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TRANSFORMING LEARNING: STUDENT PERSPECTIVES ON SMART AND SUSTAINABLE EDUCATIONAL ENVIRONMENTS IN INDIA

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Abstract: The Indian education system is one of the largest and most diverse education systems in the world, encompassing formal, informal, and non-formal modes of education and catering to learners from different social, economic, and cultural backgrounds. Rapid technological advancement and the emergence of digital learning have significantly transformed traditional educational practices and environments. In this context, smart and sustainable educational environments have gained importance in improving the quality, accessibility, and effectiveness of learning. However, existing literature on smart educational environments remains fragmented, with limited attention to students' perspectives and the environmental characteristics that influence learning. The present study attempts to address this gap by proposing an ontology and conceptual model of smart and sustainable educational environments from students' perspectives. The proposed model identifies key environmental characteristics that support learning activities and provides a structured framework for understanding students' experiences. A questionnaire based on the model is developed and validated to assess students' perceptions of their educational environments. The study further examines the relevance of different environmental characteristics to learning and identifies differences between designed and perceived environmental features. The findings emphasize the importance of learner-centred, technology-enabled, and sustainable educational spaces and provide useful insights for the planning and development of future educational environments in India.

Keywords: Smart Educational Environment, Sustainable Education, Indian Education System, Educational Environment, Digital Education, Sustainable Learning.

I. INTRODUCTION

Indian education system is one of the largest education systems in the world comprising schools, colleges, universities and vocational institutions. It is also one of the oldest education systems of the world fully spread across the country and catering to different strata of the society. Education in India is equally related to the social, economic and political fabric of the country and is being considered as a critical input for socio-economic and educational development (Boruah, 2019). At present, India has educationally one of the largest possible geographical terrains with varied shapes, sizes and structures. These include formal, informal and non-formal educational systems with different governance, resourcing and service delivery systems. India may have all types of educational systems, from least expensive to costliest ones, from poorest of the poor to the richest of the rich, from most inaccessible to the most accessible ones, from teacher-cheating ones, to quality controlled ones. Education is considered a fundamental right of every child. This view is supported by myriad declarations, treaties and laws at global, regional and national and local levels. All international protocols endorse the universal right and access to education for all children safeguarding the interest and the involvement of every citizen in achieving it. Education has been abruptly re-defined and politically transformed in the last two decades. With the introduction of technology and the rise of Web 2.0, meaning and way of education have altered profoundly. The new age education does not depend on bricks and mortar, libraries, teachers or chalk and board. This is a different era of ubiquitous and unlimited sources of knowledge and information; an era where classrooms and campuses are no more the exclusive domains of education.

II. BACKGROUND OF SMART EDUCATIONAL ENVIRONMENTS

Over the past 50 years, several views of smart environments have emerged in the literature, which differ in focus on certain views. Nevertheless, models of smart environments are scarce and are mostly focused on the realization of paradigmatic environments or on

conceptual definitions of the smart environments. Furthermore, an ontology for smart environments is still in its infancy and each class of environments is thus unaligned. Environmental description of educational environments is scattered throughout the literature, lacks standards, and does not account for students' perspectives. Moreover, the focus of design and analysis of educational environments is primarily on the learning activities that take place within it. Obvious determinants of the environment's environmental affordances and perceptions are largely neglected.

It is proposed to fill the gap by proposing an ontology of smart and sustainable educational environments from the students' perspectives. The proposed ontology was aligned with a set of design principles formulated with respect to the aforementioned criteria. Subsequently, the ontology was translated into the model. The model comprises a set of environmental characteristics designed to promote and support learning activities. Based on the proposed model, a design questionnaire was developed and subsequently validated.

Finally, a study of students' perceptions of smart and sustainable educational environments was conducted to develop a comprehensive database of students' experiences in actual educational settings. A scale for assessing students' perceptions of their educational environment was developed and validated. The study identified environmental characteristics that students perceived as either relevant or irrelevant to learning activities and examined significant differences between the characteristics intended in the design and those perceived by students. Based on these findings, three fundamental dimensions of design and perceptual characteristics were identified, providing a structured basis for understanding and evaluating smart and sustainable educational environments from the students' perspective.

