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SMART EDUCATION INDEX FOR AN EFFECTIVE EDUCATIONAL ENVIRONMENT IN THE KINGDOM OF BAHRAIN

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ABSTRACT

Aim/Purpose	The purpose of this initiative is to create a Smart Education Index (SEI) for higher education institutions in the Kingdom of Bahrain. The index will facilitate a comprehensive assessment of various components of smart education, such as learning, teaching, assessment approaches (pedagogy), digital and physical infrastructure (campus), learners, instructors, and governance.
Background	The process of digitalization is advancing in higher education globally, although not equitably. In recent years, there has been a significant rise in research focused on smart education, leading to the development of frameworks and models encompassing several aspects of education, including smart pedagogy, learners, teachers, learning environments, and campus. However, no set of comprehensive indicators is currently available to allow higher education institutions to monitor their progress in implementing smart education.
Methodology	The index was assessed by subject matter experts using a structured interview method to verify their relevance and suitability for their intended purpose.
Contribution	The proposed index will provide significant insight into the Bahraini higher education system and facilitate the achievement of the government's digital transformation strategy. Moreover, being the first in the Arab region, the proposed index possesses the capacity to elevate higher education in Arab countries, serving as a mechanism for assessment and comparison. The next stage of this project will involve normalization, allocating weights to the indicators, and conducting a pilot of the index.

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Findings	Educational experts in the Kingdom of Bahrain have stated that higher education institutions are implementing digital transformation and facilitating smart education. However, the rate of adoption varies depending on the institutions' capabilities. Furthermore, there is a lack of effective mechanisms to monitor their development and advancement. The proposed index can potentially elevate the Bahraini higher education system significantly. It aligns with the government's Digital Transformation Strategy. However, since there are currently no mechanisms or tools for monitoring and facilitating digitalization and the implementation of smart education locally or regionally, this index is a significant initiative.
Recommendations for Practitioners	Utilizing the established index, a standardized index throughout the Gulf Cooperation Council (GCC) countries can be constructed to guarantee uniformity and ensure that higher education is continually advanced and elevated throughout the GCC. In terms of quality assurance of higher education, the identified set of indicators and their sub-indicators can be integrated into the quality assurance standards to advance higher education in collaboration with the Education and Training Quality Authority (BQA), locally, and the Arab Network for Quality Assurance in Higher Education, regionally.
Recommendations for Researchers	Researchers might utilize the developed index as a framework to examine the degree to which HEIs have the necessary infrastructure, resources, and competencies to support smart education. The identified measuring items of SEI can serve as a foundation for examining the barriers that may hinder HEIs from adopting smart education and the pedagogical competencies necessary for smart teachers.
Impact on Society	Establishing a robust SEI in the Kingdom of Bahrain could facilitate the assessment of its competitive standing in the global education sector and enhance its competitive advantage in the global economy. SEI, conversely, might facilitate the establishment of continuous learning environments and encourage lifelong learning. The index would foster a societal and cultural emphasis on education beyond conventional schooling, which is crucial in an age where workforce skills are perpetually changing.
Future Research	Numerous countries worldwide have initiated digital transformation efforts; hence, performing a comparative analysis will facilitate the identification of the positive and negative aspects of these projects and highlight gaps and potential areas for improvement. Another research field is to assess the impact of such initiatives on the education sector. Exploring how smart education may assist students with disabilities and promote inclusivity, together with the impact of such support concerning the SDGs, constitutes another important study topic.

Keywords: smart education, composite indicators, higher education, evaluation, SDG4, sustainability

INTRODUCTION

Smart education is strongly linked to using advanced technology to improve teaching and learning. Technology has revolutionized education into an intelligent system that allows for more efficient, flexible, personalized, and captivating learning (Pandey et al., 2022; UNESCO IITE, BNU, & ISTE, 2022a). Smart devices, artificial intelligence (AI), the Internet of Things (IoT), and big data (Demir, 2021; Díaz-Parra et al., 2022; Lian, 2022) are presently employed to enhance services provided to teachers, learners, and other educational stakeholders. This is achieved by adjusting teaching and learning methods and content (UNESCO IITE, BNU, & ISTE, 2022b) and offering smart, customizable learning environments, thereby increasing the efficiency of education (China National Academy of Educational Sciences (CNAES), 2023). The concept of smart education has gained considerable attention and research focus (Zhu, Yu, & Riezebos, 2016) to improve the quality of learning and enable inclusive and lifelong learning opportunities (Shoikova et al., 2017; UNESCO IITE, BNU, & ISTE, 2022a). Smart education is a method that aims to enhance learners' cognitive abilities, skills, and knowledge (UNESCO IITE, BNU, & ISTE, 2022a). All of this could be done beyond physical/traditional classroom education, which, on the other hand, requires a huge transformation in the educators' role, learning content, and approaches (Zhu, Yu, & Riezebos, 2016). In addition, smart education caters to the concept of "flexible learning" by creating an appropriate setting for various forms of learning, such as formal, informal, and non-formal (Karkazis et al., 2019; Tikhomirov et al., 2015). Therefore, smart education is considered a means to accomplish Sustainable Development Goal 4, which is focused on quality education, according to the United Nations Educational, Scientific and Cultural Organization (UNESCO) (Pandey et al., 2022; UNESCO IITE, BNU, & ISTE, 2022a).

