- **Cluster Controller**: This component is responsible for managing and coordinating the resources within a cluster of servers in the cloud environment
- **Storage Controller**: The storage controller manages the storage resources in the cloud, ensuring data is stored and retrieved efficiently.
- . **Node Controller**: Node controllers manage individual nodes or servers within the cloud infrastructure.
- **Walrus:** A part of the cloud deployment process or a tool used in managing cloud services.

(d) Third Layer: User Defined Application Layer.

The third layer of the proposed TESU Model is the User-Defined Application Layer, which offers several key functionalities:

1. **Course Selection and Setup**: Users can browse and select subjects for learning based on their interests or professional needs. Additionally, professionals have the option to create their own courses and syllabus, tailored to specific industry or academic requirements.
2. **Course Verification:** Before any course becomes available to learners, it undergoes a verification process. This ensures that all content aligns with educational standards and policies set by the governing body.
3. **User Enrolment and Examination**: Once a course is verified, users can enroll and participate in the course. The system manages the examination process, allowing learners to demonstrate their understanding of the material.

4. **Certification**: After successfully completing the course and examination, learners receive a certificate. This certification is approved by the government layer, adding credibility and recognition to the learner's achievements.

This User-Defined Application Layer empowers both learners and professionals by providing flexibility in course selection and creation while ensuring that all educational content meets established standards. Overall, the components and elements in the diagram represent the various aspects and functionalities involved in managing cloud services, particularly in the education and government sectors.

6. Data Collection

To evaluate the current learner market in Uttarakhand's higher education sector, an online survey was conducted across 18 universities and institutes offering BCA and MCA programs. The study analyzed enrollment data from 2021 to 2023. Survey responses were collected through institutional authorities and verified student records. The data highlights the enrollment trends in undergraduate (BCA) and postgraduate (MCA) computing programs across universities such as HNB Garhwal University, Kumaun University, UTU, UOU, Graphic Era Hill University, DIT, IMS, and others.
The graphical representation below illustrates year-wise enrollment patterns, reflecting the consistent demand for computer application programs in the state and indicating a stable learner base for implementing the proposed TESU cloud-based education model.

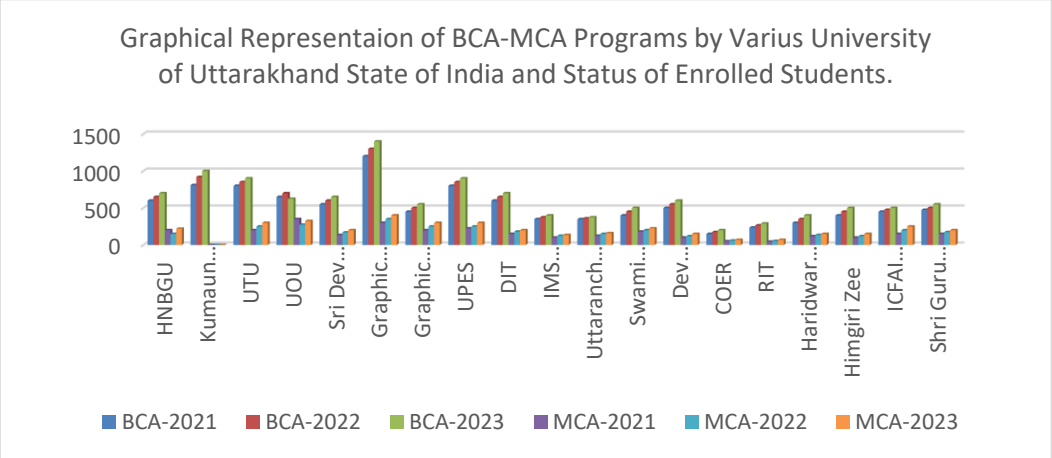


Figure 1: Enrolment Trends Across Various Universities in Uttarakhand (2021-2023)

7. Result Analysis

After exploration of the various literature and survey analysis the following points can be consider: -

- A significant gap identified is the absence of a centralized monitoring system for educational institutions in India.
- A suitable model is needed that benefits not only learners but also the government and business sectors.

- A model (TESU) is proposed that was based on centralized monitoring system as well as revenue generated business model.
- After analyses the chart of BCA and MCA as a case study for Uttarakhand the following result are given below:
    - BCA Programs: Most universities show a positive trend in BCA student numbers. The overall growth indicates a healthy interest in BCA programs.

Table 2: Analysis of Annual Growth of BCA Students

Number of Universities Analyzed: 19			
Growth from 2021 to 2022		**Growth from 2022 to 2023:**	
Mean:	9.52%	Mean:	7.71%
Standard Deviation:	3.82%	Standard Deviation:	5.23%
Minimum:	2.86%	Minimum:	-10.71%
Maximum:	16.67%	Maximum:	14.29%

From Table 2 Analysis of BCA and MCA Student Numbers Trends (2021-2023)

BCA Student Numbers Trends (Overall Trends):

- Increase in Numbers: The average number of BCA students has increased from 530 in 2021 to 617.89 in 2023.
- Yearly Growth: The average growth rate from 2021 to 2022 was 9.52%, and from 2022 to 2023, it was 7.71%

MCA Student Numbers Trends (Overall Trends):

- Increase in Numbers: The average number of MCA students has increased from 151.58 in 2021 to 200.26 in 2023.
- Yearly Growth: The average growth rate from 2021 to 2022 was 15.45%, and from 2022 to 2023, it was 18.86%.