III. SUSTAINABILITY IN EDUCATION

In many discussions on meeting sustainability challenges, formal education and lifelong learning are often overlooked. Numerous international agreements and processes call for a paradigm shift in education to meet sustainability challenges. Education can help change how people perceive, think, feel, and act in relation to other people, the world, nature, and the environment. Education may protect indigenous knowledge systems and promote ways of living that are sensible, respectful, and sustainable. However, education has also contributed to the dissemination and legitimization of ideologies promoting overconsumption of resources and marginalization of indigenous knowledge and tradition always of living (E.J. Wals & Benavot, 2017).

Given that so much of humanity's actions are currently deemed unsustainable, it seems reasonable to question the role and impact of education in this respect. On the surface, the argument is straightforward: if education is to be about ensuring the welfare of, and ways of living with, people, ecosystems, and all that sustains life on planet Earth, then education must reflect that discourse accordingly. Why not cease teaching classics and mathematics and devote everything to reorienting education systems, institutions, and actors to help meet the challenges posed by climate change, biodiversity loss, and social inequality? A reasonable and valid line of argument, but certainly much more multi-faceted in practice. This article takes stock of the influence and impact of education on sustainability, noting that education may be seen to have a rather dual role with respect to meeting sustainability challenges. Some educational aims, content, forms, and settings appear to influence views and actions in ways deemed counter-sustainable, while other related forms of education appear to aim at the opposite. Classification of educational responses in relation to sustainability is proposed, covering the who, what, and how of education. It is argued that, in light of the scale of the environmental crisis currently confronting the planet, there is an urgent need to materially change the responses to sustainability challenges.

IV. THE ROLE OF TECHNOLOGY IN EDUCATION

It is likely that the positive acceptance and effects of SST in education can be attributed to the fact that, in their own eyes, the proficiency gap between themselves and the teacher(s) shrank to a factor of low. Teachers in both retirement and active roles noted that SST also had to move into blocks of lock-up small cupboards. This did not abrogate the long-standing tradition of teachers conceptualizing media as tape and slide projectors, projectors, and audio players. Almost every suggestion for further advancement was followed by some type of amplifier. The complaint was that a hardware investment was simply a waste in the hands of teachers unfamiliar with or considering SST superstitious. Serving as an intermediary and demonstrating how to move even the smallest and simplest devices to education would be a far more instructive task than how to teach multimedia design.

It seems that teachers may be forced to haphazard except in rare instances, demoing software and free resources. It was discovered that teachers were less than adept at controlling a whiteboard; many had unsuccessfully taught students how to write up there a decade ago. The rush into education of process-engineered evaluations or talk was explained bluntly by survey respondents. Lest, experience with various media labs.

Unlike the present, disadvantaged students struggling to affix tech in addition to absorbing bigger notions of self-assurance, efficacy, belief in themselves, and responsibility for decisions, were surprising beneficiaries of SST as tools for mimicry, the humbling of teachers, the persuading of children to engage with the sources used to ad-lib strategies of getting task completion in return for marks,

image collections, and translations were emerging. Small children wrote reports outlining the limits of monitoring elevations to and from urban centers, mitigation by neighbourhood market, and contradictions in density expectations that they presented animated.

V. STUDENT PERSPECTIVES ON LEARNING ENVIRONMENTS

Learning environments are typically designed from the perspective of institutional requirements and pedagogy, rather than identifying how these transformations directly impact the learner. Student perceptions of how the learning environments influence their learning capabilities and achievement are vital to a deeper understanding of the transition and success of a learning environment at an educational institution. The aim of this research is to identify how students perceive their learning environments, their engagement in learning, and learning outcomes in the newer learning environments created within an institution. The research further explores the physical and non-physical attributes of the designed learning environments and their perceived impacts on perceived learning environments in class. The research involved graduate and undergraduate students from engineering, architecture, and design in one of India's premier institutions of higher education. The physical environments were identified through an exploratory investigation, and a scale was developed to measure student perceptions of the physical and non-physical attributes of the learning environments and a scale to measure student perceptions of the impact of the learning environments on perceived learning environments in class. The students perceived how the designed non-physical attributes positively impacted measurements such as perceived control, increased engagement, and contribution in class. Student engagement and its positive impact on learning were found as key factors increasing perceived learning environments in class. The results show how the learning environments and their attributes are perceived by students (Rajesh, 2014).