Higher education plays a crucial role in shaping a city's future and producing well-qualified individuals with the necessary knowledge, skills, competencies, and talents to develop smart cities. This has led to the recognition of smart education as a key strategy to be adopted by Higher Education Institutions (HEIs) to contribute to the creation of smart societies (Díaz-Parra et al., 2022; UNESCO IITE, BNU, & ISTE, 2022b). The design and characteristics of smart education shape the beliefs, values, and behaviors of learners, transforming them into "digital citizens." Smart education fosters the growth of 21st-century abilities by establishing a learner-centered atmosphere, enhancing learners' motivation, autonomy, and collaboration (Seh et al., 2021), resulting in a more innovative and adaptive society.

The higher education sector is making significant advancements in the digitalization of education. HEIs worldwide are incorporating information and communications technology (ICT) solutions into their education systems. While some do so quickly, others need to accelerate their progress (Dneprovskaya et al., 2018; Fernández et al., 2023). HEIs in the Kingdom of Bahrain are adopting digital transformation in education at various paces. With the current ICT infrastructure and the availability of learning management systems (LMSs) (Alaali, 2022), HEIs in the Kingdom are facilitating online instruction and student communication. LMSs are utilized for uploading and downloading course materials and assignments (Alfiras et al., 2020). However, their utilization was not maximized (AlDhaen et al., 2022). Most faculty use original course material and upload it on the LMS without adapting it for a virtual learning environment (Coutts et al., 2020). On the other hand, many HEIs in the Kingdom have now implemented efficient e-learning policies and online assessment guidelines (Education and Training Quality Authority, 2024) and initiated multiple programs to embrace digital transformation.

Unfortunately, the subject of smart education lacks significant academic research in the Arab region, particularly in the Kingdom of Bahrain, and there are no mechanisms in place to monitor the development of HEIs in this regard. At the international level, UNESCO created a Smart School Indicator System in 2022 that emphasizes innovative teaching and learning methods, digital learning environments, and progressive governance and policymaking learning environments. In addition, China has launched a smart education development index in 2023. Therefore, it is crucial to prioritize the development of an index that aligns with the educational system and requirements in the Kingdom of Bahrain and other Arab countries. This research will address two primary questions:

1. What are the essential aspects and components of a Smart Education Index (SEI)?
2. Which indicators can be utilized to assess smart education in HEIs?

What measures do HEIs employ to evaluate their environmental performance? This paper introduces a refined SEI for evaluating smart education in HEIs in the Kingdom of Bahrain to address the research questions. The indicators of the SEI were decided based on a thorough analysis of previous studies, which varied in terms of providing explicit indicators or presenting abstract concepts and expectations of smart education. The proposed indicators consist of a group of relevant sub-indicators, all derived from these studies. The paper outlines the methodology employed to develop the index, which entails the participation of experts in the field to assess and validate its suitability.

This study is significant because it is a crucial component of an innovative initiative aimed at supporting and advising HEIs and education policymakers in the Kingdom of Bahrain, as well as in the broader Arab region, in improving and advancing the national education system. This SEI, being the first in the Arab region, will serve as a tool that HEIs can use to assess and track their development and improvements, identify any shortcomings, and facilitate international benchmarking. The research paper comprises several parts, namely the literature review, the methodology employed to construct the index, the description of the index, and the conclusion.

LITERATURE REVIEW

COMPONENTS OF SMART EDUCATION

Smart education is described as the integration of advanced technologies to enhance teaching and learning. Smart education encompasses more than just technology (UNESCO IITE, BNU, & ISTE, 2022a; Zhu, Yu, & Riezebos, 2016). The smart educational environment illustrates the connection among learners, educators, and technology, necessitating that both groups become proficient users of technology. The primary challenges in implementing smart education or measuring the SEI for any educational institution are pedagogical strategies (Díaz-Parra et al., 2022) and the administration of education in a digital context, including the capacity to place learners in real-world situations and offer contextual learning support (Chukwuemeka, 2024). Consequently, SEI was constructed upon the various components of smart education and the parts of frameworks identified in previous research. Table 1 summarizes the components of smart education.