(a) If a cloud platform were to capture a portion (e.g., 50%) of the mentioned education programs, a substantial part of the overall education program could be adjusted accordingly. Since universities typically require a project and internship in the final semester, offering these through courses on a cloud platform would not only benefit learners but also generate revenue for the government.

Under the proposed TESU model, any program on the cloud platform would be affiliated with the government, ensuring compliance with all established standards.

7. Conclusion:

This case study proposes using cloud computing to overcome the lack of higher education infrastructure in Uttarakhand. It introduces a cloud-based model for universities built on the Cloud Eucalyptus framework. By hosting final-year projects and internships for BCA and MCA students on a cloud platform, universities can enhance learning while generating revenue for the government.

In India, many students prioritise degrees over skill-based certifications, limiting interest in practical learning. The TESU model addresses this by offering government-certified programs that link learners with industry needs. Unlike existing platforms like Unacademy, Coursera, or SWAYAM, TESU combines engaging, blended learning with a government-controlled business model that benefits both the government and MOOC developers.

8. Practical Takeaways

- While platforms like SWAYAM, Coursera, and Unacademy focus mainly on learning and certification, the TESU model goes further by allowing users to design and upload their own courses.
- TESU welcomes any verified expert or enthusiast to create courses, unlike SWAYAM, which limits creation to university professors. It also helps final-year students find internships and lets professionals earn by sharing their expertise.
- NASSCOM's reach is mostly limited to major tech hubs, often overlooking Tier-2 and Tier-3 cities and smaller tech entrepreneurs.
- The TESU framework, a government-integrated cloud model, centralises resources, standardises certifications, and aligns courses with market needs to boost employability.

References

[1] Aggarwal, U. (2020). Understanding the Status of Computer Education in the State of Uttarakhand: A Case Study of Roorkee. In *ICRMAT* (pp. 19-30).

[2] Smitha, R. (2019). Cloud Computing in Educational Research: Scope, Concerns and Future Implications. i-manager's Journal on Cloud Computing, (2), 35

[3] Anand, H., Kamayani (2015). Scope of Cloud Computing in Education Sector: A Review. International Journal of Recent Research Aspects, 2 (2), June 2015, 150-152

[4] Bain Company, O. (2020). EdTech in India: A Market Poised to Thrive. Retrieved from https://www.omidyarnetwork.in/team/bain-company

[5] González-Martínez, J. A., Bote-Lorenzo, M. L., Gómez-Sánchez, E., & Cano-Parra, R. (2015). Cloud computing and education: A state-of-the-art survey. *Computers & Education*, *80*, 132-151.

[6] Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable operations and computers*, *3*, 275-285.

[7] Joshi, H. C., Tewari'Fulara, B., Tamta, K. K., Chaudhury, S., & Paliwal, D. (2022). Higher Education in India and Uttarakhand: Role Of Conventional VS Open and Distance Learning Systems. *Towards Excellence*, *14*(4).

[8] Rani, S., & Kumar, P. (2019). A journey of Indian languages over sentiment analysis: a systematic review. *Artificial Intelligence Review*, *52*(2), 1415-1462.

[9] KPMG, & GOOGLE. (2021). Online education in India. India: KPMG. Retrieved 09 09, 2024, from https://assets.kpmg.com/content/dam/kpmg/in/pdf/2017/05/Online-Education-in-India-2021.pdf

[10] Ministry of Education, G. o. (2023). Final Report on All India Survey on Higher Education. Retrieved from www.education.gov.in: https://www.education.gov.in/final-report-all-india-survey-higher-education

[11] Nasscom. (2024). Markets & Industry. Retrieved from https://nasscom.in: https://nasscom.in/markets-industry

[12] Ramachandran, N., Sivaprakasam, P., Thangamani, G., & Anand, G. (2014). Selecting a suitable cloud computing technology deployment model for an academic institute: A case study. *Campus-Wide Information Systems*, *31*(5), 319-345.

[13] Khan, R., & Alam, M. A. (2017). Cloud Computing in Higher Education in India. *International Journal of Advanced Research in Computer Science*, *8*(5).8

[14] Vistro, D., Rehm Vistro, D. M., Rehman, A. U., Abid, A., Farooq, M. S., & Idrees, M. (2020). Cloud-Based Architecture for a Smart Educational System Using Modern Technology. *Journal of Critical Reviews*, *7*(10), 1493-1503.

[15] Qureshi, H., Sagar, A. K., Astya, R., & Shrivastava, G. (2021, December). Big Data Analytics for Smart Education. In 2021 IEEE 6th International Conference on Computing, Communication and Automation (ICCCA) (pp. 650-658). IEEE.