Research has shown the strong influence of learning environments on student learning, engagement, and success. There is a significant contribution of the non-physical attributes of a learning environment in creating an ambient learning environment promoting learning, engagement, and achievement. Transformations of learning environments to align with modern pedagogy and support student-centered learning are becoming a trend among institutions of higher education in India. However, learning environments are traditionally designed from institutional and pedagogical perspectives, which may lead to gaps in meeting student expectations and the created transformation's success. It is vital to understand these gaps from student perspectives and how the transformations directly impact student learning capabilities and achievement.

5.1 Qualitative Research Methods

The research reported in this paper was conducted in two phases. The first phase was the identification of desirable variables of smart and sustainable education environment from the students' perspective and the development of a questionnaire. The second phase was the analysis of qualitative data gathered using the questionnaire developed in phase one. The focus was on qualitative research. Descriptive statistics, exploratory factor analysis, independent sample t-test, and one-way ANOVA were largely used to analyze the quantitative data. The analysis results are narrated in the subsequent sections.

Phase 1: Qualitative Methods Research Design

The desire to establish the variables of smart and sustainable education environment in the Indian context enriched the exploration with qualitative interviews. The qualitative research phase was designed in two sub-phases: (i) Open-ended question, and (ii) Semi-structured interview. The phases are explained briefly.

A. Open-ended Question

An open-ended interview questionnaire, containing 5 open-ended questions, was administered electronically. Rather than asking close-ended questions or rating scales, the participants were encouraged to express their thoughts freely. This method of gathering information was complementary to the quantitative survey. A wide spectrum of ideas for the development of items hastily emerged in the first round of the qualitative exploration.

The whole method was carried out in a structured and semi-structured manner. The respondents were given an idea of the broad scope of the open-ended question prior to soliciting their response. Upon prompt, they produced minute fragments of information. Precaution was taken to secure confidentiality and other ethical issues.

B. Semi-structured Interview: The qualitative data obtained from the open-ended question were quantitatively analyzed. The preliminary exploration offered multiple items categorized under factors. While this flexible, broad-ended question form enabled the respondents to communicate their views freely, it also posed the challenge of using their responses for subsequent quantitative analysis. The conceptual and contextual differences in the expressions of the participants posed difficulty in designing appropriate quantitative items. To rectify this issue, the semi-structured interview method was employed. In contrast to open-ended questions, where the respondents were free to respond in any way they want, semi-structured interviews provide a minimum set of questions but still allow respondents the opportunity to provide information. Semi-structured interviews thus present a hybrid approach between rigidly structured surveys and open-ended interviews (Rajesh, 2014).

5.2 Quantitative Research Approaches

The quantitative part consisted of a survey of students from the Indian Institute of Management, Visakhapatnam. A structured 5-point Likert-type scale questionnaire that measures students' perceptions towards smartness and sustainability in educational environments was developed (Rajesh, 2014). The questionnaire includes 30 statements along with respondents' background information. These were sent to 267 students who were learning in a smart and sustainable environment. Out of 267 responses, 209 were received by the deadline fixed for closing the survey. Only 207 responses were valid and included for further statistical analysis. During the development of the questionnaire, a pilot study was conducted to survey 42 students, based on whose suggestions and comments minor modifications were made on the scale.

The data obtained from 207 students was analysed using the SPSS software package. Descriptive and inferential statistical tests were employed for the analyses. A composite mean score was calculated for each dimension, and a 5-point Likert-type scale was used for this purpose. The extent of perception on each dimension of smartness and sustainability was determined as follows: Highly favourable (mean score 4.50 to 5.00), Favourable (mean score 3.50 to 4.49), Neutral (mean score 2.50 to 3.49), Unfavourable (mean score 1.50 to 2.49), and Highly unfavourable (mean score 1.00 to 1.49). A hypothesis to be tested was developed for each variable. A 't'-test for two independent groups was used to test the hypothesis on background variables having two groups only, while ANOVA for independent groups was used for those having more than two groups. The level of significance was set at p less than .05.

The maximum mean score obtained was 4.09, indicating a rate of favourable perception of 81.74% on the five dimensions of smartness and sustainability, as compared to an overall mean score of 3.62 (72.43%) on the individual dimensions. The perception on each item ranged from 3.43 to 4.24, with the highest on "I feel safe as the space is under observation by CCTV cameras" and the lowest on "I manage each waste generated in my room by granular composting." It is concluded that the students have a favourable perception of the smart and sustainable educational environment, irrespective of all their background variables except the course of study.