Technology

Technology is the primary driver for smart education. It is necessary to update the education system by incorporating emerging technologies that facilitate the development of innovative teaching and learning methods, ultimately enhancing the effectiveness of learning environments (Demir, 2021; Han & Kim, 2018; UNESCO IITE, BNU, & ISTE, 2022a). This encompasses incorporating mobile technologies, social media platforms, and Open Educational Resources (OERs), among other elements. Such innovative learning environments and methods foster the development of professional skills and competencies, i.e., 21st-century skills (Lyapina et al., 2019) that are essential in today's work environment and considered key factors for success in smart cities (Lee, 2020; Seh et al., 2021; UNESCO IITE, BNU, & ISTE, 2022a; Zhu, Yu, & Riezebos, 2016).

Educational technologies like LMS enhance learning and communication between teachers and students. Additionally, it creates statistical data that can be analyzed to inform decision-making (Díaz-Parra et al., 2022). Learning analytics enables analysis of students' performance, utilization of the LMS, and engagement with learning resources. The goal is to provide a learning experience tailored and individualized to each student's needs and preferences (Singh & Miah, 2020). Big Data facilitates the analysis of all types of data (e.g., financial data), which aids in decision-making and enhances institutions' higher education system (UNESCO IITE, BNU, & ISTE, 2022a). In addition, cloud computing solutions allow learners to access the LMS and all learning resources at any time and at any location (Singh & Miah, 2020).

Table 1. Smart education components from research

Main component	Description by author	Supporting research/framework
Technology	Main enabler for smart education	Demir, 2021; Díaz-Parra et al., 2022; Han & Kim, 2018; Lee, 2020; Lyapina et al., 2019; Seh et al., 2021; Singh & Miah, 2020; UNESCO IITE, BNU, & ISTE, 2022a; Zhu, Yu, & Riezebos, 2016
Smart Learning Environment	A learning environment that encompasses both physical and virtual elements, facilitating a student-centered approach to learning	Budhrani et al., 2018; Demir, 2021; Dong et al., 2020; Han & Kim, 2018; Hwang, 2014; Koper, 2014; Pandey et al., 2022; Seh et al., 2021; UNESCO IITE, BNU, & ISTE, 2022b; Zhu, Yu, & Riezebos, 2016
Smart Teaching and Learning	Innovative pedagogical approaches and methods of instruction	Budhrani et al., 2018; Han & Kim, 2018; Heinemann & Uskov, 2018; Karkazis et al., 2019; Pandey et al., 2022; Reyes et al., 2021; UNESCO IITE, BNU, & ISTE, 2022a; Uskov, 2022; Zhu, Sun, & Riezebos, 2016; Zhu, Yu, & Riezebos, 2016
Smart Assessment	Innovative and technology-supported assessment that is personalized based on learners' performance	(Budhrani et al., 2018; CNAES, 2023; Han & Kim, 2018; Karkazis et al., 2019; Pandey et al., 2022; UNESCO IITE, BNU, & ISTE, 2022a; Zhu, Sun, & Riezebos, 2016; Zhu, Yu, & Riezebos., 2016
Smart Campus	Physical infrastructure, digital learning resources, and support services	Díaz-Parra et al., 2022; Dong et al., 2020; Lyapina et al., 2019; Pandey et al., 2022; Singh & Miah, 2020; UNESCO IITE, BNU, & ISTE, 2022b; Zhang et al., 2020
Smart Learner	An autonomous, collaborative, and efficient user of technology to achieve learning outcomes and improve skills and competencies	Budhrani et al., 2018; Demir, 2021; Pandey et al., 2022; Seh et al., 2021; UNESCO IITE, BNU, & ISTE, 2022a; UNESCO IITE, BNU, & ISTE, 2022b; Zhu, Yu, & Riezebos, 2016
Smart Teacher	Proficient in using technology to implement smart teaching methods, create innovative digital educational materials, cater to diverse learners' requirements, and offer personalized support	Demir, 2021; Díaz-Parra et al., 2022; Heinemann & Uskov, 2018; Pandey et al., 2022; UNESCO IITE, BNU, & ISTE, 2022a; Zhu, Sun, & Riezebos, 2016; Zhu, Yu, & Riezebos, 2016
Smart Education Policy	Guidelines, policies, and standards for managing and directing the development and implementation of smart education while supporting continuous improvement	CNAES, 2023; Díaz-Parra et al., 2022; Indrawati et al., 2018; Seh et al., 2021; UNESCO IITE, HSE University, & BNU, 2022); UNESCO IITE, BNU, & ISTE, 2022b

