Analysis of the development of sustainable entrepreneurship practices through knowledge and smart innovative based education system

Brij B. Gupta[1,3,4,5] · Akshat Gaurav[1] · Prabin Kumar Panigrahi[2]

Abstract

Smart and innovative education is an integral part of the development of sustainable entrepreneurship practices. Due to this, UNCED included it on its agenda. The primary goal of smart education is to teach young people to be responsible members of society in the years to come. The youth of this generation should have the opportunity to play an active role in shaping our future. For the sake of future generations, they should be taught to accept personal responsibility for their own well-being and the well-being of future generations. However, with traditional teaching techniques, this goal is not achieved; therefore, there is a requirement for the integration of cutting-edge technologies such as IoT, cloud computing, AI, and machine learning with the education process for the development of sustainable entrepreneurship practices in order to achieve a better future. In this context, we analyze the current smart education techniques proposed by different researchers that lead to the development of sustainable entrepreneurship practices. In this investigation, we also highlight the various limitations and challenges of the current smart education system.

Keywords Smart Education · Smart Campus · Sustainable Entrepreneurship · IIoT

✉ Brij B. Gupta
  gupta.brij@gmail.com

  Akshat Gaurav
  akshat.gaurav@ronininstitute.org

  Prabin Kumar Panigrahi
  prabin@iimidr.ac.in

[1] International Center for AI and Cyber Security Research and Innovations, & Department of Computer Science and Information Engineering, Asia University, Taichung 413, Taiwan

[2] Indian Institute of Management Indore, Indore, India

[3] Symbiosis Centre for Information Technology (SCIT), Symbiosis International University, Pune, India

[4] Lebanese American University, Beirut 1102, Lebanon

[5] Center for Interdisciplinary Research, University of Petroleum and Energy Studies (UPES), Dehradun, India

Introduction

The practice of forestry, which dates back hundreds of years, pioneered the concept of sustainable behavior. The forestry business grew rapidly starting in the 18th century. When it comes to sustainable forest management, cutting more trees than you can replace in the same amount of time has been defined as cutting more trees than you can replace in the same amount of time. This idea was conceived to ensure both environmental and monetary stability (Burmeister et al., 2012; Touma & Zein, 2021). After analyzing the importance of sustainable development, the researchers try to incorporate it into other domains such as the entrepreneurship and education system. In this context, the first formal definition of sustainable development is given by the Brundtland Commission Keeble (1987), All academic fields contributed to the discussion of sustainable development. Three areas make up the most frequent sustainable development model today. It aims to guarantee ecological, economic and social stability through sustainable development as represented in Fig. 1 (Shallcross & Robinson, 2007). Other competing models, such as models with extra dimensions, have also been proposed. Continuous discussion of the importance of culture as a component is an excellent example of increasing the emphasis of sustainability models. This categorization of sustainability, on the other hand, is problematic. Can economic and social activity be conducted outside of the natural world? Is there a place for humans in nature, or are we just a part of it? Regarding sustainability, do you think all three areas are equally important? This leads to further study of the concepts of sustainable development. This leads to a new dependence on sustainability topics, as represented in Fig. 2 Shallcross and Robinson (2007). Despite the ongoing debate on the concept of 'sustainable development', the so-called triple bottom line trajectory, which would see economic gain combined with social justice and environmental security, is seen as a promise for future success locally, nationally and internationally (Lawrence, 2005). However, from all the different definitions and representations of sustainable development, one thing is common: smart education is one of the important contributors of sustainable development; also, after the pandemic, the importance of smart education is improved. The change in smart education after the pandemic is presented in Fig. 3. After understanding the importance of smart education

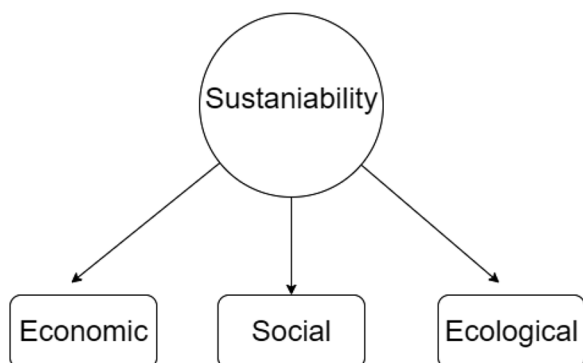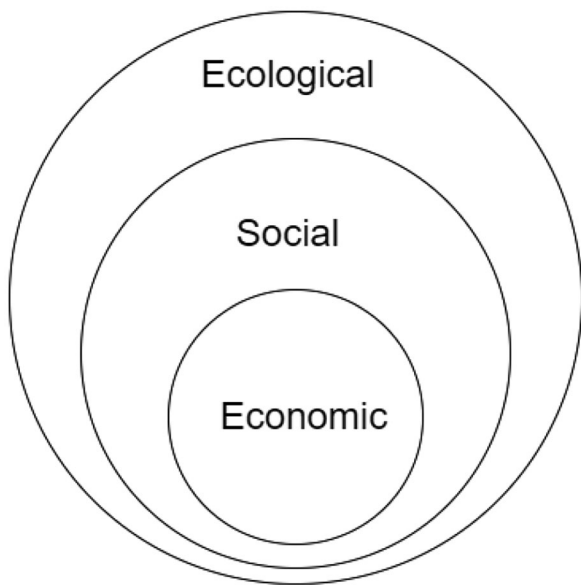**Fig. 1** Three Pillars of Sustainability

Fig. 2 Dependency of sustainability development subjects

in sustainable development in entrepreneurship, the United Nations declares the year 2005 to 2014 Decade of Education for Sustainable Development.

