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Sustainable Development Goal for Quality Education (SDG 4): A study on SDG 4 to extract the pattern of association among the indicators of SDG 4 employing a genetic algorithm

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Abstract

Sustainable Development Goals (SDG) are at the forefront of government initiatives across the world. The SDGs are primarily concerned with promoting sustainable growth via ensuring wellbeing, economic growth, environmental legislation, and academic advancement. One of the most prominent goals of the SDG is to provide learners with high-quality education (SDG 4). This paper aims to look at the perspectives of the Sustainable Development Goals improvised to provide quality education. We also analyze the existing state of multiple initiatives implemented by the Indian government in the pathway to achieving objectives of quality education (SDG 4). Additionally, a case study is considered for understanding the association among the observed indicators of SDG4. For this purpose, exploratory data analysis, and numerical association rule mining in combination with QuantMiner genetic algorithm approaches have been applied. The outcomes reveal the presence of a significant degree of association among these parameters pointing out the fact that understanding the impact of one (or more) indicator on other related indicators is critical for achieving SDG 4 goals (or factors). These findings will assist governing bodies in taking preventive measures while modifying existing policies and ensuring the effective enactment of SDG 4 goals, which also will subsequently aid in the resolution of issues related to other SDGs.

Keywords Sustainable Development Goal (SDG) · Education · Quality education · Machine learning · Right of education · Equality

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1 Introduction

Educational technology relies on academic knowledge from many fields such as communication, education, psychology, sociology, machine intelligence, and information technology in combination with practical academic experience (An & Oliver, 2021); Brill & Galloway, 2007; Januszewski & Molenda, 2013). Information and Communication Technology (ICT) is a broad phase of IT, emphasizing the function of unified communications as well as computers and software for businesses, middleware storage, and audio-visual services to enable users to access, save, transmit, understand and handle information (Schreyer, 2000; Yusuf, 2005). In the traditional education model, a teacher-centric classroom system was mostly preferred where the students are always expected to sit in front of the teacher, listening to lectures and taking notes (Pereira & Murzyn, 2001; Sibirskaya et al., 2019). In the twenty-first century, education evokes images of blended learning (Bruggeman et al., 2021; Osguthorpe & Graham, 2003; Singh, 2021), flipped classrooms (Hew et al., 2020; Wright & Park, 2021), and internet-based learning (or E-learning) (Singh et al., 2021; Winiharti & Chairiyani, 2021). Blended learning and flipped classrooms elevate a student's academic performance and perception in comparison to traditional teaching (El Sadik & Al Abdulmonem, 2021). Implementing a blended approach to instruction at various phases of undergraduate and postgraduate education might enhance learning opportunities. Blended learning represents the integration of digital and multimedia equipment like personal computers, tablets, multimedia projects, sound systems, 3D models, and augmented reality with lectures and conventional modules (Trelease, 2016). Flipped or inverted classrooms are a collaborative learning format in which typical in-class lessons and assignment activities are swapped (Güvenç, 2018; Unal et al., 2021). Students are given access to the learning material before class so that they may prepare at their leisure, while the in-class period is devoted to engaging teaching activities (Ölmefors & Scheffel, 2021). These practices include but are not limited to, case-based learning, group learning, project-based learning, research-based learning, and cooperative learning (Sasson et al., 2018).

United Nations (UN) created the Sustainable Development Goals (SDGs), also known as the Worldwide Goals, in 2015 as a global call to action to eradicate poverty, protect the environment, and guarantee that everyone enjoys freedom and harmony by 2030 (de Villiers et al., 2021). The 17 SDGs are interlinked; they determine the impact of initiatives in one domain and progress in social, economic, and environmental sustainability.[1] These SDGs require everybody's creativity, understanding, technology, and financial resources in every environment. Approximately 262 million children and teenagers are out of school today (Matthew & Kazaure, 2020). It will result in possibly adding impoverishment and marginalization for 750 million individuals (UNESCO, 2021). UNESCO develops educational resources to assist individuals in living as global citizens free of hatred and bigotry (Ty, 2021). It aims to ensure that every child and citizen has access to a good education by fostering national connections and also cultural

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[1] https://www.proschoolonline.com/blog/flipped-classroom-learning-meaning-importance-advantages

heritage and the equality of all civilizations (Addey, 2021). UNESCO acts as an idea laboratory, assisting nations in adopting international standards and managing programs that promote the free flow of ideas and information exchange.

Education ambitions are fundamentally reflected in the 2030 Sustainable Development Goal 4 (SDG 4) which is aimed to guarantee integrative and equal quality education and promote opportunities for lifelong learning for all by 2030 (Demirbağ & Sezgin, 2021; Shiohira, 2021). The roadmap for achieving the education objective, which was established in November 2015, advises governments around the world and private sector partners like Discovery Networks, Samsung[2] etc. on, how to transform pledges into action (Marope, 2016).[3] This is sponsored by the International Community through partnerships, guidance, institutional strengthening, inspection, and lobbying (Briones Alonso et al., 2021). In the context of the great challenges and opportunities for a forecast, feasible, and chosen future, the commission will focus on reconsidering the role of education, learning, and knowledge (Ahmad, 2019). SDG 4 is the goal of pristine education (Ferguson et al., 2021). It strives to offer equal and equitable education and create chances for continuous learning.

Vasudhaiva Kutumbakam, an old Indian saying that means "the world is one family," encapsulates the essence of India's approach to all areas of life, including economic growth, succinctly (Shelley, 2021). The Sustainable Development Objectives (SDGs) are therefore an integral part of the country's lengthy culture and legacy, and the goals largely represent India's development ambition (Kakar et al., 2021; Manby, 2021). India had a major influence in formulating the goals for sustainable development (SDGs). As one of the countries that have participated in the High-Level Political Forum's (HLPF) 2017 Voluntary National Reviews (VNRs), India recognizes the importance of poverty eradication and supporting growth in an ever-changing globe.[4] In India, significant advances have been made in essentializing basic education, with improvements in female enrolment and completion rates in both secondary and tertiary institutions. (Saxena, 2020). At the national level, the youth literacy rate was 94 percent for men and 92 percent for women (Jain, 2021). The gross enrollment ratio for men and girls in elementary school was 100%.[5] The new National Learning and Development Policy Objective (2020) places a special focus on the development of each individual's creative potential.[6] It is founded on the premise that schooling must develop not just intellectual capabilities, but also interpersonal, ethical, and psychological abilities and inclinations. Sarva Shiksha Abhiyan (SSA), the administration's flagship program, aims to provide ubiquitous quality education to all Indians, and it is supported by a specialized Hajdukiewicz and Pera (2020) program for nutritional needs, higher education, and professional development.[7] Ensuring comprehensive and high-quality education for everyone underlines the conviction that e-learning is one of the most potent and well-tested

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[2] http://www.unesco.org/new/en/culture/communities/partners/private-sector/

[3] https://en.unesco.org/themes/education

[4] https://sustainabledevelopment.un.org/hlpf/2017

[5] https://in.one.un.org/page/sustainable-development-goals/quality-education-in-india-sdg-4/

[6] https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf

[7] https://in.one.un.org/page/sustainable-development-goals/quality-education-in-india-sdg-4/

engines for long-term development.[8] This objective seeks to ensure that all girls and boys finish elementary and secondary schools and have fair access to effective vocational training by 2030, as well as to eradicate gender and income gaps and achieve universal access to a quality higher education (Mohanty & Dash, 2018). Furthermore, it promotes lifelong learning opportunities to acquire significant adult literacy and numeracy, as well as the construction and renovation of current education facilities that are children, handicapped, and gender-inclusive (McKay, 2018a).

The Indian government has taken the necessary efforts to guarantee the successful execution of SDG 4 (Pandey, 2018). The government of India is committed to ensuring the proper execution of SDG 4 and ensuring that, the government has taken some initiatives like National Literacy Mission, Kala Sanskriti Vikas Yojana, National Scheme for Incentive to Female Child for Secondary Education, Scholarship for College, and University Students, National Fellowship and Scholarship for Tertiary Education of ST Students, SWAYAM (Study Webs of Active – Learning for Young Aspiring Minds) Project.[9] Specific SDGs have a wide scope to cover the following: Adjusted Net Enrolment Ratio (ANER) in elementary education average yearly dropout rate in secondary education (Rao et al., 2021), Gross Enrollment Ratio (GER) in Higher Secondary (Nehru & Shahi, 2021), Number of students in class 8 attaining at least a minimum competency level in terms of nationally specified learning outcomes to be reached by the students at the end of the year, Gross Enrollment Ratio (GER) in Tertiary Education, Proportion of people with disabilities aged 15 and older who have completed secondary school, Gender Parity Index (GPI) for Tertiary Education, percentage of individuals 15 years or above who are illiterate, the proportion of schools that have access to decent amenities (electricity, drinking water), Proportion of qualified teachers at secondary schools, Secondary Pupil-to-Teacher Ratio (PTR).[10] India has made great headway toward executing the "*Education for All*" plan (Pandey, 2018). Several important programs and initiatives like Sarva Sikhsha Avyan were established as a basic right to provide obligatory elementary schooling for all children aged 6 to 14 years.[11] Programs such as Sarva Siksha Abhiyan (SSA) and Right to Education (RTE) have provided a much-needed push to India's educational sector (Pahwa & Indira, 2021). Even, the country's enrolment rates in elementary education have considerably improved.[12]

In this paper, we are looking forward to introducing and discussing India's current approach or initiatives aimed at achieving or contextualizing the SDG for education (stated as SDG 4) in the Indian perspective by incorporating them into the development of a new education policy, as well as its optimistic influence on the outcomes of quality training, as outlined by 2030. It covers basic, intermediate, and higher education trends in the nation and addresses several important challenges in the field of quality education and affordability in education. India has taken major steps to promote inclusive, equal, and excellent education (Hajdukiewicz & Pera,