Smart learning environment

A learning environment, as described in the Glossary of Education Reform (2023), refers to the various physical settings, situations, range of locations, and cultural surroundings in which students acquire knowledge. The incorporation of advanced technologies has improved learning environments, known as "technology-supported learning environments" (Hwang, 2014), by introducing intelligent features and designs to the learning environments that facilitate learning. This combines hardware (physical resources) and software (applications, LMS, online learning resources, etc.). Smart Learning Environments (SLEs) can offer personalized support both on and off campus, considering the preferences, behaviors, and needs of learners (Hwang, 2014; Zhu, Yu, & Riezebos, 2016), including those with disabilities (Pandey et al., 2022). SLEs are defined as physical settings and learning spaces that incorporate digital, context-aware, adaptable, user-friendly tools and devices to enhance learning by facilitating improved and accelerated learning processes (Koper, 2014; UNESCO IITE, BNU, & ISTE, 2022b).

Implementing SLEs in education promotes a student-centered approach, enhancing the flexibility of learning by allowing students to access educational materials at their convenience and from any location. This approach also enables students to learn independently or in groups, fostering effective interaction and collaboration with peers and teachers. According to Zhu, Yu, and Riezebos (2016), this can improve learners' cognitive skills, autonomy, personal intelligence, inventiveness, and problem-solving abilities. SLEs are recognized as one of the components or features of smart education (Budhrani et al., 2018; Pandey et al., 2022; Seh et al., 2021; Zhu, Yu, & Riezebos, 2016).

From another perspective, there is a substantial correlation between SLEs and pedagogy. According to Shoikova et al. (2017), this educational system is characterized as a new wave combining pedagogy and technology to improve the learning process. Hwang (2014) stated that "integrating intelligent tutoring or adaptive learning techniques into context-aware ubiquitous learning is a significant concern in technology-enhanced learning." This combination leads to a more effective learning process and better attainment of learning outcomes (Budhrani et al., 2018). It also fosters the development of smart learners who possess the necessary skills for the 21st century (Budhrani et al., 2018; UNESCO IITE, BNU, & ISTE, 2022a; Zhu, Yu, & Riezebos, 2016) and have the ability to seamlessly integrate into society and work environments as intelligent members of a smart city (Dong et al., 2020).

Smart campus

A smart campus is described as a technology-driven institution (Zhang et al., 2020) and an essential part of a smart education system (Díaz-Parra et al., 2022; Dong et al., 2020; Lyapina et al., 2019; Pandey et al., 2022). Many previous studies have linked a smart campus with a smart city, i.e., "a smaller version of a smart city" where it integrates various digital and physical systems and stakeholders together using specific technologies (Dong et al., 2020; Kwok, 2015; Pandey et al., 2022; Zhang et al., 2020). Those stakeholders include learners, parents, and the institution's academic and administrative staff. From one perspective, Lyapina et al. (2019) classified a smart campus as a component of smart technologies that facilitate the establishment of a "new educational environment for higher education," commonly referred to as smart education. From another perspective, a smart campus is classified as a fundamental component of the infrastructure for smart education. The report, published by UNESCO IITE, BNU, & ISTE (2022b), outlined many international initiatives to implement smart education. A project undertaken by the Ministry of Education of China involved enhancing infrastructure, specifically by redesigning physical and cyber spaces to create smart campuses to facilitate and enhance the learning process. This includes the process of revamping classrooms and laboratories, enhancing internet access, and implementing both physical and cyber security measures.

In their study, Dong et al. (2020) defined a smart campus as an educational environment that incorporates advanced technology to improve educational outcomes and cater to all stakeholders' needs. The researchers proposed a framework for a smart campus, which consists of Infrastructure and Services. The "Infrastructure" encompasses cutting-edge technologies (such as sensing devices, information processing equipment, storage, and wired and wireless communication) and competent personnel who are accountable for the advancement, execution, and maintenance of these technologies. It also encompasses technologies that facilitate learning, such as learning platforms and applications. The "Service" is designed to meet the diverse needs of various stakeholders, including lighting and temperature control, physical and digital security, learning support, accessibility, and psychological services.

The primary technologies facilitating a smart campus are cloud computing, big data, IoT, AI, extended reality, and smart devices (Dong et al., 2020; Pandey et al., 2022). These technologies collectively contribute to creating an innovative and high-quality educational environment. Pandey et al. (2022) highlighted the key technologies that buildings need to install to create smart campuses. These include, but are not limited to, internet connectivity, sensors for digital security, smart boards, mobile devices, and digital door locks. Furthermore, it is imperative that this campus be equipped with suitable advanced facilities and resources to cater to individuals with disabilities, such as people with visual and hearing impairments, as well as behavioral-specific needs (Díaz-Parra et al., 2022).