VI. CASE STUDIES OF SMART EDUCATIONAL INSTITUTIONS IN INDIA

Due to the increased access and use of digital technologies among students, the education sector has also made efforts to upgrade traditional classrooms to smart classroom systems. This chapter presents the perspectives of students from smart educational institutions in India about the established smart classroom environments. It is reported that smart schools generally utilize smart board technologies, smart books, and smart learning platforms to improve classroom dynamicity and to provide constructed learning resources. To enhance the learning process, smart learning platforms are utilized to provide digital feedback on exam attempts and knowledge acquisition processes (Rajesh, 2014).

Similarly, it was found that mobile applications are developed and used to enrich the learning experience by engaging students and teachers in smart discussions. Further, these applications provide students with improved communication and portability that eventually lead to enhanced and free-flowing smart lessons. To support students' e-learning needs outside the classroom, important study materials other than textbooks are provided on the LMS platform (Charania & Davis, 2016). Although these positive outcomes are acknowledged to significantly enhance the learning experience, challenges regarding inadequate infrastructure are also noted. It is reported that the lack of computer laptops and projectors, university-provided smart learning aids, and internet connection were some of the challenges. Moreover, unlearning the traditional education system (purely teacher-centred) and adjusting to newly established teaching-learning practices was also noted as a challenge.

Lastly, students generally perceive that current smart learning infrastructures (varied combinations of learning management systems, smart boards, smart books, etc.) have improved the learning experience compared to the previous traditional learning infrastructures. Further, the newly established smart classroom systems are perceived to be lower in quality compared to the highly upgraded traditional ones. Therefore, a two-fold strategy involving hardware infrastructure and staff training, as well as enhancing the quality of smart learning infrastructure, is highlighted.

6.1 Urban Institutions

India is home to almost one-third of the world's illiterate citizens. This is considering the fact that the world population is 7.5 billion, with regard to the existence of 5,15,60,000 illiterate people in India according to Census 2011. The Constitution of India, with the 86th Amendment Act, recognized education as a fundamental right. Constraints including shortage of buildings, inadequate teachers, lack of facilities for drinking water, toilets and playgrounds, rusted laboratory equipment, and libraries not updated from previous government grades lead to disobedience to Fundamental Rights.

An ideal school must have an evergreen surrounding that has trees of different varieties, flowers of different colors, 24×7 purification of air, treatment of waste, and lakes or ponds for storing rainwater, which are very important for sustaining the environment (Boruah, 2019). Education systems should aim to create resilient futures and sustainable societies through helping individuals develop a range of different views of the world. Designers have called for improved understanding of learning in order to create effective learning environments. Traditionally, learning environments were conceived of as either physical or pedagogical, while more recent views consider how the social, curriculum, policy, and technology affect learning. Although reckonings of learning environments as contexts

for learning are increasing, there is limited understanding of how people engage in these environments or whether a preference exists for one type of learning environment over another.

6.2 Rural Institutions

Rural institutions play a key role as the base for non-formal education, but with a government-led approach and adoption of top-down laws by the local administration and institutions, they rarely pursue their own self-development initiatives. While these institutions have been recognised for advising adults in a more recent role, they are selective players in rural education. The Panchayati Raj institutions, whose duties encompass rural education, have largely failed because they have been unable to integrate non-formal schools with other educational planning. Senior officials of the Panchayati Raj institutions have little or no perception about two or three things concerning the importance of non-formal education work in child education in the rural context.

These institutions do have a substantial number of trained teachers, both qualified and unqualified. At the same time, they have some specific features that tend to dampen the spirit of the initiation, if any. For instance, it is beyond belief that teachers still continue to be employed in these schools who have not crossed even the primary stage of education and whose conduct is undesirable. Specific features apart from training are participation of a few parents in the management of the institution. The school building is still not built in many areas of the education programme. In these areas, the teaching-learning process system is completed by conducting classes in the open air in any of the streets with few benches and utensils for learning.

The performance of different non-formal education institutes is being assessed through the passes and fails of children in different examinations. They have never been exposed to any new technique or a new teaching methodology in which the joy and need to learn would be brought forth by the teacher in their own thinking process. They are unaware of the new educational approaches. Almost all the teachers make use of different textbooks prepared by different agencies in the education programme offered. They have little or no time to make use of other books for children that would help them in developing their life skills. No aids are being used and available in the learning process of children; therefore, their interest is fading away, which has led to certain disabilities in learning achievements of children (Boruah, 2019).