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[8] https://www.niti.gov.in/writereaddata/files/SDG_3.0_Final_04.03.2021_Web_Spreads.pdf

[9] https://ggiindia.in/goal-4-quality-education/

[10] https://www.niti.gov.in/writereaddata/files/SDG_3.0_Final_04.03.2021_Web_Spreads.pdf

[11] https://www.aicte-india.org/reports/overview/Sarva-Shiksha-Abhiyan

[12] https://ris.org.in/newasiaforum/achieving-sdg-4-india-moving-quantity-quality-education-all

[2020](). Although the education sector in India has seen tremendous development, the SDG's Objective 4 has still a long way to go (Rao et al., [2021]). Such efforts will demand solid policies, careful supervision, and the funding needed. These efforts will substantially enhance a prosperous future, good jobs, and a better living standard through a decade-long educational mission for 2030, to enhance inclusive, equal, and decent education.[13]

2 Aims and objectives

The goal of this research is to assess the Indian government's attempts to fulfill the Sustainable Development Goals for Education (SDG 4), particularly in the time frame 2030. In addition, we want to achieve the following objectives:

I. Analyzing the perspectives of Sustainable Development Goals for Education (SDG 4).

II. Investigate the current state and the accomplishments of the Indian government initiatives taken to implement SDG 4.

III. Apply an association rule mining algorithm to extract the pattern of association among different indicators of SDG 4 (Case study on Indian scenario).

3 Organization of paper

The paper is organized into the following sections; *Related work* presents an overview of research works and surveys on sustainable development objectives, with a focus on the Sustainable Development Goals for Education (SDG 4) and other related issues. Mainly, the work in this study is conducted in two phases. *In Phase 1*, we emphasized more on exploring the insights of SDG, SDG 4, and various initiatives taken by the Indian Government for the accomplishment of SDG 4 in India. In specific Phase 1 includes the following sections; *Sustainable Development Goals (SDG)* section presents the sketch of the SDGs established by the United Nations to promote global development and peace. The section on *the current state of SDG 4 implementation and achievement* focuses on the current successes and evaluation of actions undertaken by governments all around the world. The crucial *Initiatives by the Indian Government to attain Sustainable Development in Education* are discussed in the next section. In *Phase 2*, our main objective is to analyze the SDG 4 dataset (India country dataset only) for extracting the useful pattern of association among the indicators of SDG 4. For the achievement of this objective following steps are performed that are organized into the following subsections; *Analysis and methodology* subsection elaborates the way data is collected, how the pre-processing of the dataset is performed and includes the explanations of the methods, tools, and algorithms employed to achieve the specified objective. The graphical representation

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[13] https://www.researchgate.net/publication/327721156_Will_India_Achieve_SDG_4_by_2030

along with the statistical outcomes are represented in the *Results* section. In the *discussion* section, the elaborative interpretation of the obtained outcomes concerning the outlined research objectives is given. Besides, the *conclusion and future recommendations* section summarizes the conducted research work and suggests the direction for future work to assist concerned stakeholders.

4 Related work

The concept of sustainable development is not new (Tomislav, 2018). Many scholars have committed their efforts to developing ways to ensure the planet's survival. Since its inception, the United Nations has been dedicated to making the world a better place to live (Ban, 2016). To attain that aim, all member countries developed the Millennium Development Goals through a series of meetings. According to the research of Sachs and McArthur (2005), the Millennium Development Goals had little influence on the worldwide landscape. To accomplish the goal of sustainability, all United Nations member countries agreed in 2015 at the Sustainable Development Summit to establish sustainable development goals (SDGs). Since then, experts from all over the world have been reviewing and evaluating the aims of the Sustainable Development Goals and making recommendations that would pave the way for a more sustainable and developed future for all.

Muff et al. (2017) in their work stated that the 17 SDGs served as the foundation for the planet's long-term viability. These objectives directly target the difficulties and seek a constructive solution to the situation. Among the seventeen SDGs, SDG 4 is aimed at creating a sustainable education system for the people of the world. This SDG 4 contains seven objectives that address gender inequality in education, dropout rates in elementary, secondary, and higher education, and developing opportunities for the disadvantaged class, such as individuals from scheduled castes, indigenous people, and people with disabilities, among others. It also includes three sub-objectives that can help accomplish the seven targets listed in SDG 4.

Similarly, the Indian government has launched a slew of activities aimed at highlighting and achieving SDG 4 goals. SWAYAM[14] and DIKSHA,[15] among other attempts, have shown to be ineffective in the present pandemic scenario (Singh et al., 2021).

Several scholars have emphasized the necessity of eliminating gender disparities in education. Women are graduating at a greater rate and with higher marks. The government of India has created scholarship programs such as UDAAN[16] to improve the spirit of women and encourage them to pursue technical and vocational education. Scholarships have a significant influence on students since it has been seen that students who get scholarships are more inclined to engage in academic pursuits. Furthermore, because most scholarships are merit-based, it motivates

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[14] https://swayam.gov.in/

[15] https://diksha.gov.in/

[16] https://www.india.gov.in/spotlight/udaan-program-give-wings-girl-students

students to study properly. After reviewing all of this research, we can conclude that the significance of Sustainable Development Goals is limitless. However, it should be noted that several obstacles must be overcome to attain sustainability.

Rammohan and Vu (2018) discovered that women's schooling attainment in India continues to trail significantly behind that of males. The findings give quantitative evidence of the involvement of many economic and social factors in educational gender inequalities. However, the patrilocal exogamy norm, in which wives migrate to co-reside with their husband's kin, is associated with poorer outcomes for women's schooling compared to men's schooling; and, according to anthropological research, gender-differentiated inequities in education are more pronounced in Northern India.

According to Pandey (2018), India has made significant progress toward implementing the *Education for All program*. As a *Fundamental Right*, numerous significant programs and policies have been implemented to provide free and compulsory education to all children aged six to twelve years. The government must look at some of the major issues affecting quality education and accessibility in India's educational system. Beena (2019) pointed out the work that India has promised to offer all children with inclusive and equitable quality education by 2030. Initiatives such as the *Sarva Shiksha Abhiyan* (SSA) and the *Right to Education* (RTE) have given India's education system a much-needed boost. However, significant progress toward universalizing primary education has been accomplished, as seen by improvements in enrolment, retention, and other physical infrastructure.

Sajan and Medona (2021) address the fact that India has had a rich scientific and knowledge legacy from ancient times. However, decades of foreign control wiped out the country's knowledge systems. Modern India boasts a rich intellectual history, as well as world-class education and research institutes like the Indian Institutes of Technology (IITs), the Indian Institute of Science (IISc), and prominent universities. The resources offered, however, are only available to a wealthy minority, not to the majority who cannot afford them. Though equal access to information and education is one of the fundamental rights guaranteed by the Indian Constitution, it is a Herculean task to achieve. Informatics can help to make resources more accessible and learning a more open and free activity, independent of geographical distance or individual economic circumstances. E-learning enables the sharing of study resources in several media formats, including live interactions, videos, slideshows, word documents, and PDFs, as well as the delivery of live online courses and communication via chats and messages. The article investigates the Indian government's intentions to transform knowledge and education systems to be network-compliant, intending to provide fair access to everyone. We anticipate that the findings of this research will assist the Indian government in strengthening its activities and considering immediate steps to achieve sustainability in the Indian education system.

The proposed work is unique in its terms, as we are looking forward to exploring the work and initiatives that are being executed and accomplished by the Indian government for the accomplishment of the SDG 4 goal of education. Further, we are motivated to dig inside the SDG 4 dataset obtained from NITI Aayog to get insights into the pattern of association that exist among the different indicators of SDG 4.

5 Sustainable development goals (SDG)

Sustainable development goals seem to be at the foundation of modern global government schemes focused on making the globe a fairer place to live (World Health Organization, 2016). These SDGs are particularly dedicated to promoting sustainable development and also will act as a protracted sustainability roadmap (Mensah, 2019). Specifically, the SDGs are more inclusive and effective than their forerunners, the Millennium development goals (MDGs) (Battersby, 2017). All agreed United Nations members created a blueprint for bringing prosperity to the globe and ensuring its preservation. The framework is currently known as the Sustainable Development Goals (SDGs). These SDGs are a rallying cry for both rich and developing countries to take urgent action to forge global cooperation. These SDGs targets a variety of challenges, including poverty, quality education, gender equality, economic growth, and climate change (refer to Fig. 1).

To achieve sustainable development by 2030, all countries must commit to putting global goals into action (Naidoo & Fisher, 2020). The United Nations has formed a department to give considerable support to nations to help them achieve sustainability. In this research, our main focus is on exploring the insights of SDG 4 (explained in Sect. 5.1). We also aim to look at the current state of SDG 4 implementation and accomplishment (refer to Sect. 5.2). Further, we are committed to analyzing varied crucial initiatives taken by the Indian government for achieving the goals of SDG 4 (explained in Sect. 5.3).

5.1 Sustainable Development Goal 4 (SDG 4)

Education for everyone has always been an important component of the agenda for sustainable development (Agbedahin, 2019; Leicht et al., 2018). According to Wals and Kieft (2010) internationally, there is a rising acknowledgment of education for sustainable development (ESD) as an essential component of excellent education and a vital facilitator of sustainable development.