A smart classroom is considered a component of a smart campus (Heinemann & Uskov, 2018; Singh & Miah, 2020). A smart classroom is a learning environment equipped with technology and supports various activities such as teaching, learning, presenting smart content, automated assessment and evaluation, interaction, and feedback and support. This definition is supported by Saini and Goel (2019), Alfoudari et al. (2021), and UNESCO IITE, COL, & BNU (2022). Smart classrooms have advanced hardware and software, including smart boards, document and HD video cameras, projectors, computer systems, and other similar technologies (Uskov et al., 2017). This facilitates seamless exchange of knowledge, efficient teamwork, effective communication among learners, and the interaction between teachers and learners without any limitations on time or location, enabling remote learning and communication. As the SLEs, which include smart classrooms, encompass both physical and digital learning environments, they are considered integral components of a smart campus for the purposes of this project.

Smart pedagogy

Smart pedagogy refers to enhanced and innovative methods and strategies used in teaching and learning. These are considered smart when emerging technologies back them. Effective teaching methods improve learners' abilities and proficiencies (Daniela, 2019) by facilitating collaborative, adaptable, and reflective learning, where learners are motivated to actively participate and organize their learning process (UNESCO IITE, BNU, & ISTE, 2022b; Zhu, Sun, & Riezebos, 2016). Smart pedagogy is a crucial component of smart education, necessary to accommodate digitally focused learners (Demir, 2021; Heinemann & Uskov, 2018; Pandey et al., 2022; Uskov, 2022; Zhu, Yu, & Riezebos, 2016). Smart education seeks to cultivate proficient graduates who are well-prepared for the challenges of the 21st-century workforce and daily life. However, this objective cannot be accomplished through the conventional method of lecturing, where teachers' knowledge serves as the primary source of information (Pandey et al., 2022). Instead, it should be tailored to accommodate individual learners' diverse needs and abilities. In addition, this approach encourages flexibility and inclusiveness in education, enabling individuals to engage in lifelong learning (Reyes et al., 2021; UNESCO IITE, BNU, & ISTE, 2022a). Game-based learning, interactive e-books, and learning by doing are examples of smart teaching and learning methods (Heinemann & Uskov, 2018; UNESCO IITE, BNU, & ISTE, 2022b; Zhu, Sun, & Riezebos, 2016).

Previous research has identified specific characteristics of smart pedagogy (Budhrani et al., 2018; Karkazis et al., 2019; Pandey et al., 2022; UNESCO IITE, BNU, & ISTE, 2022a; Zhu, Sun, & Riezebos, 2016) that enhance learners' performance and competencies. The following features are included:

- Personalized and adaptive learning involves adjusting the content, activities, and assistance provided depending on the monitoring and analysis of learners' profiles, needs, and performance.
- Collaborative learning involves creating learning communities by engaging in group-based activities. This approach begins with small groups of learners with similar interests and experiences. The goal is to enhance the learning experience by encouraging interaction and collaboration among individuals with diverse interests and backgrounds.
- Problem-based learning involves learners engaging with real challenges, requiring them to employ creativity in discovering, analyzing, and implementing appropriate solutions.
- Inclusive learning encompasses considering and accommodating the skills and requirements of all learners, including those with special needs or disabilities. It also involves facilitating many forms of learning, such as formal, informal, and non-formal.

- Improved assessment and feedback should align with advanced methods of teaching and be tailored to the learners' performance levels. Customized and adapted informative feedback should be adapted to learners' specific needs and performance levels. It can be delivered in various formats, including virtual dashboards (Zhu, Yu, & Riezebos, 2016).

Smart learner

A key component of smart education is the presence of a smart learner, sometimes referred to as the "essence of smart education" (Budhrani et al., 2018; Demir, 2021; Seh et al., 2021; Zhu, Yu, & Riezebos, 2016). The objective of smart education is to enhance learners' competencies and skills to fulfill the requirements of life and work in the 21st century, such as creativity, critical thinking, problem-solving, communication, and leadership (Budhrani et al., 2018; Pandey et al., 2022; Tikhomirov et al., 2015; Zhu, Sun, & Riezebos, 2016). By incorporating inventive teaching and learning methods that involve real-life scenarios, learners will become more actively involved and creative. This will enhance their ability to critically analyze situations and identify quicker and more effective solutions in various contexts (Lee, 2020; Tikhomirov et al., 2015; Zhu, Yu, & Riezebos, 2016). The UNESCO IITE, BNU, & ISTE (2022b) report states that in a smart education setting, learners have the opportunity to enhance their "socio-emotional" skills, including self-management, social awareness, and relationship skills. Learners can acquire socio-emotional skills by consistently interacting, engaging, and communicating with their peers and teachers, regardless of their different backgrounds or cultures. This also enhances their cross-cultural skills (Zhu, Yu, & Riezebos, 2016). In addition, learners develop their "digital citizenship" skills and get a greater understanding of the various ways technology is used while also considering ethical concerns.