VII. BENEFITS OF SMART AND SUSTAINABLE LEARNING ENVIRONMENTS

For this paper, the authors surveyed students to understand their perceptions regarding smart and sustainable educational environments. A total of 727 students participated in the study, showing positive views about smart classrooms, digital and technological gadgets in classrooms, and futuristic approaches towards education. It was revealed that the participation level varies based on their entry into the colleges and universities (Rajesh, 2014).

In the past decade, India has witnessed a phenomenal growth rate in education infrastructure catering to various streams and different levels. Educational institutions, being the temples of learning, play a pivotal role in shaping the future of students. With rapid technological advancements, the traditional form of education has been reoriented towards modern pedagogy. The phenomenon of embedding technology in educational institutions has been morphed towards smart education and smart classrooms, incorporating an ecosystem which connects students, teachers, administrators, and parents. Transforming the present-day classrooms into smart classrooms is a daunting challenge in terms of financial investments, physical transformation of the existing classrooms, technological choices, integration of e-content, and above all, acceptance of the new system by the students and faculty.

7.1 Enhanced Learning Outcomes

A prevalence of technology in contemporary societies has issued a passion to interrogate its role within education. Educational institutes are responding to calls to adapt Environmental Scan technologies to renovate learning and facilitate new models of participation. Both the need and potential for interactivity in learning and the assumption that learning can take place in situ propelled an exploration of smart education in learning for sustainability. This conception diverges from conventional faculty-oriented transmission modes to inclusive constructions of meaning and knowledge through interactions with peers, professors, and within a situated social context. Such interaction is afforded by collaborative soft- and hardware tools, present both in the physical and virtual environments of educational institutions.

Awareness of how and by whom adaptive technologies will be created and implemented is crucial in this representation of smart education.

Technical development is often presented in two neoteric thoughts: on an individual level, it refers to a cumulative progression of invention. The last two decades appeared as a renaissance of the internet and its technologies that shape everyday life. More complex structures are realized—wholes are holistically consistent and interdependent systems of wholes in a hierarchy of complexity levels. Innovation thus alters being and society rather than merely enhancing fabrication capabilities.

Technology is changing the world—not only as an instigator of maximum productivity but in its correlate biopolitical governance, in which life itself is administrated to optimize the ratios of events to variables and minimize deviations from the norm. The joy of

education would most probably be eradicated along with the expertise of its professors. Students would face a world where all simple systems are governed without delay and discretion by algorithms.

In India, the education system is criticized for quality and access issues. Extended classrooms are conceived to distribute non-sequential event systems from a manufacturer's perspective. Foreshadowed in the design of multimedia lecture theatres, it facilitates live broadcasts in the classroom. By the abolition of the one model fit in all, students can learn at their own pace and availability while residing in more realistic environments. This approach, however, is accused of non-transparency, passive reception, and niche use if local provision units do not become constructivist educational entities themselves. As a counter-proposal, an articulated classroom cluster with systems for student generation and production is presented.

7.2 Increased Student Engagement

Increased Student Engagement is a subtheme that encompasses the three immersion aspects of Designing, Building, and Managing SDSE. The SDSE doesn't just lead to increased student engagement; it also leads to improved motivation and enthusiasm for studies and projects. Students are very eager to participate in all activities related to the design, construction, and management of the SDSE. Notably, in the design and management phase, the students take the initiative while the teachers mostly observe the students at work. The students were highly involved and engaged when they were managing the SDSE, with extra hours worked voluntarily in the evenings and on weekends in tandem with technology, math, and art classes to prepare presentations of the SDSE for school events (Nisiotis & Kleanthous, 2019).

The students expressed various aspects of increased engagement, motivation, excitement, enjoyment, and fun. They mentioned that they were very engaged and involved in every aspect of the SDSE designing, building, and managing work. Their friends were astonished when they heard their excitement and enthusiasm for studying a few subjects like math and ICT used in managing the SDSE. The engagement was attributed to diverse interlinked aspects of SDSE experiences emerging from the three immersion aspects. These include students learning many new concepts by designing, building, and managing the unique SDSE of direct personal interest throughout the four-year project, collaboration with each other and with the out-of-school professional building architect, diversification of tools, materials, projects, roles, ways of learning, and cultural codes, active involvement and peer scaffolding with other older students outside their grade, and dealing with urgent situations by trying to solve challenges immediately when they arise (Maduro, 2019).