Apart from this, the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil, produced Agenda 21 in 1992, which includes Education for Sustainable Development (Burmeister et al., 2012; Al-Abbas & Saab, 2022; Hamadeh et al., 2020; Nikolaidis et al., 2022). According to the UN, the primary goal of smart education in sustainable development is to instill in the next generation the values of civic responsibility. Student participation in a democratic society and the creation of the future should be a component of their education. Sustainable development requires them to acquire self-awareness and stewardship for present and future generations (De Haan, 2006; Tarhini et al., 2022; Yunis et al., 2020). However, existing levels of unsustainable behavior and overconsumption suggest that smart educational initiatives need to be put in place in an effective manner. Therefore, a comprehensive system redesign must be needed to question old
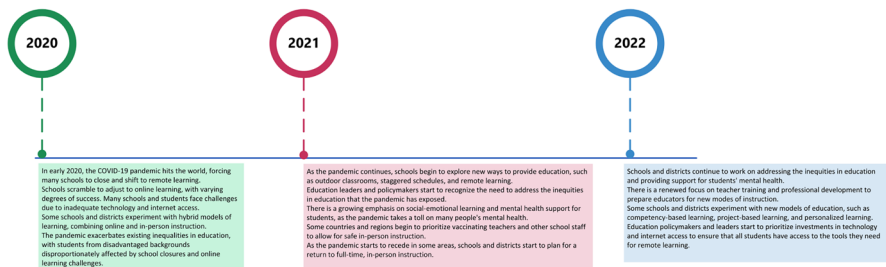

Fig. 3 Change in Education System After Pendemic

paradigms and change our thinking toward a sustainable future. In this context, after understanding the importance of smart education for the development of sustainable entrepreneurship concepts, we analyze the current smart education frameworks and platforms to better understand the present limitations and challenges in the research domain. The main contributions of this research are as follows:

- Gives a brief definition of smart education and presents its relationship with the development of Sustainable Entrepreneurship
- Analysis the challenges and limitations of present smart education paradigms and lists some of the future challenges of the same.

Research methodology

A detailed literature study was conducted to determine the need for a smart and innovation-based education system for the development of sustainable entrepreneurship. In order to get a better understanding of the research field, the following are the steps: Selection of the database, modification of the research criteria, coding of recovered material, and evaluation of the information. Because the Web of Science database contains fewer indexed journals than Scopus, this study uses the Scopus database as a sample to limit the chance of missing important articles throughout the search process.

Eligibility criteria

All the Scopus-indexed publications published between 2000 and 2022 in English were included in the article to show the current state of research around the world.

Data source

We used the Scopus database to collect the information about the paper published in the Scopus-indexed journals; the data was gathered in June 2022.

Evaluation of research topic

There is a great deal of interest in the influence of cutting-edge technology on the growth of sustainable entrepreneurship due to the smart and innovative education system. In order to analyze the development and dependence of sustainable entrepreneurship and smart education, we used the Scopus data set to conduct our research. Figure 4 provides a visual representation of the structure of our database. Figure 4 shows the 166 papers from 2009 to 2022 that make up our dataset.Hence, we can conclude that sustainable entrepreneurship development is a hot issue, with more than 525 different writers contributing to the literature throughout this period. Figure 5a shows a rapid increase in the number of articles published between 2016 and 2022, as expected. From Fig. 5a it is clear that the annual growth rate of the
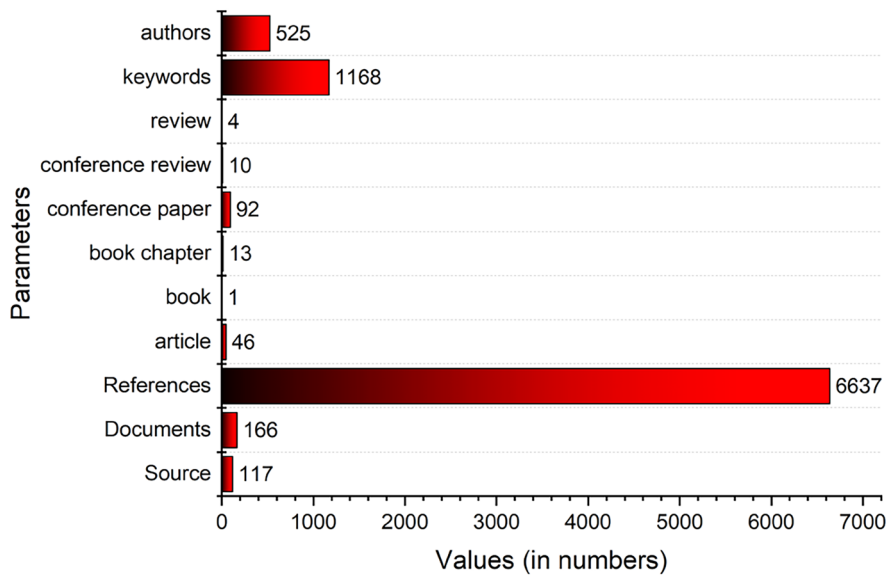
Fig. 4 Overview of Database

articles is 35.59%. From Fig. 5b, it is clear that a large number of computer science researchers (27%) are working to develop new models and protocols to improve sustainable development.

In this part, we examine the current research orientations and trends. To begin, we look at how the paper's keywords are distributed. The main keywords of the paper represent the main topic of the paper. As the frequency of a term grows, so does its size in Fig. 5c, which shows the frequency of keywords throughout our study database. According to Fig. 5c, the following are the most essential terms with an incidence frequency greater than five:

- sustainable development (90)
- internet of things (86)
- engineering education (55)
- artificial intelligence (24)
- students (24)
- internet of things (iot) (23)
- smart city (22)
- learning systems (17)
- big data (16)
- e-learning (14)

The distribution of researchers according to countries is also an important and helpful feature in understanding the development of the respective research area. This indicator shows the efficacy of research in a country. Figure 5d depicts the contricountries' contribution to developing theories and models for sustainable entrepreneurship
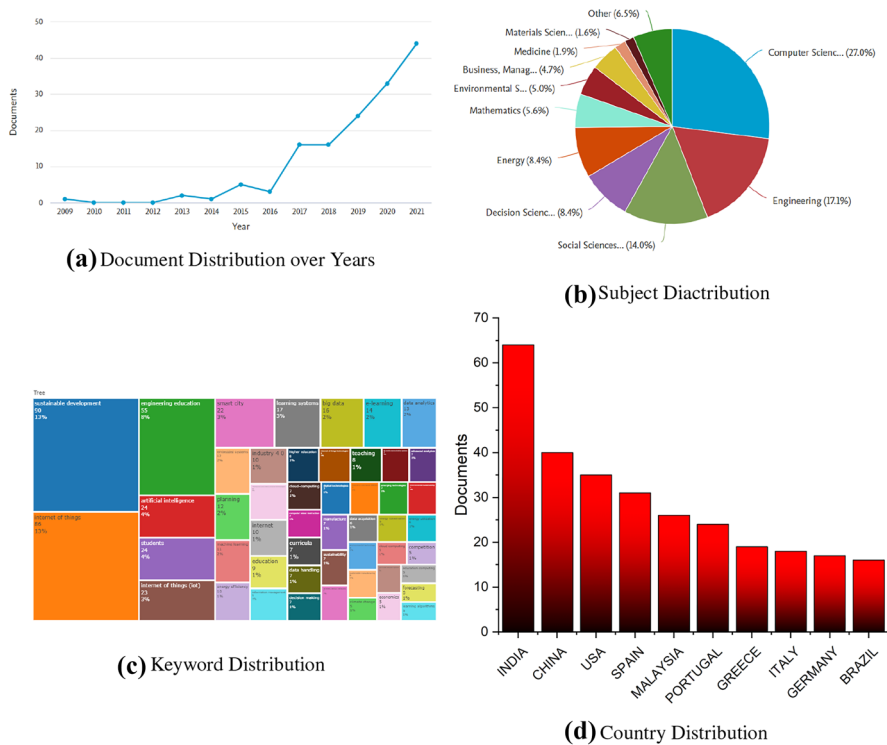
(a) Document Distribution over Years