SDG 4 (refer to Fig. 2) is intended to ensure inclusive and equitable quality education and to encourage lifelong learning opportunities for everyone, and it includes seven objectives and three methods of implementation (Ferguson et al., 2018; McKay, 2018; Webb et al., 2017). Even though the goals were formed through a lengthy consultation process led by member countries, civil society, educators, unions, intergovernmental agencies, regional organizations, the private sector, research organizations, and endowments were all engaged (Elmassah et al., 2021). Later, the Higher Education Sustainability Initiative (HESI) was established as a collaboration of several sponsoring UN entities such as UNESCO, UN-DESA, UNEP, Global Compact, and UNU, to galvanize commitments from higher academic institutions to instruct and promote research on sustainable development (Paulette, 2019). This involves greening campuses and assisting with regional sustainable practices. GAP and HESI seek to assist universities in developing sustainability plans in collaboration with the larger community, as well as assisting institutions in implementing sustainability into academic

activities, administration, strategy, and management. The details of SDG 4 and its components are explained in the subsequent paragraphs.

SDG Target 4.1 Aiming that all girls and boys get affordable, inclusive, and high-quality primary and secondary education by 2030, resulting in relevant and effective learning outcomes (Miles & Singal, 2010; Raina, 2019). A minimum of 12 years of free, publicly funded, accessible, equal, and decent quality primary and secondary education – including at least nine years are mandatory and lead to meaningful educational outcomes – should be provided to all without prejudice (Heymann et al., 2020; Kovač Šebart et al., 2021).

SDG Target 4.2 Assure that all girls and boys have access to high-quality early childhood education, care, and pre-primary education by 2030 so that they are prepared for elementary education (Haslip & Gullo, 2018; Murray, 2021). It is urged to provide at least a year of free and obligatory comprehensive pre-primary education, administered by well-trained instructors, as well as childhood development and aftercare (Hazegh, 2019; Impact Initiative, 2021).

SDG Target 4.3 Ensure that all women and men have equitable access to cheap and high-quality technological, vocational, and post-secondary schooling, including universities, by 2030 (Owens, 2017; Shiohira, 2021). It is critical to remove obstacles to professional development and technical and vocational education and training (TVET) beginning at the secondary level (Douse & Uys, 2018; Wilson, 2001), as well as to postsecondary education, including university, and to create possibilities for lifelong learning for adolescents and adults (Gregg, 2007; Kallen & Bengtsson, 1973; Laal et al., 2014). University education should be gradually made free, in accordance with the existing international accords.

SDG Target 4.4 Boost the number of young people and adults with necessary skills, including technical and vocational skills, for jobs, decent-paying jobs, and entrepreneurship by 2030 (Blanchflower, 2019; McKinley & Huebner, 2018). Access to TVET must be made more equitable while maintaining quality. Training programs should be expanded and varied via the use of a variety of education and training methodologies, so that all adolescents and adults, particularly girls and women, may gain appropriate information, skills, and competencies for decent employment and livelihood (Hamburg, 2020; Picatoste et al., 2018). Aside from job-specific skills, emphasis should be placed on producing advanced sensory and non-cognitive/transferable skills such as pattern recognition, logical analysis, ingenuity, team cohesion, interpersonal skills, and dispute resolution, which can be applied across a variety of work environments (Avsec & Jagiełło-Kowalczyk, 2021; Mumford & Gustafson, 1988; Whetten, 2011).

SDG Target 4.5 Eliminate gender inequalities in education and guarantee equitable access to all types of technical and vocational education for the disadvantaged, including disabled individuals, native communities, and vulnerable populations,
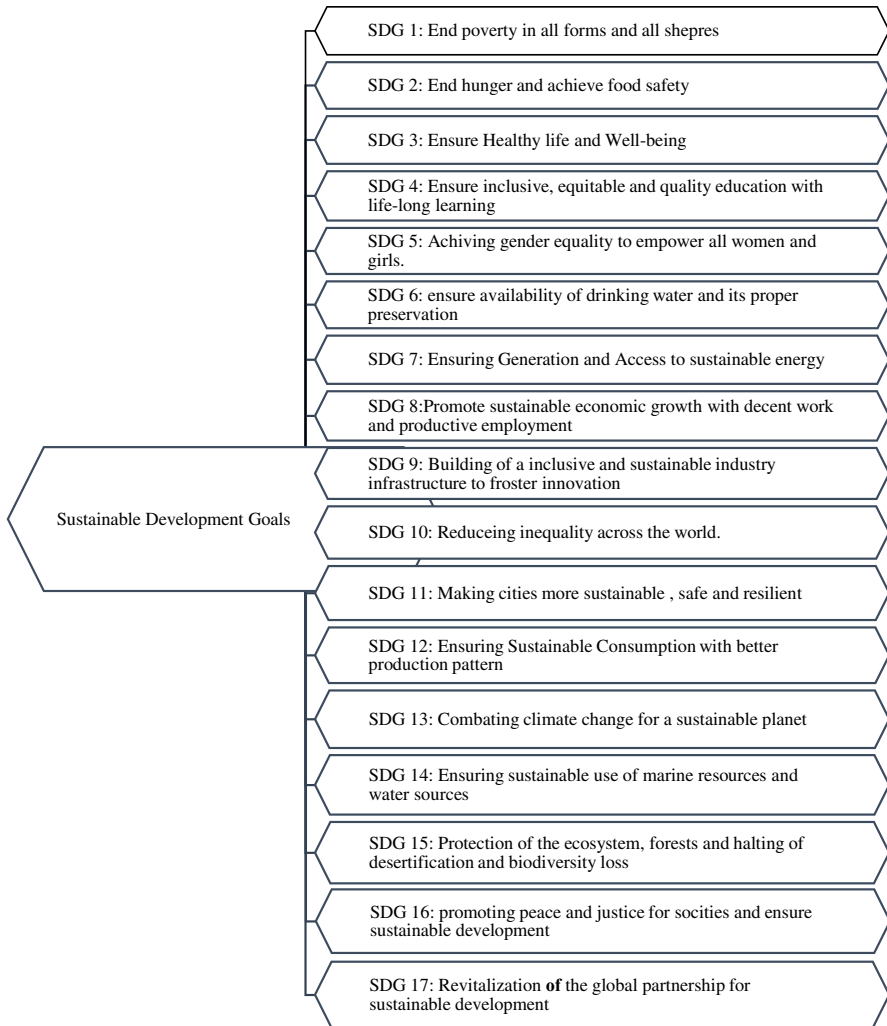
Fig. 1 Sustainable Development Goals (SDG)

by 2030 (Do et al., 2020; Felice, 2002). Everyone, regardless of gender, age, race, color, ethnicity, language, religion, political or other beliefs, national or social origin, property, or birth, should have equal access to inclusive, equitable quality education (Braveman, 2010; Koehler, 2016; Mitchell, 2016). Persons with disabilities, indigenous peoples, ethnic minorities, and the impoverished are vulnerable populations that require special attention and specialized measures. According to the statement, all girls and boys, women and men, should have an equal chance to receive a high-quality education, succeed at equal levels, and get equal advantages from education (Koehler, 2016; Mechanic & Tanner, 2007; Morawa, 2003; O'Reilly, 2007).
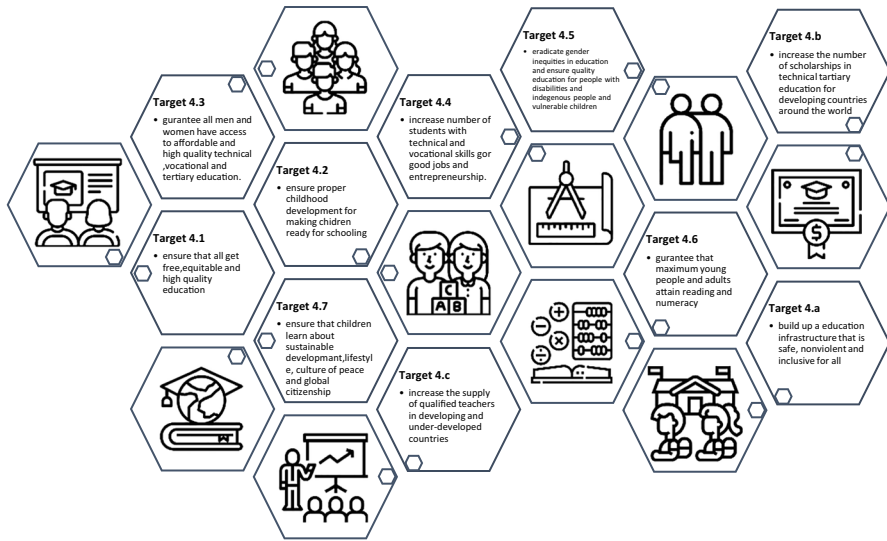
Fig. 2 Sustainable Development Goal (SDG) 4 and its components for education

Gender-based abuse, child marriage, early pregnancy, and a high burden of domestic tasks all require particular consideration.

SDG Target 4.6 Make sure that just by 2030, all adolescents and a significant number of adults, including women and men, have achieved reading skills and quantitative skills (Harrowell et al., 2018; Park et al., 2017). The modern view of readability as a spectrum of competency levels in a particular environment underpins the ideas, methods, and activities toward this objective. It goes far beyond the basic divide of literate vs illiterate (Akrong, 2021). As a result, action towards this objective aims to ensure that by 2030, all young individuals worldwide have attained appropriate and recognized competence levels in functional reading and numeracy abilities that are equal to levels attained upon successful implementation of primary education (Grotlüschen et al., 2020;Hanemann, 2019).