Smart learners must possess certain qualities in order to thrive and prosper in an intelligent learning environment. Zhu, Sun, and Riezebos (2016) and Demir (2021) have classified these technologies as autonomous, collaborative, and efficient users of technology.

- Autonomous individuals are self-directed and self-organized. They are driven to focus on their personal requirements and capacities and can independently plan, manage, and customize their own learning. This results in enhanced comprehension and attainment of the desired learning outcomes. This is enhanced and fortified by the ongoing assistance of experienced teachers, informed evaluations, and motivation to foster greater self-reliance.
- Collaborative users involve active participation in a learning environment where learners engage and communicate with their classmates and teachers. When teachers foster a nurturing learning community, it promotes the development of learners' abilities in group work and communication.
- Efficient users of technology. To participate in a smart learning environment, one must become proficient in using ICT tools and applications. This will allow them to maximize the advantages of the flexible learning opportunities provided and attain the needed skills, competencies, and learning outcomes.

Smart teacher

Smart education has transformed the learning process from being teacher-centered to being student-centered. To achieve this, it is necessary to enhance the role of the teacher to align with the new paradigm (UNESCO IITE, BNU, & ISTE, 2022a). The transition involves moving from being an information provider to becoming a facilitator of learning (Pandey et al., 2022), as the conventional practice of lecturing in a classroom is no longer suitable. ICT has enabled the development of adaptable, creative, and interactive teaching and learning methods, along with monitoring and support systems. This necessitates teachers to be proficient in the relevant technologies to be effective users of technology (Demir, 2021; UNESCO IITE, BNU, & ISTE, 2022a; Zhu, Sun, & Riezebos, 2016).

Prior studies have highlighted that a key aspect of smart education is the presence of well-trained human capital (Díaz-Parra et al., 2022) and exceptional teachers (UNESCO IITE, BNU, & ISTE, 2022a), referred to as "smart teachers" (Demir, 2021; Zhu, Yu, & Riezebos, 2016), i.e., those who have technological self-efficacy (Omar & Ismail, 2021). Smart teachers possess the necessary technology expertise and abilities to creatively and effectively create and modify their educational materials, approaches, and assessment methods while addressing the diverse requirements and skill levels of the learners. They should also offer appropriate informative feedback and personalized assistance, including technological support. In a smart learning environment, it is important for teachers to effectively utilize tracking and monitoring systems (Heinemann & Uskov, 2018) and prioritize the security of learning materials and students' records (Pandey et al., 2022).

To foster a collaborative community, it is necessary to promote student engagement and interaction with their peers, including those with disabilities (UNESCO IITE, BNU, & ISTE, 2022a). Smart teachers must also possess creativity (Díaz-Parra et al., 2022) in developing inventive, real-world, problem-based learning experiences. This approach helps students enhance their skills and competencies, become more self-directed, and develop greater awareness and responsibility (UNESCO IITE, BNU, & ISTE, 2022a). Achieving this necessitates the provision of ongoing training on emerging technologies for teachers to effectively provide smart pedagogy and technological support to learners (Demir, 2021; UNESCO IITE, BNU, & ISTE, 2022b; UNESCO IITE, HSE University, & BNU, 2022).

In their study, Zhu, Sun, and Riezebos (2016) define smart teachers as "professional guides" and outline three primary roles these teachers play in a smart learning environment. (1) An instructional designer is responsible for designing and implementing effective instructional models and activities using the latest ICT resources. They also create course content and materials tailored to diverse learners' needs and promote lifelong learning. (2) A facilitator is an individual who leads and gives clear directions on the subject matter while also motivating learners to actively engage, communicate, and work together, thus fostering a collaborative community. (3) A technology support provider is a teacher who should possess proficient technology skills to effectively assist learners with technical issues during their learning journey.

Smart education policy

Governments and HEIs must prioritize establishing rules and regulations to control the digital transformation in education. This is necessary to ensure this process's successful and sustainable implementation and continual improvement (UNESCO IITE, BNU, & ISTE, 2022b). Nevertheless, there is a lack of comprehensive policies and governmental initiatives aimed at promoting smart education. These efforts are currently in their early developing stages and have not been given sufficient attention in research on smart education (Seh et al., 2021; UNESCO IITE, COL, & BNU, 2022). Examples include Singapore, the pioneer in advocating specialized policies through its "Smart Nation" initiative (UNESCO IITE, BNU, & ISTE, 2022b), and Finland, which has established and supported similar efforts (Ministry of Education and Culture, 2023).