(b) Subject Diactribution

(c) Keyword Distribution

(d) Country Distribution

Fig. 5 Details of Research Area

based on smart education. According to Fig. 5d, the top nations with the most published articles are:

- India
- China
- USA
- Spain
- Malatsia

Analysis of sustainable development paradigms

Sustainable development has become a generally acknowledged notion in practice, national policy, and international politics during the previous two decades, and it is now generally acknowledged (Hahn & Knoke, 2010).

Since 2000, political leaders throughout the globe have embraced sustainable development as their preferred paradigm for social growth and development (Waas et al., 2011). Due to this worldwide acceptance, experts in different domains provide many definitions of sustainable development.The term "sustainability" was coined in 1972. The United Nations Summit on the Human Environment conducted its first

international conference in Stockholm with the goal of studying specific environmental challenges. The Brundtland Commission (1987) provided the groundwork for the widespread use of the term "sustainable development" after this meeting (Babashamsi et al., 2016; Hahn & Knoke, 2010; Ruggerio, 2021). In order to give a clearer understanding of sustainability and sustainable development, Dobson (Martins, 2010) presents 300 different definitions of sustainability. In simple terms, we can say that development that meets the requirements of the current day without sacrificing those of future generations is known as sustainability (Babashamsi et al., 2016). According to some authors, ensuring the continuance of human existence eternally, maintaining the productivity of economic systems, preserving biodiversity, and a combination of these things are all examples of sustainability (Gowdy, 1999; Lawrence, 2005). Since the Brundtland Report in 1987, the term "sustainable development" has been synonymous with environmental science and has become a development paradigm. International treaties and many nations' constitutions and laws have adopted the notion since the Rio de Janeiro Earth Summit in 1992, when it was first introduced (Alvarado-Herrera et al., 2017; Gore, 2015; Luke, 2005). However, sustainability and sustainable development are still seen as multidimensional processes that are difficult to describe in practical terms, even in the most basic terms. It's unclear if sustainable development should be seen as a trade-off or a feasible optimal level (Babashamsi et al., 2016). Scholars and practitioners alike have come to recognize the importance of sustainable development as a growing field of study. Environmental conservation and poverty reduction have been the primary goals of sustainable development since its inception. A considerably wider variety of concerns and factors are being considered in sustainability today than in the past. Numerous measures are proposed, ranging from conservation and pollution reduction to providing basic requirements and democratization (McEntire, 2005).

Analysis of smart education models

The development of a better digital society can be aided by high-quality education enhanced by contemporary technology. New information gained by people participating in off-campus controlled learning procedures and voice training and instruction will likewise help to economic development and job creation in society. Due to this, quality education is involved in the Sustainable Development Goals of the United Nations (Goal 4) (Robles-Gomez et al., 2021).

The integration of various digital and communication technologies into higher education teaching practices has been a hallmark of the twenty-first century's pedagogy and teaching practices. More and more students are seeking an education through computer-mediated instruction (CME), which uses the most up-to-date educational technology, including better bandwidth and more virtualized services (Li & Xiao, 2021; Sood & Rawat, 2022). There is a wide range of cutting-edge technologies that could be used in the field of education (Chen, 2021). There is a new branch of education technology dubbed 'Smart Education' at the moment. An educational model known as "smart education" is one that is specifically designed for today's generation of digital natives. Compared to traditional classroom teaching

approaches, smart education is a participatory, collaborative and visual paradigm that aims to increase student engagement and allow instructors to adapt to students' talents, wants, and learning preferences (Nikolov et al., 2016). In this new arena, emerging technologies such as the Internet of Things (IoT), Cloud Computing (Suresh et al., 2021), Fog Computing, Big Data Analytics, and 5G/6G Networking are critical. Professionalization in the teaching process is facilitated by using smart classroom technology that empowers instructors with greater planning and enrichment of their lectures, as well as flexibility in adapting to the demands of classmates and classroom settings. An authoritarian person is no longer an authoritative character in this student-centric meaning, but is instead an educator who serves as a mentor and learning partner. One of the benefits of smart schooling is its access to enormous amounts of data (Waqas et al., 2017). Incorporation of these newly discovered technologies may provide useful features that can be broadly used to advance education for sustainable entrepreneurialism. Multiple technologies can be used concurrently in the "Smart Classroom," an example of a smart education application (Memos et al., 2020).Also, student behavior can be predicted using intelligent educational systems, and security measures can be devised for network breaches using these systems (Suresh et al., 2021; Zhong et al., 2018). Due to an ever increasing pool of information, the sector of education plays an increasingly significant role. When it comes to learning models, there are a variety of approaches to finish the educational process for each learner (Toapanta et al., 2019). Visual classrooms are also the type of smart classrooms that are used by schools to educate students (Li & Xiao, 2021). Schools are now more than ever being asked to help raise awareness about the need for sustainable development. Education's importance is clear here both in terms of its current size and in terms of its potential for growth in the future. Future generations must be equipped with the scientific and technical know-how to deal with climate change and other issues. Schools and educational programs are increasingly highlighting the need for sustainable development. According to several recent studies, energy-saving campaigns and education campaigns have been implemented in a number of countries during the last decade (George & Lal, 2021; Hu et al., 2022; Paganelli et al., 2019). With the advancement of current information technology, a new educational mode, visual distance education, has emerged in addition to visual classrooms. Online classroom education is the newest kind of distant visual education that relies on digital technology, namely the Internet, to flourish. The use of visual distance in education represents a radical change in the way students learn. Computers and networks are inextricably linked to the fast advancement of theoretical learning in the educational system. Visual distance education, on the other hand, has evolved over time. Create a new means of communication between professors and students and between students by moving fixed, centralized teaching points to the Internet (Li & Xiao, 2021). With distant education becoming more important, a wide range of organizations—including corporations and schools—agree that the use of artificial intelligence and other technologies like machine learning and the Internet of Things is essential to an integrated distance learning solution. It will need a new way of thinking and a new set of abilities from all involved if we are to make progress in our educational systcentralizede while also adapting to new social standards (Nunez & Padilla, 2020).