SDG Target 4.7 Ensure that all learners have the knowledge and experience necessary to achieve sustainable development by 2030, including through effective teaching and sustainable lifestyles, civil rights, sexual equality, appreciation of cultural diversity, harmony and pacifism, internationalization, and appreciation of diversity and culture's involvement in sustainable growth, among many other things (Askerov & Askerov, 2010; Vrdoljak & Meskell, 2021; Windorf, 2020). It is critical to prioritize academia's involvement in the fulfillment of social rights, democracy, and good governance in all sectors, from local to global. Such education's material must be practical, with an emphasis on both intellectual and non-cognitive elements of learning (Garcia, 2016; Gibbons, 1998). Education for sustainable development (ESD) and global citizenship education (GCED) may be obtained via multicultural

understanding and multinational comprehending education (Deng, 2019; Winter-steiner, 2018; Žegunienė, 2020).

SDG Target 4. a Construct and improve educational facilities that are child, handicapped, and sex sensitive, and that would provide safe, peaceful, equitable, and productive teaching practices for all (Ahmad, 2015; Beck, 1990; Gordon & Browne, 2016). This goal emphasizes the need for appropriate infrastructure facilities and fair, effective education settings for all people, irrespective of their past or physical condition.

SDG Target 4. b By 2020, significantly increase the number of fellowships open to students from poor nations for tertiary education enrollment. Sponsorship may be extremely beneficial in giving chances to adults and young people who might otherwise be unable to complete their studies (Spooren et al., 2017; Sugiyarti et al., 2018; Turner, 1960). Grants should be aimed at young individuals from socioeconomically disadvantaged, in accordance with the SDG 4—Education 2030 focus on fairness, inclusiveness, and excellence.

SDG Target 4. c Influence the availability of competent teachers significantly by 2030, notably through the international collaboration for professional development in developing nations, particularly the least developed countries and small island developing states. According to Secretary-General Ban Ki-moon, educators are critical to attaining all of the SDG 4 objectives. The scarcity and unequal distribution of properly qualified teachers, particularly in poor regions, exacerbates the equity gap in schooling.

5.1.1 Other Sustainable Development Goals that are directly connected to SDG 4:

A   Health and happiness (*SDG 3 target 3.7*) -By 2030, provide universal access to sexual and reproductive healthcare services, including family planning, data, and information, as well as the incorporation of reproductive rights into government policies and programs (Cowell, 2006; Eide & Showalter, 2011).
B   Gender equality (*SDG 5 goal 5.6*)-Number of nations with legislation and rules ensuring access to reproductive healthcare services, knowledge, and education for women between 15–49 years (Unterhalter et al., 2014; Whaley et al., 2013).
C   Good work and long-term growth (*SDG 8 target 8.6*) -By 2020, greatly decrease the number of young people who are not in work, schooling, or development.
D   Responsible consumption and manufacture (*SDG 12 objective 12.8*)-By 2030, making sure people worldwide have the necessary insights and knowledge for sustainability and environmentally friendly lifestyle choices.
E   Climate change abatement (*SDG 13 goal 13.3*)-Improve teaching, information campaigns, and infrastructural ability in environmental protection, adaptability, education and awareness, and warning.

5.2 The current state of SDG 4 implementation and accomplishment

The world is in the grip of Covid-19's destruction. Education systems throughout the world are among the worst affected. Covid has erased 20 years of educational progress (Khan et al., 2020; Rohwerder, 2020). Furthermore, 101 million, or 9% of students in grades, will be unable to meet basic reading competence by 2020 (Calet et al., 2017; Gamu & Damole, 2021). According to a recent poll, around 55% of the population is illiterate (Amin, 2019; Olaniran, 2020). To be more exact, 9 percent have minimal competence, while the remainder has no proficiency (Pienaar et al., 2021). There is deterioration in the situation, which is causing delayed progress in school completion (Aina et al., 2018). Although participation in structured pre-primary schooling is increasing (Alcott et al., 2020). In terms of numbers, it has risen from 65 percent in 2010 to 73 percent now (in 2019) (Chatterjee et al., 2020). Even if the completion rate of secondary and elementary education has marginally risen, fundamental school infrastructure is still lacking in many institutions throughout the world. According to *Dr. David Perry*, the COVID-19 pandemic's impact on education is a "*generational tragedy*".[17] According to him, the most vulnerable children and those who cannot access virtual education are more likely to drop out of school and be coerced into early marriage or child labor. Perry stated that to meet the education objectives outlined in the Global Goals, we must prioritize remedial and catch-up initiatives. In 2019, there were only 92 literate women and girls 15 years of age or older for every 100 literate males and men of the same age. According to Carr et al. (2021), the pandemic will result in a reversal of recent gains toward educational fairness.[18]

6 Initiatives by the Indian government to attain sustainable development in education

India, being the home to one-sixth of all humanity, holds the key to the achievement of the 2030 Agenda.[19] Since Indian independence, successive Indian governments have addressed several key challenges in education by introducing new educational policies and schemes as a part of its development agenda i.e., '*Sarva Shiksha Abhiyan*', '*Rashtriya Madhyamik Shiksha Abhiyan*', '*Right to free & compulsory Education Act*' etc. (Saini et al., 2021; Singh et al., 2021). However, as per the 'British Council India report, the current Indian education system is guided by different objectives and goals but is primarily based on the policies of yesteryears (Mohanty & Dash, 2018).

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[17] https://undocs.org/en/E/2021/58

[18] https://www.un.org/development/desa/en/news/sustainable/sustainable-development-goals-report-2020.html

[19] https://sustainabledevelopment.un.org/memberstates/india

SWAYAM PROGRAMME The program gets its name from Study Webs of Active – Learning for Young Aspiring Minds (Kumar & Mahendraprabu, 2021). Instructors from government-financed schools like IITs, IIMs, and central universities will provide online training to residents of the nation as part of this initiative.[20] All courses will be available for free study. If the learner desires an Authenticated Certificate, a modest cost will be charged. In the first phase, IIT Bombay, IIT Chennai, IIT Kanpur, IIT Guwahati, University of Delhi, Jawahar Lal Nehru University, IGNOU, IIM Bangalore, IIM Calcutta, and Banaras Hindu University will train students in engineering education, social science, power, governance, and science courses on their own and with the assistance of academic staff from international schools.

National E-Library The E-Library is envisioned as an online portal that will democratize access to knowledge by ensuring quality content from central universities and top-ranked academic institutions is obtainable in a digital format that students, working professionals, and researchers across the country can easily access via laptops, smartphones, tablets, and PCs.[21] The international partnership has been offered by Israel, Norway, UK, UNESCO. The National E-Library has been operating since the 2015 academic year.

SAKSHAM It is a program to facilitate differently-abled students with scholarships.[22] The AICTE has agreed to give 1000 scholarships each year to differently-abled students to pursue technical education purely on merit in the qualifying test. The scholarship amount would be Rs. 30,000 or tuition costs, whatever is less, plus Rs. 2000 monthly for ten months also as a contingency allowance.

Beti Bachao Beti Padhao Abhiyan The Ministry of Primary Education and Literacy has assisted the Ministry of Women and Child Development in implementing the "Beti Bachao Beti Padhao" Abhiyan in 100 districts across the country to improve the gender ratio and the position of the female child.[23] The "Beti Bachao Beti Padhao" Abhiyan is instituting an incentive for School Administration Boards that accomplish 100 percent migration of females at all stages of schooling.

UDAAN UDAAN is a Central Board of Secondary Education (CBSE) project that enables underprivileged girl students as well as other students from vulnerable positions and minorities to transition from school to post-secondary technical learning, particularly in Mathematics and Science.[24] The initial mission of UDAAN is to tackle the low enrollment of girls in engineering institutions, which is now around 23% of girls against 77% of boys. It seeks to bridge the gap in quality between post-secondary and engineering education entry systems by focusing on three dimensions: curriculum design, transaction, and assessment. This will be accomplished

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[20] https://swayam.gov.in/about

[21] https://ndl.iitkgp.ac.in/

[22] https://plan-international.org/eu/saksham-india

[23] https://wcd.nic.in/schemes/beti-bachao-beti-padhao-scheme

[24] https://www.india.gov.in/spotlight/udaan-program-give-wings-girl-students

through enhancing and complementing Mathematics and science curricula at the Senior Secondary level. The CBSE will give free and online resources to the whole student population, with additional incentives and assistance available to a thousand chosen underprivileged females each year.

Swami Vivekananda Single Girl Child Scholarship for Research in Social Sciences The University Grants Commission (UGC) has devised this initiative, which offers 300 scholars with Junior Research Fellowships worth Rs. 8,000/—10,000/- monthly beginning in every academic year.[25]

PRAGATI The goal of this project is to assist girls in advancing in technical education.[26] The AICTE plan provides for the selection of one girl per family with a household income of fewer than 6 lakhs per year to pursue technical education based on merit in the qualifying examination. The system will be executed by the individual state governments' authorized admission centers. Scholarships are intended to assist 4000 females every year. The scholarship amount is Rs. 30,000 or tuition costs, whichever is less, plus Rs. 2000 per month for ten months as a contingency allowance.

Ishan Uday Students from the North East Region are eligible for a special scholarship program.[27] From the 2014–15 academic year, the UGC has introduced a unique scholarship scheme for students from the North East Region. The scheme envisions awarding 10,000 scholarships to students from the North East Region whose family income is less than Rs. 4.5 lakh per annum, with scholarships ranging from Rs. 3,500 to 5,000 per month for studying at the undergrad level at colleges/universities across the country.