Different management teams expressed unique aspects of the increased engagement, motivation, and excitement for the work involved in managing the SDSE. Some students were eager and enjoyed volunteering for a job that most others would consider boring, such as manually logging the water and energy usage readings. They were motivated to come to school early before classes to prepare the presentation slideshow, to stay overnight working from a distance on the presentation video, to try to capture and post in real-time every project, and to quickly come to the rescue of the unforeseen management issues.

VIII. CHALLENGES IN IMPLEMENTING SMART EDUCATIONAL PRACTICES

In the educational environment, student feedback on the institution's performance is vital for enhancing service quality further. It is a critical issue for higher education institutions to meet student expectations and demands to maintain student quality. Based on student feedback, institutions can create awareness of the areas needing improvement. There was a significant demand for quality in higher education institutions. It will be a challenge for institutions to meet the needs of students who expect great conveniences since many educational institutions have now shifted online. The success or failure of a college depends on student satisfaction (Rajesh, 2014). The student's perception of classroom environment (PCE) will reveal how different aspects of classroom environments were perceived by undergraduate engineering college students. The advent of new ICTs in education has raised new challenges in terms of advancing equity and inclusion. Open educational resources, their quality, and perceptions of service quality are important factors that affect the individual and institutional readiness to embrace open educational resources in higher education. The universities are not much better in influencing students positively concerning these characteristics. It shows a dismal picture in the case of the academic environment, with a majority of the students expressing dissatisfaction with these characteristics. Educational professionals know that student engagement is the heartbeat of effective instruction. To ensure academic engagement, university students must feel that lecture activities are useful and share information with classmates. Re-designing learning context is a key factor influencing student engagement.

Due to the pandemic situation, tele-learning was the need of the hour with a shift from classroom to online mode of teaching. Students' perception of how their motivation and learning changed from offline to online mode, students' perception of short-span activities during e-class, and future challenges and advantages of e-learning needed to be understood. In the recent surge to online learning, a plethora of research has emerged exploring the pedagogical impact of technological interventions during the COVID-19 pandemic. Nevertheless, the concerns, challenges, and issues of instructors operating in higher educational institutes in remote and semi-urban India remain under-explored. A qualitative thematic analysis of data from 30 in-depth interviews with the academic staff of an Indian university marks the first steps in an under-explored research area. While teachers and students adapted to online education overnight, a number of challenges remain to be addressed. Tele-learning is an important need of the hour now because of the accelerated use of technology for teaching and learning processes due to the COVID-19 pandemic.

8.1 Infrastructure Issues

Educational infrastructure can be a combination of learning techniques, learning tools, and physical environment. In order to understand its present status, a few questions have been addressed under such categories by students, who have experienced these attributes over a wide range of educational setups in India. The Physical Infrastructure relates to the building of the school, classrooms, and the items in the building which affect the learning environment in a school setup. It comprises attributes like condition of the buildings, proper access to classrooms, furniture for learning, availability of a separate place for effective teaching, proper access to ICT-based tools, essential amenities for students' comfort, provision of a separate setup for co-curricular activities, and provision of facilities to accommodate all students in a class, library, etc. In a smart setup, the newly introduced furniture which causes discomfort and loss of concentration, newly introduced ICT tools, especially projectors in classrooms which give trouble, lack of facilities to make full use of the amenities in this competitive age, and learning environment in a classroom which affects the mental setup are some notable aspects. The government and the managements have to work together in order to have the infrastructure smart, sustainable, and qualitative.

The Learning Tools relate to the attributes which affect the willingness of students to learn in a smart and effective way. It comprises attributes like a smart board for effective teaching-learning, the presence of devices for retrieval of resources, effective smart tools for giving assessment, provision of digital assets, ICT-enabled tools for improvisation of presentations, the availability of a complete web portal for retrieval of data and co-curricular learning resources and tools, provision of student-friendly software for accessing academic data, educational resources, and skill development, etc. Among other tools in use in some reputed institutions, the presence of smart study material for a deep understanding with clarity and an education-oriented and friendly setup for social media interaction are notable. These attributes can be implemented in a proactive way through 24×7 availability of all necessary tools, responsibility for better and effective functioning, and periodic quality control checks (Bajpai et al., 2019).