Presently, our day-to-day activities are being transformed by the Internet revolution and new technologies are being developed for various objectives. The development of a better digital society may be aided by high-quality education enhanced by modern technology (Robles-Gomez et al., 2021).

Smart education for sustainable development in smart city

Some scholars believe that big technology companies are funding the smart city initiative in an effort to commercialize public data (Hollands, 2015; Allam & Newman, 2018; Krivy`, 2018), while others believe that it is nothing more than a political and economic PR stunt (Angelidou, 2017; Gupta & Sheng, 2019). Smart cities, on the other hand, provide an appearance of technological prowess and pervasiveness that eclipses the ideals of a sustainable and resilient city.An sustainable urban environment and able to withstand natural disasters is a hallmark of a "smart city." Therefore, to better understand the relationship between smart city and sustainable development, the author presented as a comparison (Ahvenniemi et al., 2017). Hence, a smart city considers all of the preceding principles about cities, such as environmental sustainability and resiliency. An example of its ubiquity may be seen in the worldwide spread and adaptations of the idea and related projects throughout the world. Sustainability, urbanization, and technological innovation have all contributed to the rise of 'smart sustainable cities.' Smart cities' ability to accommodate a broad range of academic and professional disciplines, as well as their ability to include green environment into its definition, is shown by such a quick evolution of the smart city idea to include environmental sustainability (Al-Ayyoub et al., 2019; Oh, 2019; Shankar et al., 2021).

In order to build smart cities, communities must be supported and processed by technology. Intelligent city development is based on the use of cloud computing and big data analytics, two crucial components that can simultaneously provide enormous amounts of data for both the public and commercial sectors while also improving community safety, health, and welfare. Smart education is a critical component in the development of a smart city. In a smart city, there is a high level of educational excellence in the areas of basic education, technical training and certification, universities and community colleges, e-learning facilities, lifelong learning, andinnovation in educational technology (Alhaidary et al., 2018; Suresh et al., 2021; Yamaguchi & Gupta, 2021). So, by integrating innovation and technology into the idea of interdisciplinarity education, we can design a strategy to use the smart city concept for sustainable entrepreneurialism.

Rather than considering a smart city as a danger to conventional city-making disciplines, it may be seen as a chance to grow and surpass the existing level of sustainable development via intelligent education.

Smart education for sustainable development in industry 4.0

Automation, integration, and real-time data sharing in production processes are all part of what is referred to as "industry 4.0," which is seen as a collection of interconnected

digital solutions and technologies that must all be adopted by businesses, society, and individuals alike. Operations managers in today's production environments face new challenges as a result of the Internet of Things, the Industrial Internet, cloud-based manufacturing, and smart manufacturing (Koleva & Andreev, 2018; Sharma et al., 2022; Zemmouchi-Ghomari, 2021). Scientists and business leaders are debating how to handle the arrival of "Industry 4.0" and its associated issues. What is more, despite how long it took for the first two industrial revolutions to take place, the last two took place in only three decades. Our current era has passed the "Industry 4.0" tipping point that was predicted during the digital revolution of the late 1980s. We live in an era where nations always compete against one another to maintain their advantages over their neighbors. Innovation, research, and development are now recognized as essential instruments for the company to remain competitive and expand its position as a leader. Providing answers to a wide range of technological and social problems is a key responsibility of engineers in establishing a country's long-term competitive edge (Walia & Katiyar, 2015; Ewa et al., 2023).Industry 4.0 is already reshaping the world of work due to its rapid advance. So, initial and ongoing training will need to include new materials and methodologies. Digital and physical media are intertwined in today's integrated manufacturing process. Despite globalization and widespread automated production, industry 4.0 still puts people at the center of its operations. This means that training and certification will become even more critical in the future (Huba & Kozak, 2016; Marti & Puertas, 2022). Therefore, when it comes to Industry 4.0, the most critical function is smart education. For industrial companies to reap the full advantages of Industry 4.0, combining digital technology with smart education expertise and abilities is necessary. Creating a genuinely linked digital world will need a shift from Industry 4.0 to a broader vision of digitalization, where the IIot leads to sustainable development.

Role of smart campus for smart education

For a more environmentally friendly future, universities and colleges are essential for the advancement of knowledge and innovation, particularly in the creation of environmentally friendly products and technology for everyday use (Zaballos et al., 2020). Students' expectations for university campus life have risen in the age of smart classroom technology, and they are open to experimenting with new ways to study. Technology such as the Internet of Things (IoT) and cloud computing may help create an eco-friendly, student centric campus that improves academic performance and also reduces waste (Revathi et al., 2020). "Smart campus" refers to digital systems that handle university mandell as approaches to increase university student intellect and make knowledge transfer more efficient (Zaballos et al., 2020). A smart campus aims to provide a more efficient and enjoyable learning environment for students, faculty, and staff. Smart apps and networked technologies are used to enhance communication and make better use of resources, while also improving the quality and performance of services on and around the campus (Ikrissi & Mazri, 2020).