Ishān Vikās Ishan Vikas is a powerful approach to bringing chosen students from the North-Eastern states' school and college levels into close touch with the IITs, NITs, and IISERs during their holiday times.[28] A typical ten-day visit to one of these schools is planned, in the form of either exposure or an internship. Each school will send one teacher to follow a group of about 32 pupils from classes IX and X, as well as eight teachers. In the summer and winter, the college students would be divided into two groups of 32 students each. During the academic year, about 2016 college students and 504 instructors from N-E will tour renowned institutes such as IIT/NIT/ IISERs. or Centrally Funded Technological Institutes) will be accepted with scholarships and travel. Each year, about 250 students from 25 institutions will visit 16 IITs and 6 NITs (to begin with, six NITs are being considered). A summary of all the initiatives of the Indian government and their connections with the SDG elements are represented in Table 1.

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[25] https://www.ugc.ac.in/svsgc/

[26] https://en.wikipedia.org/wiki/Providing_Assistance_for_Girls_Advancement_in_Technical_Education_Initiative

[27] https://www.ugc.ac.in/ner/

[28] https://cs2.iiserb.ac.in/activities/ishan_vikas_about.php

Table 1 Summary of initiatives and their associations with SDG4 elements

S. No	Name of the Initiative	Key Objectives	Associated SDG Elements
1	Swayam Programme	• Online training • Free Study • Equivalence with Interatiomational standards	SDG 4.2 SDG 4.3 SDG 4.4
2	National E-Library	• Quality Content • Digitization • International partnerships • Online accessibility	SDG 4.2 SDG 4.4 SDG 4.5 SDG 4.1
3	Saksham	• Help differently-abled students • Scholarships • Merit-based accommodations	SDG 4.6 SDG 4. a SDG 4. b
4	Beti Bachao Beti Padhao Abhiyan	• Women and Child development • Targetted up to 100 districts • Improve gender ratio • Special Incentives to schools promoting girls for education	SDG 4.2 SDG 4.3 SDG 4.5 SDG 4.7
5	UDAAN	• Upbring underprivileged girl students from vulnerable positions • Promotes mathematics and science studies • Encourage girls to engineering studies • Three-dimensional focus: Curriculum design, transaction, assessment	SDG 4. a SDG 4. b SDG 4.6
6	Pragati	• Bring girls into the technical education • Selection of at least one girl per family • Executed by the individual state government • Assist 4000 females per year	SDG 4.1 SDG 4.3 SDG 4. c SDG 4.5
7	Ishan Uday	• Targeting students from northeast regions • Special scholarship program • More than 10,000 scholarships per year	SDG 4. a SDG 4.5 SDG 4. b
8	Ishān Vikās	• Close touch with IITs • Ten-day visit for exposure • Targeting students from northeast regions	SDG 4.1 SDG 4.2 SDG 4.4

Apart from all these initiatives few other programs like Padhe Bharat Badhe Bharat (PBBB), The Rashtriya Avishkar Abhiyan (RAA), Information and Communication Technologies (ICT), Saransh, Shaala Siddhi (Self–assessment of all schools and External Evaluation of sample schools), Pota Cabins – Residential Schools for Children in LWE-affected areas, Pratibha Parv – Strengthening Quality of Education in Government Schools, Saakshar Bharat – Sustaining and Enhancing Efforts in Adult Education Swachh Vidyalaya has been started or upgrading to improve quality education in India (Sharma et al., 2020).

The state governments in collaboration with the central government have started a few programs for the development of education and to remove the barriers (like increased dropout rate among rural students) (Rajput et al, 2020).

The Bihar government started *Mukhyamantri Balika Cycle Yojana* to provide affordability to students especially girls to come to school. This program has not only improved the school enrolment among girls but has drastically reduced the dropout rates. The state government of Gujarat started '*Migration Card and Migration Monitoring Software'* to track and monitor migrating students. Since migration for seasonal employment is one of the most crucial factors for dropouts from school. The Mizoram state initiated the '*Each One Teach One Method'* program for making education reachable to every student in the state. The state government of Himachal Pradesh started the '*Reaching to out of School children'* program to make sure no student should remain out of school.

7 Apply an association rule mining algorithm to extract the pattern of association among different indicators of the SDG 4 dataset (Case study on Indian scenario)

7.1 Data analysis and methodology

The data analysis and methodology include details on the database collection for the study procedure, information on data preprocessing and filtration, techniques, and computational methods designed to achieve the stated objectives of this study (refer to Fig. 3).

7.1.1 Data collection

The data for the purpose and research is gathered from trustworthy sources such as the World Bank data repository,[29] UNSTATS,[30] UNESCO,[31] as well as others. We have considered yearly statistics from 1990 to 2020, intending to achieve the objectives of this study. In specifically, the attributes of the dataset are derived from World

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[29] https://data.worldbank.org/
[30] https://unstats.un.org/sdgs/indicators/database/
[31] https://en.unesco.org/themes/education2030-sdg4

Bank Sustainable Development Metrics,[32] UNICEF Data Archives,[33] UNDESA Open Access Archives,[34] UNSTATS,[35] and WHO SDG indicator databases.[36] Some data was also gathered through surveys conducted by the government of India and preserved at the data archive of India, the ASER Center of India,[37] and the ministry of education[38] of India. Data was also obtained from reputable data source websites such as Trade Economics,[39] Knoema,[40] and Kaggle.[41] The collected data is organized in the following indicators (I_1 to I_{11}) as shown in Table 2.

7.1.2 Data pre-processing

The data collected from multiple sources is first integrated (Wold et al., 2010). As the integration of the dataset facilitates the adequate handling and attainment of specified objectives of the study to explore the association among the indicators of SDG 4. Further, the filtration and cleansing of data are performed as the subsequent processes of data pre-processing (Hariharakrishnan et al., 2017). This procedure facilitates the removal of abnormalities from the data set and prepares it for analysis (García et al., 2015).

Data in the real world is frequently sparse, noisy, and erratic (Famili et al., 1997). This might result in low-quality data collection and, as a result, low-quality models based on that data (Bilalli et al., 2018). Data Preprocessing includes procedures that can organize data into a correct shape for better comprehension in the data mining process to solve these challenges. In the process of data cleaning, we target eliminating the data outliers, restoring null values, normalizing noisy data, and rectifying inconsistencies in data (Dasu & Johnson, 2003). It is an important stage in the data preparation process since incomplete, inaccurate, or erroneous data might jeopardize the trustworthiness of study results (Xiong et al., 2006). We processed our data for further analysis using two approaches.

7.1.3 Handling the missing values

During the evaluation of the data set, it was discovered that certain indicators had null (or no) values. It contributes to the problem of uncertainty and heterogeneity in data evaluation. We used the Interpolate Method to solve the problem (Chai et al., 2020). Interpolation is a technique for estimating unknown data points between two data points.

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[32] https://datatopics.worldbank.org/world-development-indicators/
[33] https://data.unicef.org/resources/resource-type/datasets/
[34] https://www.un.org/en/desa
[35] https://unstats.un.org/sdgs/indicators/database/
[36] https://www.who.int/data/gho/data/indicators
[37] https://www.asercentre.org/
[38] https://www.education.gov.in/en
[39] https://tradingeconomics.com/
[40] https://knoema.com/
[41] https://www.kaggle.com/

A set of data points, gathered by sampling or testing, are frequently used to indicate the values of a variable for a small number of independent variable values. Interpolation, or estimating the value of a variable for an intermediate position of the independent variable, is frequently necessary. Data that represents a specific pattern or periodicity is referred to as time-series data. Analyzing time-series data differs from typical data frames in a few ways. We can't utilize mean imputation approaches to cope with missing values when we have time-series data. Interpolation is a strong approach for filling null values in a time-based dataset and is thought to be the efficient strategy for filling missing values in most circumstances. That's why after careful consideration we picked Linear Interpolation as the best approach required for analyzing the data sued in this study. For this study, the Linear interpolation approach is employed, and the mathematical model for linear interpolation is given in Eq. 1. Linear interpolation is a method of computing intermediate data between measured values by plotting the data hypothetically between two nearby values obtained (Huang, 2021; Noor et al., 2014). Linear interpolation is defined as the concatenation of linear interpolants between each pair of data points on a set of data points (m0, n0), (m1, n1),…, (mn, nn). Furthermore, because we have identical data for each category in the database, it aids in a comprehensive quantitative evaluation of the data set.

$$(n) = n1 + (m - m1)\frac{(n2 - n1)}{(m2 - m1)} \tag{1}$$

where,

m   point in the x-axis

n   point in the y axis

m1   nearest upper point in the x-axis

n1   nearest upper point in the y-axis

m1   nearest lower point in the x-axis

m2   nearest lower point in the y-axis

7.1.4 Data normalization

Data normalization is an important element of data pre-processing. The process of learning and the resultant model may be harmed by the noise that affects the input characteristics or output class. The level to which noise impacts the database can be measured in terms of each attribute's data value, as well as the attribute's lowest, peak, and standard deviation. To correct the noise in our data set, we chose the Relative Neighborhood Graph Edition Filtration method among a variety of data
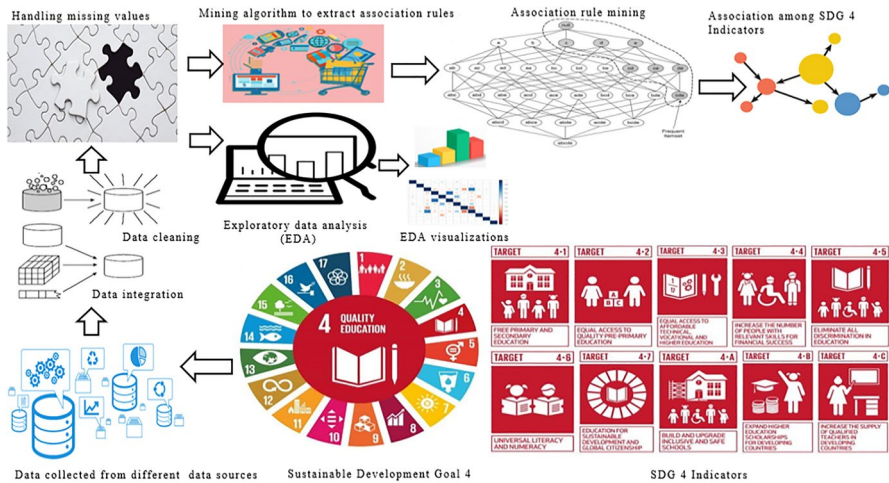
Fig. 3 Data analysis methodology