8.2 Teacher Training and Support

The success of any educational initiative lies in its implementation, which is a complex process that requires strong support systems and appropriate procedures to implement effectively. A period of behavior-building follow-up is indispensable for arming the teachers to implore their new learning into action, especially when it requires a paradigm shift. In this context, this paper describes the effect of an effective follow-up strategy on the implementation of a teacher development program. The program was intended to develop the teachers' understanding of process-based teaching and use it in classrooms. The follow-up strategy consisted of a certification process of the teachers along with observational support. The field support supervision was laden with technical inputs for implementing the program in classrooms (Qazi, 2008).

This change process involved the switch from a teacher-centered mode of instruction to a pupil-centered one. No single approach for changing teachers' practice is effective for every teacher in every context. Consultative support from the field staff was needed for developing a thorough understanding of process-reconstructive teaching and designing alternative tasks relevant to the students' context. A preparatory step to such assistance is to form a network of committed volunteers who have mastered the task and can propagate the innovation with greater credibility and enthusiasm. This was attempted in the two districts by providing peer-based training to volunteer teachers of mountain schools. The teachers' perceptions of the influence of the program are documented individually as case studies. Follow-up support is an essential element of a teacher development program, as it allows the teachers the time to adapt the new concepts and skills to their classroom context and to tailor their implementation to local needs.

IX. POLICY RECOMMENDATIONS FOR SMART EDUCATION

Transforming learning in India requires policy shifts and research inputs. This ongoing research aims to gather student perspectives on smart and sustainable school buildings in India. An exploration of existing literature on student perceptions and participation in the architectural and urban design process of educational environments reveals conceptual frameworks. Research methods utilize a mixed-methods approach to obtain quantitative data from surveys and qualitative data from interviews and focus groups. Concurrently, research findings from the qualitative component are analyzed and discussed, forming the basis for recommendations on enhancing learning from the student's perspective. India is undergoing extreme growth, with urban centers rapidly expanding due to rural-urban migration, resulting in an informal housing crisis. Contemporary school buildings are typically blueprints by untrained or unaccountable professionals, leading to new school buildings being operationally inefficient or entirely unoccupied. A fast-growing smart school movement with a focus on state-of-the-art facilities exists alongside sustainably certified green schools, but no pre-existing knowledge or funding exists for how the buildings affect pedagogy or well-being. The necessity to find a structured method for enhancing student's perspective is evident (Rajesh, 2014).

Research towards gathering usable knowledge regarding the buildings from student surveys, which align with preexisting academic contentions that school buildings participate in teaching, learning, and student behavior, and develop an analytical framework to examine student participation in the building and planning process is warranted. Lessons are learned and methods proposals for assessing future smart and green projects from the student perspective, extending beyond school buildings to include planning and governance, are suggested. It is concluded that increasing participation of student interests and thus professional accountability is needed. Research in relation to India's growth and priorities is also outlined. Current green efforts are criticized, and an agenda is proposed to experimentally critique sustainability-oriented design strategies. Uncertain governmental accountability on inclusive smart planning is highlighted, calling for research specific to accountability in the context of global immigration flows, wherein intelligent definitions of marginal and excluded actors arise that deviate from those of existing workflows and planning discourses.

X. FUTURE TRENDS IN EDUCATIONAL ENVIRONMENTS

As the 21st century continues its trajectory in technological advancements, it is imperative to examine the future of learning environments, in particular, the expectations of users in the wake of these advancements. A vision that incorporates emerging technologies in the learning environments is demanding. It is broadly believed that future learning environments should adopt an open, accessible, and socially interactive design integrated in a single digital platform that simulates and supports different styles of dialogues and interactions (Rajesh, 2014). Moreover, envisioned learning environments should reflect and include continuously evolving sustainable elements. Based on the research findings, India can pave a long way in transforming educational campuses into smart and sustainable educational environments.

Future campuses can be termed installations that comprise autonomous delivery robots, item-decreasing robots, surfacing/cleaning robots, and security/monitoring robots. Smart VR glasses integrated with facial recognition and language translation technologies can facilitate an ambient intelligent learning experience. On a connected note, MSKTTMS can basically be termed as a service-oriented university campus that can be developed into smart and sustainable educational environments. Moreover, Indian universities can opt for actively involving students and creating awareness along with their co-designing to bring about required transformations. The need for this co-designing in scientific collaboration with a sustainable and smart approach is vital. Such co-designing can be recognized as a setting wherein students are given the chance to devise solutions, thus giving them greater ownership. Awareness can be created by planting the seeds of sustainability in schools and colleges through workshops/programs. Co-designing methodologies can be planned for students, and these methodologies can be described as systems thinking or creative gaming for play-based models. This research study proposes the role of governance of campus-based innovations in social engagement and knowledge solutions that contribute to the co-design governance of future smart GSG institutions. Moreover, this research study also discusses the concept of a future smart, connected, sustainable, and equitable educational institution. Further research studies can be conducted on the role of platform conditions that drive co-design innovations in education or urban environments.