The smart campus where students, faculty, and staff may thrive while also benefitting from increased service quality, reduced energy use, and a more secure and environmentally friendly setting. It may be transformed into a digital space thanks to the addition of a wide variety of smart gadgets and cutting-edge technology. The term "smart campus" refers to the devices, apps, and technologies required to provide campus users, such as students, faculty, staff, and visitors, with new and improved experiences, increased efficiency, and access to cutting-edge applications and services. As a general rule, the establishment of a smart campus involves the achievement of certain goals, such as providing excellent and intelligent services, improving environmental sustainability, cutting operating expenses, and generally improving campus communication and education. In other words, a "smart campus" is a notion that encompasses a wide range of electronic and physical devices that may exchange information and work together to provide a variety of campus-related services. Smart campus services may be comparable to those offered by a smart city, but they may be tailored to meet the specific requirements of the campus community. Cloud computing, embedded computing, artificial intelligence, biometrics, and other Internet of Things (IoT) technologies, as well as other smart applications, are part of the smart campus development process. IoT-based Cloud-Integrated Smart Classroom for Smart and Sustainable Campuses will revolutionize classroom teaching methods, leading to increased efficiency and effectiveness. Using this technique will instill a sense of urgency in the student body to meet deadlines. It's possible for faculty and school administrators to devote more time to classroom instruction rather than focusing on classroom management and classroom monitoring (Revathi et al., 2020). Universities have recently been interested in the Internet of Things and cloud computing as a means of creating smart campuses. Various infrastructure and facilities are linked together in a Smart Campus, which enables security and tracking, as well as effective use of resources such as personnel, energy, and water (Table 1).

Collaborative learning environments and national e-learning grids can be built using information and communication technologies to facilitate standardization and high-quality education for engineers, resulting in the development of high-caliber engineers with a research-oriented and solution-oriented mentality.Digital technologies in engineering education have a greater chance of success and long- term use when used in a well-thought-out staged method. The step-by-step process described here will make it simple for institutions to use this technology and reap the rewards it offers (Walia & Katiyar, 2015). Comfort in educational settings has been shown to be a significant factor in learning success and society's growth, according to recent research. Air quality, temperature, and noise are all factors that contribute to a person's sense of well-being. Unobtrusive technology can be used to measure these factors, allowing for respectable but incompleteto createusions to be drawn. Many efforts have been made to develop ICT-based solutions toward more accurate and full ones (Zaballos et al., 2020).

Students' education and the planet's well-being are both improved as a result of the campuses' increased digital connectivity. Students may access their homework and exam results through web portals on their phones and PDAs. With the convenience of online video Lecturing, students may participate in classroom lectures from home or wherever else they have internet access. Students who skip class can be tracked

Table 1 Highly Cited Papers in the Domain of Smart Education

References	DOI	Total Citations	TC per Year	Normalized TC
Tuptuk and Hailes (2018) J Manuf Syst	https://doi.org/10.1016/j.jmsy.2018.04.007	182	36.4	11.5099
Ahadma et al. (2020) Sustainable Cities Soc	https://doi.org/10.1016/j.scs.2020.102301	128	42.667	9.1826
Zhang et al. (2019) J Clean Prod	https://doi.org/10.1016/j.jclepro.2019.118198	126	31.5	12.8681
Dlodlon and Kalezhi (2015) Proc Int Conf Emerg Trends Networks Comput Commun, ETNCC	https://doi.org/10.1109/ETNCC.2015.7184801	114	14.25	4.75
Lin et al. (2017) Sustainability	https://doi.org/10.3390/su9050786	80	13.333	3.2
Yadav et al. (2020) Comput Ind	https://doi.org/10.1016/j.compind.2020.103280	75	25	5.3804
Latif et al. (2017) Future Internet	https://doi.org/10.3390/fi9040093	60	10	2.4
Dhamija and Bag (2020) TQM J	https://doi.org/10.1108/TQM-10-2019-0243	52	17.333	3.7304
Lazaroiu and Roscia (2017) Int Conf Renew Energy Res Appl Icrera	https://doi.org/10.1109/DISTRA.2017.8191102	51	8.5	2.04
Wiesner et al. (2017) Int J Autom Technol	https://doi.org/10.20965/ijat.2017.p0017	38	6.333	1.52
Huba and Kozák (2016) ICETA - IEEE Int Conf Emerg Elearning Technol Appl Proc	https://doi.org/10.1109/ICETA.2016.7802083	37	5.286	2.3617
Ramakrishna et al. (2020) Sci Technol Soc	https://doi.org/10.1177/0971721820912918	24	8	1.7217
Zhang et al. (2021) Sustainable Energy Technol Assess	https://doi.org/10.1016/j.seta.2020.100986	23	11.5	12.4938
Fariha Banu et al. (2020)	https://doi.org/10.1016/j.procs.2020.05.012	23	7.667	1.65

using IoT devices and warnings can be sent to encourage students to stay on top of their schoolwork and locate misplaced personal belongings. In cafeterias, offices, and other administrative settings, payments can be made quickly and easily using digital devices. Microcontroller boards, sensor modules, and wired and wireless interfaces comprise the IoT hardware. Input and output data from sensor modules are processed and sent to the cloud through the software module (Revathi et al., 2020).

Smart education and sustainable growth are still in their infancy on our university campus, despite the fact that we have seen some improvement. In the academic literature, just a few studies describe contemporary smart campus plans (Zaballos et al., 2020). The educational institutions of the period had to accommodate all students, instructimproved due toe and effort went into making these places efficient, but little or no thought was given to how comfortable they might be for everyone using them or how much of a positive impact they could have on the environment. In addition, the smart campus is exposed to a wide range of security vulnerabilities and dangers that restrict its ability to grow and evolve (Ikrissi & Mazri, 2020). In addition, the smart campus has been probed for several security flaws and assaults. To effectively handle certain difficulties and implement appropriate smart campus security, certain security solutions and procedures must be implemented based on key security objectives, including authentication, confidentiality, integrity, and avail- ability.

Theoretical and practical implications

From the qualitative analysis of literature related to the sustainable development of the entrepreneurship sector through knowledge and innovative intelligent education system. Currently, sustainable development practices are widely accepted. In the past, sustainable development was related to the environment, but now it is applicable to all other domains such as education, economics, business, etc. Teachers and students are now able to connect in new ways thanks to the incorporation of the newest technology into the educational system. As a result, the teaching and learning process will be improved and the context in which students learn will be expanded. The integration of items might facilitate innovations in teaching and learning into the Internet. The Internet of Things (IoT) offers a more appealing learning environment for students, as well as more data about the learning process that instructors may use better to understand their students' learning paces and challenges. As a result, IoT and e-Learning will have to be usedtilized to teach more people about ICT and other sectors (Prasanna, 2017).