Indrawati et al. (2018) and Díaz-Parra et al. (2022) have highlighted that educational policies and regulations are key elements in smart education. These policies could be implemented at both the governmental and institutional levels and should encompass all forms of learning (formal, informal, and non-formal) as well as cater to various types of learners, including those with disabilities. The policies should be all-encompassing, adaptable, and sensitive to various cultural factors, technological progress, and significant ethical and security issues (UNESCO IITE, COL, & BNU, 2022).

The report conducted by UNESCO IITE, BNU, & ISTE (2022b) addressed crucial factors to consider and provided illustrations of globally adopted policies in smart education. These include:

- The identification of the expected outcomes (knowledge, skills, and competencies) of learners was also underscored by Tikhomirov et al. (2015).
- Ensuring the identification, maintenance, and updating of the necessary infrastructure, including human, financial, and ICT resources.

- Establishing the standards for creating and applying advanced and technology-enhanced teaching methods, high-quality digital educational materials, and assessment methods.
- Establishing the criteria for creating, executing, and overseeing smart learning environments.
- Identifying methods for managing and securing data.
- Identifying strategies for conducting research, monitoring progress, and consistently making improvements.

Seh et al. (2021) examined the factors that influence the implementation of smart education. Some of these factors require attention from higher levels of institutional management and alignment with government plans to ensure effective, efficient, and long-lasting implementation. These encompass frameworks or models for implementing smart education, monitoring systems, data management and security, human resources development, criteria for the development of learning content and material, financial matters, managing and maintaining ICT infrastructure, and supportive governmental policies and regulations.

Smart Education Frameworks and Indices

There are existing frameworks and models for smart education. Zhu, Sun, and Riezebos (2016) proposed a framework for smart education that has three primary components: teacher, student, and technology. The teacher prioritizes student-centered, personalized, and collaborative pedagogy, utilizing technology to deliver instruction, feedback, and assistance to students. In a student-centered environment, the role of the teacher shifts from being a knowledge provider to that of a facilitator and moderator. The learner's presence in this framework pertains to the abilities, skills, and behavior for which customized learning environments cater to the learner's individual needs and interests. Technology enhances the educational process by creating opportunities for learners to interact with their peers and teachers, granting access to learning resources at any time and place, and offering tools to analyze learners' actions, leading to a customized learning experience. This framework underwent additional development by the same group of researchers (Zhu, Yu, & Riezebos, 2016). The framework consists of a smart learning environment, which is supported by technology; smart pedagogy, which reflects the teachers' responsibility in designing and implementing advanced teaching and learning methods; and encompasses the smart learner, where both the smart environment and pedagogy assist and support learners in developing their skills and competencies and develop their sense of autonomy.

Guided by the framework introduced by Zhu, Yu, and Riezebos (2016), Demir (2021) also listed the teacher, learner, educational technology, and innovative or enhanced approaches to teaching and learning as the primary components of smart education. The researcher created a framework for smart education that incorporates technological improvements, which, when integrated into teaching and learning methods, improves the educational environment and converts it into a "smart" one. The framework classifies technologies based on their function and impact on the educational process into three categories. These are "essential technologies" that convert traditional classrooms into smart classrooms, such as LMS and virtual classrooms; "enriching technologies" that enhance the effectiveness of the educational process, such as game-based learning and extended reality; and "supportive technologies" that establish the foundation for a smart education system, such as cloud computing and social networks.

Han and Kim (2018) have conducted a study aiming to assess the level of satisfaction among students about the integration of advanced technologies, namely those related to the 4th industrial revolution, in the field of education. This integration aimed to create a smart educational environment, leading to enhanced efficacy and, subsequently, higher levels of satisfaction. The researchers devised a conceptual framework for smart education centered around the development of the abilities of learners through technological developments such as the IoT, multimedia processing, distributed computing and control, communications, and big data. The framework encompasses three key aspects that, as indicated by the researchers, are the main indicators of smart education, specifically:

LMS, personalized learning system, and learning content service. The LMS enables users to access learning resources at any time and from any location, improves communication between teachers and students, and monitors students' progress, among other functions. The students' utilization of the LMS fosters their autonomy and independence. The Learning Content Service utilizes big data and analytics to offer various learning resources tailored to students' individual needs. This, in turn, enhances students' capacity to independently manage the resources they require depending on their own needs.

In 2022, UNESCO IITE, BNU, & ISTE introduced a National Framework for Smart Education, which consists of three primary components: innovative teaching and learning approaches (enhanced pedagogy), digital learning environment, and progressive governance and policymaking (UNESCO IITE, BNU, & ISTE, 2022b). The framework prioritizes teachers, learners, and parents, who are the main stakeholders in the "education ecosystem." Enhanced pedagogy emphasizes the incorporation of diverse teaching and learning approaches, such as student-centered activities, and the utilization of innovative assessment methods facilitated by technology to enhance learners' skills and competencies. Additionally, it highlights the development of a "learner community" by fostering communication with peers. Smart learning environments prioritize the utilization of digital devices and resources to facilitate the educational process, ensuring seamless connectivity for all users and addressing concerns related to security, data privacy, and technology ethics. The governance and policy-making component underlines the importance of creating a distinct vision for smart education and emphasizes the role of technology in influencing the future of education. Governors need to prioritize the development of infrastructure to support advanced ICT requirements and invest in the training and preparation of teachers and education providers to effectively participate in a smart education environment.