Table 2 Indicators of Sustainable development goal for education (SDG 4)

Indicator	SDG	Description
I_1	4.1.1.C	The proportion of young people in lower secondary grades
I_2	4.2.1.ger	Gross Enrollment Ratio in Organized Learning (Pre-primary and Primary)
I_3	4.c. overall	Pupil Teacher Ratio
I_4	4.5.1.b.gpi	Gender Parity Index
I_5	4.1.1. a	The proportion of young people in pre-primary grades
I_6	4.6.1. a	Proficiency level attained by a population
I_7	4.1.1. ii	Mathematics proficiency in primary level
I_8	4.1.1. b	Scholarship amount offered to underprivileged students
I_9	4.5.3.c. secondary	Discrimination in secondary education enrollment Rate
I_{10}	4.3.1	Participation of youth and adults in training
I_{11}	4.7	Tertiary education enrollment according to GPI

normalization approaches (Jaromczyk & Toussaint, 1992). Further, the mathematical representation of the Relative Neighborhood Graph Edition Filtration method is given in Eq. 2.

$$x(xi, xj)\epsilon \leftrightarrow d(xi, xj) \leq \max \begin{matrix} \{d(xi, xj), d(xj, xk), d(xj, xk)\}, \\ \forall xk \in TR, k \neq i, j \end{matrix} \qquad (2)$$

where

x (xi, xj)   are the initial points

d (xi, xj)   is the distance of the considered data point from the corresponding point

xi, xj, xk   are the values of the data

TR   indicates the training set

The pattern in this procedure determines the parameters of the data class and constructs a closeness undirected graph [G = (V, E)], in which each vertex(V) correlates to a Training Set instance (TR). There is a set of edges E, and (x_i, x_j) belongs to E if and only if x_i and x_j fulfill some neighborhood relation, and these instances are called graph neighbors. The point graph neighborhood is made up of its graph neighbors. As a result, the data is normalized with more relevant data for the remaining variables.

7.1.5 Exploratory Data Analysis (EDA)

Exploratory Data Analysis (EDA) is a process for analyzing and investigating data sets, summarizing their major properties, and applying data visualization tools (Behrens, 1997). With the use of descriptive statistics and pictorial depictions, exploratory data analysis corresponds to the crucial process of doing first investigations on data to uncover patterns, spot anomalies, test hypotheses, and check assumptions. In the initial step, the implication of various statistical evaluations provides an understanding of the dataset. This implication helps in obtaining the appropriate results, as well as making it simpler to identify patterns from the dataset, rule out data anomalies, test hypotheses, and check assumptions. EDA is mostly used to uncover patterns that go beyond the formal modeling or inferential statistical tasks, as well as to offer a deeper knowledge of the data set elements and their connections (Braham & Ben-Zvi, 2017; Makar & Rubin, 2009; Ratner, 2017). The significant elements that shape the nature of EDA and its structural model are as follows:

$$EDA = VIS + MA + MF + INT \tag{3}$$

where

VIS   Visual Analysis

MA   Multiple Analyses

MF   Model-Free

INT   Interactive

It is essentially the same as researching data before making any type of claim. EDA help in ensuring that the results are legitimate and relevant to any

intended business objectives and goals. Kendall's method of correlation is one of the most reliable mathematical methods of creating a plot in EDA (Lapata, 2006; Mao, 2018; Muñoz-Pichardo et al., 2021). The method follows the following equation:

$$\tau = \frac{2}{n(n-1)} \Sigma sgn(x_i - x_j) sgn(y_i - y_j) \qquad (4)$$

where,

(x_i, y_i) higher variable points in the plot

(x_j, yj) lower variable points in the plot

$$sgn(x) = \begin{cases} 1, x > 0 \\ -1, x < 0 \\ 0, x = o \end{cases}$$

$$\tau = \begin{cases} when\ \tau\ is\ zero,\ equal\ number\ od\ concordances\ and\ disconcordances \\ when\ \tau\ is\ positive,\ concordance\ happend\ more\ than\ disconcordances \\ when\ \tau\ is\ negative,\ disconcordances\ happen\ more\ than\ concordances \end{cases}$$

For this study, we can take data values of *n* attributes (or indicators) measured at a specific instance of time. We can select all possible pairs of observations (x_i, y_i) and (x_j, y_j). Overall, there are $N = n(n-1)$ *the* possible number of pairs.

$$\tau = \frac{n_C - n_d}{N} \qquad (5)$$

where,

n_c Number of concordant pairs

n_d Number of Disconcordant Pairs

EDA acts as a primer step for the implication of other advanced data analytic tasks like *data modeling*, *classification*, *clustering*, *thresholding*, *multivariate visualizations*, and *predictive modeling* (Iraji et al., 2021; Trevino, 2001; Xu, 2003).

7.1.6 Numeric Association rule mining

Association rule mining is employed to examine and extract the unique patterns and rules from a huge quantity of data (Zhao & Bhowmick, 2003). The Numeric Association Rule Mining (NARM) is the best approach as these patterns indicate remarkable linkages and interactions between distinct factors between the SDGs. Furthermore, the identification of interesting connections and links among vast collections of data objects is made possible by association rule mining. NARM is used in this article to find the connection between SDG 4 and other SDGs. Association rules aid in the identification and forecasting of relational properties relying on data from beneficial properties training datasets. Most of the algorithms in classical association rule mining operate in two stages (Hahsler, 2017). All frequent itemsets are discovered in the first phase, and rules are created in the second (Hipp et al., 2000). It is observed that the traditional association rule mining methods only operate with binary or categorical (qualitative) data items and do not work efficiently for numeric (quantitative) data items (Zaki, 1999). For this purpose of extracting and electing the association rules from the numeric dataset, the NARM algorithms (methods or techniques) like the distribution method, the discretization method, and the optimization method are utilized. In this study, we are using a Biology Inspired NARM, more precisely a genetic algorithm (QuadMiner algorithm). The parameters required for the evaluation of the collected quantitative dataset are as follows (refer to Eqs. 6 and 7) (Rastogi & Shim, 2002):

$$\text{Feature1}[\text{lowerI1}, \text{upperI1}], \text{Feature2}[\text{LowerI2}, \text{upperI2}] \Rightarrow \text{Feature3}[\text{lowerI3}, \text{upperI3}]$$
(6)

$$\frac{\text{value of data in Antecedent} \cap \text{Consequent}}{\text{value of data in Antecedent}}$$
(7)

where each character is associated with a lower and upper bound. When compared to categorical association rules, these rules are broader and contain more information (Mata et al., 2002; Zaki, 1999).

7.1.7 Genetic Algorithm Approach

The genetic algorithm is an example of an evolutionary algorithm. It is a biology-inspired algorithm that follows the *Darwinism* adaptive theory concept (Moslehi & Haeri, 2020; Shahin et al., 2020). In specific, we are utilizing the *QuantMiner* genetic algorithm rather than other genetic algorithms such as *GENAR* and *GAR-PLUS* because QuantMiner, unlike other genetic algorithms, is based on identifying appropriate intervals in the dataset by maximizing both support and confidence (Salleb-Aouissi et al., 2013). The population size, number of generations, mutation rate, and crossover rate are all needed parameters for the *QuantMiner* genetic algorithm (Nagao & Seki, 2016). *QuantMiner* is a heuristic algorithm that mines statistical association rules. QuantMiner operates on a collection of constraint patterns directly. In addition, *QuantMiner* has a predefined rule framework for the generation of quantitative association rule that is either selected by the user or derived by the

system. It acts as the primer point for the rule mining operation. Using a Genetic Program, the algorithm searches for the optimum intervals for the numeric characteristics that occur in each rule template. A rule pattern is specified by the collection of characteristics that appear on both the lateral sides of the rule. The value for each category attribute is either set by the user in the framework or calculated by *QuantMiner*. Let $I_1 \ldots I_n$ be the non-instantiated quantitative attribute. QuantMiner approximates the frequent patterns based on $I_1, \ldots, I_n$, i.e., the collection of variants $J_1, \ldots, J_n$ such that $I_1 = J_1 \ldots I_n = J_n$ is frequent and generates a rule framework. The formal description of the *QuantMiner* is given in Algorithm 1.

```
Input: Dataset Parameter: I1, I2 …..In; n: the number of
parameters, Minimum Support (Min_sup), Minimum confidence
(Min_conf), Population Size (pop_size), Number of generations
(Ngen), Crossover rate (CR), and mutation rate (MR).
Step 1. Deal with missing Values
Step 2. Select the set of attributes and let R be a rule
template for these attributes
Step 3. for each r in R
        Check if r's support is < Min_sup
            If true: Penalize fitness
        Check if r's confidence is < Min_conf
            If true: Penalize fitness
        Generate population (P) of pop_size
        Set k = 0
        While k <= Ngen
        Apply CR and MR on P
        Make new generation of population with condition
        P <= pop_size
        Calculate fitness
        Choose one with the best fitness for the next
        generation   and set them as P
        k++
Step 4. Return R
```

7.2 Results and analysis

In the first phase of evaluation, we applied the explanatory data analysis to the dataset concerning the 11 indicators of SDG 4 (refer to Table 2). We ultimately gain a basic understanding of the dataset by doing exploratory data analysis. Table 3 represents the standard statistic measures (mean, standard deviation, min value, and max value) of the data respective to all indicators of SDG 4. These values aid in identifying data variations, average value, and the range of the data set. Further, Fig. 4 visualizes the overview of the data set representing the lowest, highest, median, and denser range of the data corresponding to indicators of SDG 4. It is observed that the minimum value for '*I1*' is 39.7 and the maximum is 97.71, whereas the whole data set is scattered around the range of 72–96.