Future challenges

There is a broad scope of sustainable development in the entrepreneurship sector through smart education and training. However, there are still many challenges to develop this field of research. The difficulties of teacher education include addressing institutional awareness, building professional development models for ESD, focusing on sustainability in the educational community, transforming educational systems and

structures, and maintaining educational programs for ESD. Because official curriculum does not enforce sustainability and teacher certification criteria do not discuss sustainability, these difficulties rarely occur. The lack of policy to promote ESD, the lack of knowledge of the relevance of ESD, the lack of support from education ministries, and the inability to coordinate efforts between environmental, education, health, and agriculture departments are other problems (Shallcross & Robinson, 2007).

Keeping up with the rapid pace of technological change is a constant struggle for countries today in an increasingly competitive world. Everyone from government officials to corporate leaders to nongovernmental organization activists to academics, and everyday individuals is increasingly worried about their countries' ability to compete in the new information economy. Engineers have a critical role in creating a long-term competitive edge for the nation by proposing inventive solutions to a wide range of technological and social problems. Due to this, it is crucial to consider how different academic institutions throughout the nation provide engineering education and how this education can be standardized and high-quality in geographically dispersed academic institutions (Walia & Katiyar, 2015). In addition to this, technology is also a problem as most smart education classrooms and colleges do not have proper technology (Memos et al., 2020). In addition to this, there are no specific technologies or standards through which smart education can be used to achieve sustainable development in entrepreneurialism (Paganelli et al., 2019; Sood & Rawat, 2022). Also, advanced training in multiple platforms and technologies is needed to enable hands-on exercises and active engagement, according to the results of the Distance Learning Survey. Participants in distance education must adopt a new way of thinking and doing. Technical difficulties and a poor internet connection made it difficult for both teachers and students to maintain a high level of participation and enthusiasm in the class in the face of these difficulties (Nunez & Padilla, 2020).

Conclusion

The management of natural resources and the lives of people outside the metropolises are receiving increasing attention across the globe as sustainable development becomes more of a medium-term requirement rather than a long-term objective. Due to this, sustainable development goal, goal 4 (quality education) will be easier to achieve with today's technology. Since the advent of digital technology, the complexity of education promotion has continued to increase. Teachers and students alike are enthusiastic supporters of technology-enhanced learning, due to its emphasis on equity and convenience, as well as its openness and interactivity. Smart education can only be achieved with the help of a well-designed and cost-effective set of tools. Education providers must adapt their strategies and resources to accommodate students who are not physically present throughout the learning/teaching process. Dropout rates may be cut in half by providing students with remote-virtual technology that helps them develop the skills they'll need for a career in teaching. As a result, students and future citizens will be better equipped to comprehend and contribute to today's sustainability issues. Due to the importance of smart education, it is considered an integral part of the sustainable development of entrepreneurialism.

Hence, the primary goal of smart education is to teach young people how to be responsible members of society in the future. Students should be able to engage in a democratic society and contribute to the long-term development of that society. They must learn to be self-reliant and considerate of the needs of future generations, according to the principles of ecological and entrepreneurship sustainability.

Data availability Data will be available as per the request to the authors.

References

Ahad, M., Paiva, S., Tripathi, G., & Feroz, N. (2020). Enabling technologies and sustainable smart cities. *Sustainable Cities and Society, 61*. https://doi.org/10.1016/j.scs.2020.102301

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., & Airaksinen, M. (2017). What are the differences between sustainable and smart cities? *Cities, 60*, 234–245.

Al-Abbas, M., & Saab, S. S. (2022). Gender inequity in engineering higher education: A case study of an american university in a middle eastern country. In *2022 10th International Conference on Information and Education Technology (ICIET)*, (pp. 345–354). IEEE.

Al-Ayyoub, M., Al-Andoli, M., Jararweh, Y., Smadi, M., & Gupta, B. (2019). Improving fuzzy c-mean-based community detection in social networks using dynamic parallelism. *Computers & Electrical Engineering, 74*, 533–546.

Alhaidary, M., Rahman, S. M. M., Zakariah, M., Hossain, M. S., Alamri, A., Haque, M. S. M., & Gupta, B. B. (2018). Vulnerability analysis for the authentication protocols in trusted computing platforms and a proposed enhancement of the offpad protocol. *IEEE Access, 6*, 6071–6081.

Allam, Z., & Newman, P. (2018). Redefining the smart city: Culture, metabolism and governance. *Smart Cities, 1*, 4–25.

Alvarado-Herrera, A., Bigne, E., Aldas-Manzano, J., & Curras-Perez, R. (2017). A scale for measuring consumer perceptions of corporate social responsibility following the sustainable development paradigm. *Journal of Business Ethics, 140*, 243–262.

Angelidou, M. (2017). Smart city planning and development shortcomings. *TeMA Journal of Land Use, Mobility and Environment, 10*, 77–94.

Babashamsi, P., Md Yusoff, N. I., Ceylan, H., Md Nor, N. G., Je, S., & Natabadi, H. (2016). Sustainable development factors in pavement life-cycle: Highway/airport review. *Sustainability, 8*, 248.

Burmeister, M., Rauch, F., & Eilks, I. (2012). Education for sustainable development (esd) and chemistry education. *Chemistry Education Research and Practice, 13*, 59–68.

Chen, M. (2021). Corporate Responsibility and Future Education Develop- ment in the Era of Information Technology. In *2021 4th International Conference on Information Systems and Computer Aided Education*, (pp. 770–774). ACM, Dalian China. https://doi.org/10.1145/3482632.3483014

De Haan, G. (2006). The blk '21' programme in germany: A 'gestaltungskompetenz'-based model for education for sustainable development. *Environmental Education Research, 12*, 19–32.

Dhamija, P., & Bag, S. (2020). Role of artificial intelligence in operations environment: A review and bibliometric analysis. *TQM Journal, 32*, 869–896. https://doi.org/10.1108/TQM-10-2019-0243

Dlodlo, N., & Kalezhi, J. (2015). The internet of things in agriculture for sustainable rural development, pp. 13–18. https://doi.org/10.1109/ETNCC.2015.7184801

Ewa, D. E., Egbe, E. A., Ukpata, J. O., & Etika, A. (2023). Sustainable subgrade improvement using limestone dust and sugarcane bagasse ash. *Sustainable Technology and Entrepreneurship, 2*, 100028.