10.1 Emerging Technologies

The need for smart and sustainable educational environments in 21st-century schools is based on emerging educational theories and global trends in information and communication technologies. Technologies for assessment focus on tracking the effectiveness of the learning environment vis-à-vis student learning. Learning analytics focus on tracking students' progress in online and hybrid learning platforms. Emerging technologies in education are mobile phones, which are powerful educational tools by which learning is imparted and are considered as ubiquitous technologies. When used with proper planning and care, mobile phones have the potential for improving learning outcomes. Cloud has emerged as a widely adopted technology for secure, scalable online e-learning systems. Users can access their data and services anywhere from any device, which spurs cloud education services growth. A great deal of work has been done on cloud computing characteristics, issues, and risks. Emerging issues in cloud computing are presented to identify the unchartered territories for researchers. Several surveys cover cloud computing security issues and risk assessment surveys in detail (Rajesh, 2014). While Indian higher education is scrambling to move to digital technologies, pedagogy insists on retaining traditional approaches.

10.2 Global Comparisons

The project is contributing to setting up new SMART and sustainable K–12 educational environments in India, in line with national policies and the views of state governments. The focus is mainly on two dimensions: integrating passive and active dimensions in existing new educational environments in K–12 education. It will include equipment management regarding technology such as SMART boards, projector screens, and projectors. Also, projects for existing new integrated K–12 educational environments will include policy suggestions for managing K–12 environment designs in building new educational environments. Promoting WISE-INDIA practices, learning with a purpose: It consists of introducing the latest, doable, and sustainable practices according to constructs: Well-Being, Perseverance, Social Awareness, and New Knowledge through hands-on projects and approachable thought dissemination/mentoring in K–12 educational environments and after-school programming. Previous global studies will support the goals of implementation research, user views, and their definition of construct comprising SMART and sustainable schools.

In 2022, online surveys were conducted with open- and closed-ended questions. For the introduction of both traditions through one-and-a-half-hour presentations, country-focused sessions were held with researchers. Then, user views were gathered through interviews and questionnaires. Drafts that included input from global researchers at online workshops were sent to users in both countries. Online surveys consisting of multiple-choice, ranking criteria, low-high scaling questions, compelling open-ended questions, and tasks adhering to national policies were responded to online by 806 students.

User groups for the studies in India were six kinds of K–12 schools that represented different pillars of the system—affiliated government, government-aided, learning and medium diversity (private, English-medium, logical thinking), and zero exclusion (SKUS). The schools are SMART classrooms practiced by students aged 9–18 (primary (9–10), high (10–15), secondary (16–18)). Countries were compared according to their user responses regarding SMART and sustainable educational environments (Rajesh, 2014).

XI. CONCLUSION

India has deployed school infrastructure of over 700,000 school buildings with much sophistication. However, currently, 20% of them are ceasing to be used for education. Educational outcomes or fitness index of those still in use are poor to abysmal. Consequently, 230 million Indian school-age children do not attend school. Permaeduculture is proposed as a holistic transdisciplinary framework to converge ideas and technologies from diverse disciplines towards treating the pathologies of the school built environment. Field awareness of students of what is wrong with their infrastructure, shaking off complacency and apathy of teachers and parents, and enabling them to agree to act is the prime deliverable. Resultant knowledge and awareness feed into stakeholder proposals triangulated with metrics to help or obligate authorities to act. As a first step to promote permaeduculture through student awareness, a modular participatory action research tool was developed. Seventy-seven English-Hindi and dependent variables of 138 major contributors and correlators were defined with an initial state, cause-effect structure, and flow. Generally positive impacts on learning hazards each contributor has on their own school are shown. This paper concludes the example of Case 1 of permaeduculture implementation and notes a co-design need for some state and diffuse variables towards scaling to wider-scope education and youth awareness-action engagement.

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