Paradoxically, the strength of the link between the indicators can be figured out using correlation metrics. The correlation matrix (refer to Table 4) depicts the association between each dataset concerning the others. The correlation results reveal that there is a tight relationship between indicators I4, I5, I6, I9, and I10. The correlation between 'I2' and 'I5' is 0.91, indicating that they are highly and positively connected, whereas the correlation among indicators 'I3' and 'I7' is 0.30 signifying a low degree of dependency. The correlation strength can be observed by going through the Pearson coefficient table (see Table 5). The high degree of connectivity among 'I2' and 'I5' indicators stipulates that the Gross enrollment ratio in organized learning is significantly connected to the number of young individuals in elementary schools.

Further, QuantMiner is used to generate association rules among the data set. Table 6 represents the number of rules associated with the respective support measure. It is observed that around 4052 rules were generated at a support rate of 50 to 60% range with 100% of confidence. The least number of rules is associated with a support rate of above 90 percent at the maximum degree of confidence. Figure 5 represents a visualization of the rules associated with each transaction of the data set at the support rate of 90%. We have represented the visualization of only 90% support for the reasons of reducing complexity and fitting data inside the arc diagram. The size of the dots in the figure signifies the weight associated with that particular indicator. Each arc connectivity symbolizes the association among specified rules inside the provided dataset.

8 Discussion

Research Objective I: *Analyzing the perspectives of Sustainable Development Goals for Education (SDG 4).*

SDG 4 aims to make the world a more sustainable place to live (Kumar et al., 2016). Every aspect of society, as we all know, is linked to one another and the impact of one factor on the other parts of society can be either beneficial or harmful (Chalmers, 2019). Education is such a significant component of contemporary civilization that it can influence all other aspects of society (Durkheim, 2012). For example, to eliminate unemployment, a trained workforce is needed which is possible with education (Brown & Lauder, 1996). Furthermore, to achieve gender equality in all areas, educating females is required so that they may gain the same abilities as males and have the same rights (Unterhalter & Aikman, 2007). SDG 4's goals are to address all global issues that are directly or indirectly related to education and that may be addressed via effective global citizen education (Griffiths, 2021).

Additionally, to obtain effective learning outcomes the aims are to provide affordable and high-quality primary and secondary education to every student, 12 years of free education, funding, and equality of education by targeting a deadline near the end of 2030 (Ferguson & Roofe, 2020). The SDG is keen to improve students' efficiency from the very early stages of education by engaging well-trained instructors, childhood development programs, and free education programs. The efficient

implementation of the SDG4 is supposed to lead to the possible solution to many global issues like unemployment, gender inequality, and others.

It was expected that by the end of 2030, all adolescents, including women and men have achieved at least reading and quantitative skills. It is to be ensured that all learners have the knowledge and experience necessary to achieve sustainable development within the prescribed period (Malik, 2018).

Research Objective II: *Investigate the current state and the accomplishments of the Indian government initiatives taken to implement SDG4*

The education system throughout the world gets greatly affected by the sudden rise of Covid-19 (Singh et al., 2021). India is among the worst affected nation by this novel coronavirus (Pillai et al., 2020). The Indian government has taken several initiatives for making education possible during this period (Singh et al., 2021). Apart from the current state, the government of India is keen to provide high standard education by regulating timely updating and needly changes in the education system. The current released New Education Policy 2020 is among the continuation process of educational growth under the Sustainability development goal (SDG 4).

The Indian government has come up with many efforts to address the issues in the implementation of SDG4 (Mohanty & Dash, 2018). The SWAYAM program and the National E-Library are launched with the motive to deliver quantity and quality in education. These programs enable students to enroll in courses taught by the top professors from IITs, IIMs, and other prestigious universities, as well as access associated academic materials (Kumar & Mahendraprabu, 2021). These campaigns have been quite helpful in educating the general public about the Covid-19 predicament (Singh et al., 2021). As the whole educational system moved to an online format, this project gained traction and expanded its scope. The Indian government has launched programs such as Beti Bachao Beti Padhao and PRAGATI to address issues such as gender discrimination (Jadhav & Bagul, 2021). According to current statistics, the nation's Gender Parity Index (GER) has improved dramatically, according to the All-India Survey on Higher Education (AISHE) 2019–20.[42] Female involvement in higher education climbed by 18.2 percent throughout this time.[43] The government sustained focus on girls' education, women's emancipation, and the enfranchisement of socially and educationally backward communities, according to the report, is reflected in the increased participation of women, SCs, and STs in postsecondary education (Sahoo, 2016).

Some of the significant achievements with the implementation of these initiatives are:

- In 2019–20, cumulative participation in higher education is 3.85 crore, up from 3.74 crores in 2018–19, representing an increase of 11.36 lakh (3.04 percent). In 2014–15, there were 3.42 crore students enrolled.[44]

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[42] https://www.education.gov.in/sites/upload_files/mhrd/files/statistics-new/aishe_eng.pdf

[43] https://ruralindiaonline.org/en/library/resource/all-india-survey-on-higher-education-aishe-2019-20/

[44] https://www.thehansindia.com/hans/education-careers/indias-higher-education-enrollment-stands-at-385cr-690189

Table 3 Basic outlook of the data from EDA

Indicators	Mean	Standard Deviation	Minimum	Maximum
I1	78.45784694	18.45859991	39.45017	97.71132
I2	101.9767742	7.607140675	91.5	110.9
I3	30.46367742	7.479495364	19.676	45.5
I4	0.744433	0.173974	0.5321	1.1
I5	101.4313989	8.004036083	91.1465	114.53832
I6	68.00483021	11.61212291	52.87452698	85.8558502
I7	36.37709677	7.511266285	25.14	45.258
I8	123,679,550.3	15,073,584.96	97,318,112	145,802,544
I9	49.70714	21.21664	17	82.5
I10	0.757884	0.184754	0.520219982	1.10283
I11	1.09262	0.053237	0.95002001	1.168255

- In 2019–20, the Gross Enrolment Ratio (GER), or the proportion of students in the qualifying particular age group enrolling in postsecondary learning, is 27.1 percent, compared to 26.3 percent in 2018–19 and 24.3 percent in 2014–15.[45]
- In Higher Education, the Gender Parity Index (GPI) for 2019–20 is 1.01, up from 1.00 in 2018–19, showing that women of appropriate age groups have better access to postgraduate schooling than boys.[46]
- 3.38 million students are enrolled in undergraduate and graduate programs. Nearly 85 percent of the pupils (2.85 crores) were registered in the six major fields of humanities, sciences, commerce, engineering and technology, medical science, information technology, and computer science.
- In 2019–20, the pupil-to-teacher proportion in postsecondary learning is 26 and even the overall population of educators is 15,03,156, with 57.5 percent males and 42.5 percent females.[47]

Research Objective III: *Apply an association rule mining algorithm to extract the pattern of association among different indicators of SDG4(Case study Indian Scenario)*

The data concerning the Sustainable Development Goals is collected from multiple reputable resources over the previous 30 years for the Indian region.

We can look at the link between the multiple SDG 4 objectives using the association rule mining approach. The generated rules demonstrate the association among the indicator of sustainable development at a fixed level of confidence over a variation among the support values. Following are the few possible interpretations of the association among the indicators that we have extracted with the implication of the association rule mining algorithm (refer to Sect. 7.2):

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[45] https://www.ndtv.com/education/gross-enrolment-ratio-in-higher-education-improves-in-2019-20-aishe-report

[46] https://timesofindia.indiatimes.com/home/education/news/18-more-women-in-higher-education-in-5-years/articleshow/83415039.cms