Faritha Banu, J., Revathi, R., Suganya, M., & Gladiss Merlin, N. (2020). Iot based cloud integrated smart classroom for smart and a sustainable campus, pp. 77–81. https://doi.org/10.1016/j.procs.2020.05.012

George, G., & Lal, A. M. (2021). A personalized approach to course recommendation in higher education. *International Journal on Semantic Web and Information Systems (IJSWIS), 17*, 100–114.

Gore, C. (2015). The post-2015 moment: Towards Sustainable Development Goals and a new global development paradigm. *Journal of International Development, 27*(6), 717–732.

Gowdy, J. (1999). Economic concepts of sustainability: relocating economic activity within society and environment. Sustainability and the social sciences: a cross-disciplinary approach to integrating environmental considerations into theoretical reorientation. Londres, Zed Books, 162–181.

Gupta, B. B., & Sheng, Q. Z. (2019). *Machine learning for computer and cyber security: Principle, algorithms, and practices*. CRC Press.

Hahn, W. A., & Knoke, T. (2010). Sustainable development and sustainable forestry: Analogies, differences, and the role of flexibility. *European Journal of Forest Research, 129*, 787–801.

Hamadeh, W., Bahous, R., Diab, R., & Nabhani, M. (2020). Using social media to enhance second language learning. *Computer-Assisted Language Learning Electronic Journal, 21*, 132–149.

Hollands, R. G. (2015). Critical interventions into the corporate smart city. *Cambridge Journal of Regions, Economy and Society, 8*, 61–77.

Hu, B., Gaurav, A., Choi, C., & Almomani, A. (2022). evaluation and comparative analysis of semantic web-based strategies for enhancing educational system development. *International Journal on Semantic Web and Information Systems (IJSWIS), 18*, 1–14.

Huba, M., & Kozak, S. (2016). From e-Learning to Industry 4.0. In S Smokovec (Ed.), *2016 International Conference on Emerging eLearning Technologies and Applications (ICETA)* (pp. 103–108). IEEE, High Tatras, Slovakia. https://doi.org/10.1109/ICETA.2016.7802083

Ikrissi, G., Mazri, T., 2020. A Study of smart campus environment and its security attacks. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLIV-4/W3-2020*, 255–261. https://doi.org/10.5194/isprs-archives-XLIV-4-W3-2020-255-2020

Keeble, B. R. (1987). The brundtland commission: Environment and development to the year 2000. *Medicine and War, 3*, 207–210.

Koleva, N., & Andreev, O. (2018). Aspects of Training in the Field of Operations Management with Respect to Industry 4.0. In *2018 International Conference on High Technology for Sustainable Development (HiTech)* (pp. 1–3). IEEE, Sofia. https://doi.org/10.1109/HiTech.2018.8566581

Krivy`, M.,. (2018). Towards a critique of cybernetic urbanism: The smart city and the society of control. *Planning Theory, 17*, 8–30.

Latif, S., Qadir, J., Farooq, S., & Imran, M. (2017). How 5g wireless (and concomitant technologies) will revolutionize healthcare? *Future Internet, 9*. https://doi.org/10.3390/fi9040093

Lawrence, G. (2005). Promoting sustainable development: the question of governance. In *New directions in the sociology of global development*. Emerald Group Publishing Limited.

Lazaroiu, C., & Roscia, M. (2017). Smart district through iot and blockchain (pp. 454–461). https://doi.org/10.1109/DISTRA.2017.8191102

Li, Z., & Xiao, H. (2021). Design of visual distance teaching platform based on Internet of things and embedded software system. *Journal of Ambient Intelligence and Humanized Computing*. https://doi.org/10.1007/s12652-021-03202-z

Lin, K., Shyu, J., & Ding, K. (2017). A cross-strait comparison of innovation policy under industry 4.0 and sustainability development transition. *Sustainability (Switzerland), 9*. https://doi.org/10.3390/su9050786

Luke, T. W. (2005). Neither sustainable nor development: Reconsidering sustainability in development. *Sustainable Development, 13*, 228–238.

Marti, L., & Puertas, R. (2022). Sustainable energy development analysis: Energy trilemma. *Sustainable Technology and Entrepreneurship, 1*, 100007.

Martins, R. H. D. S. (2010). Sustainable development requires an integrated design discipline to address unique problems. tripleC: Communication, Capitalism & Critique. *Open Access Journal for a Global Sustainable Information Society, 8*, 28–35.

McEntire, D. A. (2005). The history, meaning and policy recommendations of sustainable development: A review essay. *International Journal of Environment and Sustainable Development, 4*, 106–118.

Memos, V. A., Minopoulos, G., Stergiou, C., Psannis, K. E., & Ishibashi, Y. (2020). A Revolutionary Interactive Smart Classroom (RISC) with the Use of Emerging Technologies. In *2020 2nd International Conference on Computer Communication and the Internet (ICCCI)* (pp. 174–178). IEEE, Nagoya, Japan. https://doi.org/10.1109/ICCCI49374.2020.9145987

Nikolaidis, P., Ismail, M., Shuib, L., Khan, S., & Dhiman, G. (2022). Predicting student attrition in higher education through the determinants of learning progress: A structural equation modelling approach. *Sustainability, 14*, 13584.

Nikolov, R., Shoikova, E., Krumova, M., Kovatcheva, E., Dimitrov, V., & Shikalanov, A. (2016). Learning in a smart city environment. *Journal of Communication and Computer, 13*, 338–350.

Nunez, S., & Padilla, J. M. (2020). Industry 4.0: An Integrated Distance Learning Solution. In *2020 6th International Conference on Science in Information Technology (ICSITech)* (pp. 29–34). IEEE, Palu, Indonesia. https://doi.org/10.1109/ICSITech49800.2020.9392072

Oh, D. S. (2019). Building Inter-Personal Competence in Architecture and Urban Design Students through Smart Cities at a Higher Education Institution. *Sustainability, 11*, 7179. https://doi.org/10.3390/su11247179

Paganelli, F., Mylonas, G., Cuffaro, G., & Nesi, I. (2019). Experiences from Using Gamification and IoT-based Educational Tools in High Schools towards Energy Savings. arXiv:1909.00699

Prasanna, S. (2017). Expanding the learning environment by using Internet of Things for eLearning. In *2017 International Conference on Intelligent Sustainable Systems (ICISS)* (pp. 361–364). IEEE, Palladam. https://doi.org/10.1109/ISS1.2017.8389430

Ramakrishna, S., Ngowi, A., Jager, H., & Awuzie, B. (2020). Emerging industrial revolution: Symbiosis of industry 4.0 and circular economy: The role of universities. *Science, Technology and Society, 25*, 505–525. https://doi.org/10.1177/0971721820912918

Revathi, R., Suganya, M., NR, G. M., et al. (2020). Iot based cloud integrated smart classroom for smart and a sustainable campus. *Procedia Computer Science, 172*, 77–81.