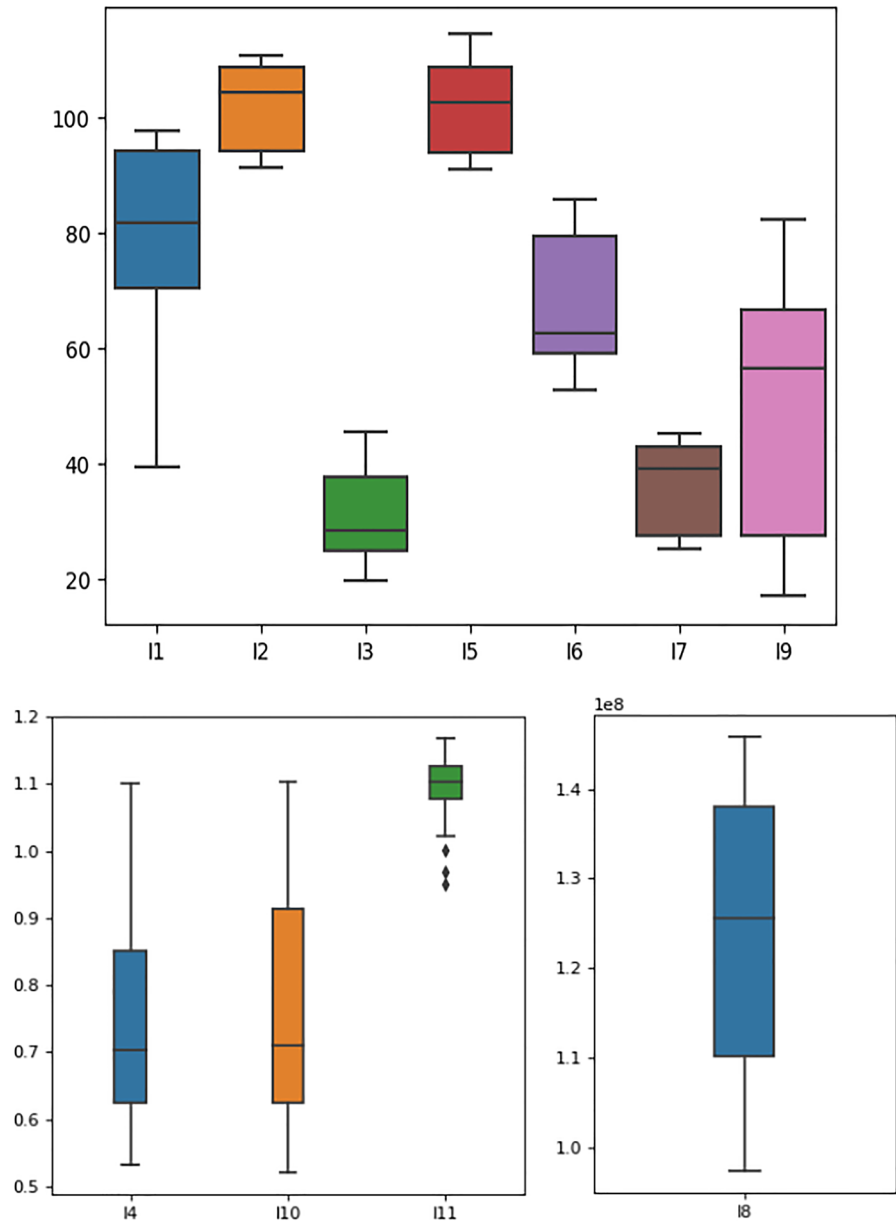[47] https://highereducationplus.com/student-vs-teacher-ratio/

Fig. 4 Box plot extracted from the analysis of the dataset

- The Gender Parity Index has a strong link to youth and adult training participation. According to the famous poet, Kazi Nazrul Islam[48] "*Everything great in the*

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[48] https://papers.iafor.org/wp-content/uploads/papers/iice2015/IICE2015_07777.pdf

Table 4 Correlation matrix

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11
I1	1	0.886103	-0.74864	0.764607	0.824801	0.688844	-0.63196	0.903865	-0.80362	0.777612	0.40657
I2	0.886103	1	-0.6976	0.748999	0.914259	0.768446	-0.74718	0.928251	-0.82161	0.769451	0.565291
I3	-0.74864	-0.6976	1	-0.5537	-0.56339	-0.33934	0.307793	-0.64811	0.553802	-0.55896	-0.47555
I4	0.764607	0.748999	-0.5537	1	0.580915	0.858876	-0.84286	0.645293	-0.94995	0.994068	0.567998
I5	0.824801	0.914259	-0.56339	0.580915	1	0.651673	-0.64426	0.982081	-0.6982	0.606054	0.451884
I6	0.688844	0.768446	-0.33934	0.858876	0.651673	1	-0.94636	0.669437	-0.92939	0.881908	0.446669
I7	-0.63196	-0.74718	0.307793	-0.84286	-0.64426	-0.94636	1	-0.64849	0.911427	-0.86662	-0.51257
I8	0.903865	0.928251	-0.64811	0.645293	0.982081	0.669437	-0.64849	1	-0.74808	0.670839	0.460511
I9	-0.80362	-0.82161	0.553802	-0.94995	-0.6982	-0.92939	0.911427	-0.74808	1	-0.97007	-0.55927
I10	0.777612	0.769451	-0.55896	0.994068	0.606054	0.881908	-0.86662	0.670839	-0.97007	1	0.576854
I11	0.40657	0.565291	-0.47555	0.567998	0.451884	0.446669	-0.51257	0.460511	-0.55927	0.576854	1

Table 5 Pearson correlation coefficient

Correlation Coefficient Value	Indication
1 ≥ r ≥ 0.60	High Correlation
0.60 ≥ r ≥ 0.30	Moderate Correlation
0.30 ≥ r ≥ -0.50	Low Correlation
-0.50 ≥ r ≥ -0.90	Negligible Correlation

Table 6 Perfromance measures and number of association rules

Support (%)	Confidence (%)	Number of Rules
50 – 60	100	4052
60 – 70	100	2878
70 – 80	100	206
80 – 90	100	153
90 – 100	100	60
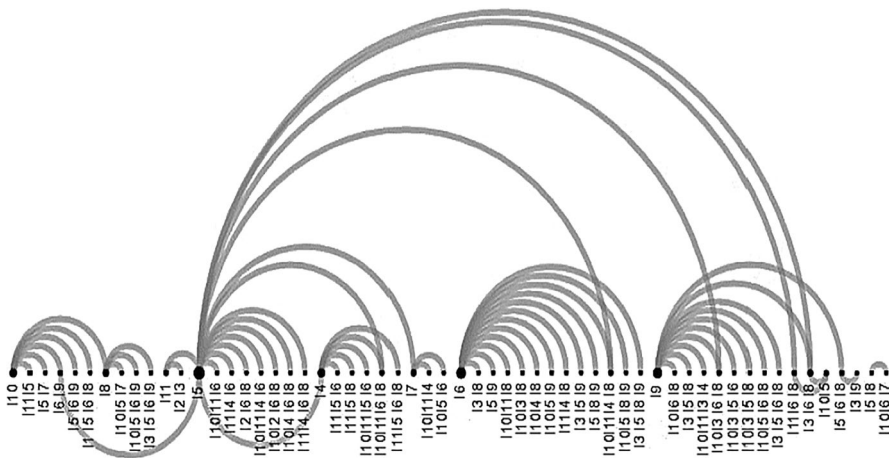
Fig. 5 Visualization of rules with a support rate between 90 to 100%

world, all the works, beneficial and good, half must be credited to woman, and to a man half only we should." We could grow the number of adolescents and adults in training if we could reduce the disparity between genders in terms of enrollment in educational institutes and training facilities. Which will address two pressing issues: unemployment and gender disparity.

- The Gross Enrolment Ratio in Organized Learning has a strong relationship with the percentage of young people at primary levels (Kingdon, 2007). Pre-primary and primary learning are two terms for organized learning. The more pupils enroll in elementary school, the more fundamental literacy is taught to them. And this has an impact on a given age group's gross enrollment ratio. Govern-

ment initiatives have a direct influence on this. Many impoverished children have enrolled in elementary school as a result of government efforts such as "Free Primary Education" and "Mid-day Meal." As a whole, the literacy rate has risen significantly.

- The percentage of young people in secondary school is linked to measures such as the quantity of scholarship funding available to impoverished pupils (Brock, 2010). Due to financial difficulties in the family, many students leave out after elementary school. As a consequence, many brilliant brains are denied the opportunity to blossom. Scholarships enable these great minds to develop and broaden their horizons.

Since the SDG4 indicators are associated with each other so upgrading one indicator will reflect its consequences on the other indicator as well. We have found several such associations (as discussed above) of patterns among individuals and groups of indicators. The findings will aid the appropriate authorities in their investigation of SDG 4 implementation in the nation. Because the findings reveal a link between several SDGs, relevant parties may now focus on aspects that need to be prioritized. Working to ensure the correct implementation of the other SDGs can significantly simplify the implementation of SDG 4 because one or more SDGs can have an impact on it directly or indirectly. Furthermore, governments should review their current initiatives to see whether they might be reinforced based on the conclusions of this article's SDG relationship analysis. This will contribute to the effective implementation of the SDGs and promote a higher quality of life for all populations.

9 Conclusion and future recommendations

Worldwide nations are engaged in making education better, and available to every citizen of their respective countries. SDG 4 under the Sustainability development program is motivated to provide quality education by removing the barriers of poverty, funding, costly education, discrimination, and unavailability of resources. India is no longer behind in making the needful changes in its education system; the timely release of the national education policies is among such initiatives. This paper investigates the insights of the sustainable development goals for the upliftment of education, and the efforts put forward ensuring to reach the milestone by the end of 2030. Further, the accomplishments of the Indian government have also been investigated for the implementation of SDG4. The current state reveals the number of planned and upcoming proposals are in the way of the achievement of SDG 4 objectives. The final section of the findings pointed out the association among the different indicators of SDG 4 by implementing a machine learning-based association rule mining technique. The correlation among the indicators indicates the presence of interdependency among the indicators and will assist the regulatory bodies to perform any changes in these measures of sustainable development goals for education in the future. These findings will assist not only governing bodies in taking preventive measures while modifying existing policies and ensuring the effective enactment of SDG 4 goals but also benefits society by understanding their role to bring

sustainability to the world. The current study is only limited to the SDG4 objective and goals, whereas for a need of sustainable environment around us then the evaluation of all the sustainable goals yields equal importance.

Author contribution All authors contributed to the data collection, analysis, and writing of the manuscript.

Data availability The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Code availability Not applicable.

Declarations

Ethics approval The research meets all applicable standards concerning the ethics of experimentation and research integrity, and the following is being certified/declared true. As an expert scientist and along with co-authors of the concerned field, the paper has been submitted with full responsibility, following the due ethical procedure, and there is no duplicate publication, fraud, plagiarism, or concerns about animal or human experimentation.

Conflicts of interest/Competing interests It is to specifically state on behalf of all authors that "No Competing interests are at stake and there is No Conflict of Interest" with other people or organizations that could inappropriately influence or bias the content of the paper.

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