Robles-Gomez, A., Tobarra, L., Pastor-Vargas, R., Hernandez, R., & Haut, J. M. (2021). Analyzing the Users' Acceptance of an IoT Cloud Platform Using the UTAUT/TAM Model. *IEEE Access, 9*, 150004–150020. https://doi.org/10.1109/ACCESS.2021.3125497

Ruggerio, C. A. (2021). Sustainability and sustainable development: A review of principles and definitions. *Science of the Total Environment, 786*, 147481. https://www.ncbi.nlm.nih.gov/pubmed/33965820, https://doi.org/10.1016/j.scitotenv.2021.147481

Shallcross, T., & Robinson, J. (2007). Is a decade of teacher education for sustainable development essential for survival? *Journal of Education for Teaching, 33*, 137–147.

Shankar, K., Perumal, E., Elhoseny, M., Taher, F., Gupta, B., & El-Latif, A. A. A. (2021). Synergic deep learning for smart health diagnosis of covid-19 for connected living and smart cities. *ACM Transactions on Internet Technology (TOIT), 22*, 1–14.

Sharma, K., Anand, D., Mishra, K., & Harit, S. (2022). Progressive study and investigation of machine learning techniques to enhance the efficiency and effectiveness of industry 4.0. *International Journal of Software Science and Computational Intelligence (IJSSCI), 14*, 1–14.

Sood, S. K., & Rawat, K. S. (2022). Fog-assisted virtual reality-based learning framework to control panic. *Expert Systems, 39*. https://doi.org/10.1111/exsy.12700

Suresh, P., Keerthika, P., Sathiyamoorthi, V., Logeswaran, K., Sentamil- selvan, K., Sangeetha, M., Sagana, C., et al. (2021). Cloud-Based Big Data Analysis Tools and Techniques Towards Sustainable Smart City Services. In Butun, I. (Ed.), *Advances in Computational Intelligence and Robotics* (pp. 63–90). IGI Global. https://doi.org/10.4018/978-1-7998-7468-3.ch004

Tarhini, A., Harfouche, A., & De Marco, M. (2022). Artificial intelligence based digital transformation for sustainable societies: The prevailing effect of covid-19 crises. *Pacific Asia Journal of the Association for Information Systems, 14*, 1.

Toapanta, S. M. T., Lopez, J. M. V., Soledispa, R. S. T., & Gallegos, L. E. M. (2019). Definition of a Security Prototype for IoT Applied to Higher Education. In *2019 Third World Conference on Smart Trends in Systems Security and Sustainablity (WorldS4)* (pp. 115–120). IEEE, London, UK. https://doi.org/10.1109/WorldS4.2019.8904028

Touma, W. R., & Zein, S. E. (2021). Entrepreneurship ecosystem in lebanon. *Communications of the ACM, 64*, 62–63.

Tuptuk, N., & Hailes, S. (2018). Security of smart manufacturing systems. *Journal of Manufacturing Systems, 47*, 93–106. https://doi.org/10.1016/j.jmsy.2018.04.007

Waas, T., Hugé, J., Verbruggen, A., & Wright, T. (2011). Sustainable development: A bird's eye view. *Sustainability, 3*, 1637–1661.

Walia, H., & Katiyar, S. (2015). Building engineering e-learning grid to foster engineering aptitude and Engineering attitude by leveraging ICT. In *2015 International Conference on Green Computing and Internet of Things (ICGCIoT)* (pp. 65–68). IEEE, Greater Noida, Delhi, India. https://doi.org/10.1109/ICGCIoT.2015.7380429

Waqas, A., Malik, H. A. M., Karbasi, M., Nawaz, N. A., & Mahessar, A. W. (2017). Cloudsis: An application of cloud computing for smart school management system. *University of Sindh Journal of Information and Communication Technology, 1*, 35–38.

Wiesner, S., Marilungo, E., & Thoben, K. D. (2017). Cyber-physical product-service systems – challenges for requirements engineering. *International Journal of Automation Technology, 11*, 17–28. https://doi.org/10.20965/ijat.2017.p0017

Yadav, G., Kumar, A., Luthra, S., Garza-Reyes, J., Kumar, V., & Batista, L. (2020). A framework to achieve sustainability in manufacturing organisa- tions of developing economies using industry 4.0 technologies' enablers. *Computers in Industry, 122*. https://doi.org/10.1016/j.compind.2020.103280

Yamaguchi, S., & Gupta, B. (2021). Malware threat in internet of things and its mitigation analysis. In *Research Anthology on Combating Denial-of-Service Attacks* (pp. 371–387). IGI Global.

Yunis, M., Markarian, C., & El-Kassar, A. (2020). A conceptual model for sustainable adoption of ehealth: Role of digital transformation culture and healthcare provider's readiness. *Proceedings of the IMCIC*.

Zaballos, A., Briones, A., Massa, A., Centelles, P., & Caballero, V. (2020). A Smart Campus' Digital Twin for Sustainable Comfort Monitoring. *Sustainability, 12*, 9196. https://doi.org/10.3390/su12219196

Zemmouchi-Ghomari, L. (2021). How industry 4.0 can benefit from semantic web technologies and arte-facts. *International Journal of Software Science and Computational Intelligence (IJSSCI), 13*, 64–74.

Zhang, A., Venkatesh, V., Liu, Y., Wan, M., Qu, T., & Huisingh, D. (2019). Barriers to smart waste management for a circular economy in china. *Journal of Cleaner Production 240*. https://doi.org/10.1016/j.jclepro.2019.118198

Zhang, Y., Geng, P., Sivaparthipan, C., & Muthu, B. (2021). Big data and artificial intelligence based early risk warning system of fire hazard for smart cities. *Sustainable Energy Technologies and Assessments, 45*. https://doi.org/10.1016/j.seta.2020.100986

Zhong, H., Zhu, W., Xu, Y., & Cui, J. (2018). Multi-authority attribute-based encryption access control scheme with policy hidden for cloud storage. *Soft Computing, 22*, 243–251.