The framework also addresses inclusivity and equity and promotes a culture of continual improvement. Subsequently, UNESCO has implemented a Smart School Indicator System (UNESCO IITE, HSE University, & BNU, 2022), which has six indices. The initial index is "the right to education," which evaluates the degree to which the right to education is realized on a national scale, principally through mandatory education. The second index refers to "the infrastructure," which encompasses the technological resources of the school as well as the presence of necessary skills and credentials required for the transition to smart education. The third index, known as "the process index," assesses the progress of teaching and learning methods, educational technologies, professional development of instructors, and data-driven strategies. The fourth index, known as the "national level index," examines the factors and resources that support the implementation of smart education at the national level. This includes assessing the progress made in the education sector, the capacity to invest in necessary school infrastructure, and the influence of national initiatives on smart education. The fifth index is the "school level index," which signifies the school's role in adopting smart education. This involves fostering student autonomy as a vital aspect of personalized learning and improving instructors' ICT knowledge to effectively teach in a smart environment. The sixth index, known as "the teacher index," focuses on the capacity and qualifications of instructors.

China has formulated a "Strategic Action Plan for Education Digitalization," which served as the foundation for establishing its Smart Education Development Index at the national level (CNAES, 2023). The primary objective of this index is to provide an unbiased description of the current development state, assess the development level, identify practical issues, propose solutions, predict future trends, offer guidance for development, and offer substantial support for the high-quality advancement of smart education. The index was developed after a thorough analysis of smart education characteristics. The index encompasses four dimensions, comprising 12 sub-dimensions, which in turn consist of a total of 32 measurement indicators. The first dimension is "environment," which has three sub-dimensions (ICT infrastructure, digital education resources, and cyberlearning space). The second dimension, "teaching and learning," encompasses four sub-dimensions: digital literacy of teachers, utilization of resources, transformation in teaching and learning practices, and transformation in assessments. The third dimension, "governance," encompasses three sub-dimensions related to data accessibility, ICT-based management, and cyber and data security. The fourth dimension is "talent literacy" and includes two sub-dimensions: digital literacy of students and laborer digital skills.

The Transforming Education through Technology Masterplan 2030 of the Ministry of Education Singapore (2024) aims to improve teaching and learning in schools via technology (UNESCO IITE, BNU, & ISTE, 2022b) and emphasizes four major components (Ministry of Education Singapore, 2024). The primary focus is the student, with the objective of cultivating digitally self-empowered future leaders and providing them with 21st-century skills, thereby fostering self-direction, collaboration, and proficient, ethical utilization of technology. Furthermore, equipping students with key digital competencies allows them to provide innovative and creative solutions to global challenges. The second component is the teacher, who must proficiently employ technology to create creative content and assist students in improving their learning experience. Teachers must possess pedagogical proficiency and consistently pursue professional development to be current with technological innovations applicable to teaching, learning, and assessment. The third component is educational institutions, which must be digitally equipped, smart, adaptive, flexible, and responsive to students' requirements. The fourth component is the integration of the entire system via networking, collaborations, and the engagement of all relevant stakeholders.

The examined frameworks and indices encompass SLEs and smart pedagogy. The latter refers to transformative or innovative teaching and learning approaches, including innovative assessment. Both SLEs and smart pedagogy are supported by technology, which serves as a catalyst for their smart implementation. The frameworks also recognize smart learners and smart teachers as the primary stakeholders in smart education. The integration of technological advancements in education has the potential to enhance their intelligence, abilities, and expertise, which is prominently highlighted in Singapore's Masterplan. Additionally, it has the capability of transforming the focus of education from being teacher-centered to being student-centered. Furthermore, the report conducted by UNESCO IITE, BNU, & ISTE (2022b) has identified an additional factor: the governance of smart education. This encompasses the establishment of an appropriate system with necessary policies and regulations, as well as the provision of experienced human resources and adequate ICT infrastructure to ensure the sustainability of smart education. These were emphasized in Singapore's Masterplan and considered as major indicators in the UNESCO smart school indicator system and China's index. However, none of the mentioned frameworks and indices explicitly identified "smart campus" as one of the indicators, which was identified as a major component of smart education, as described earlier in this paper. As the SLEs, which include smart classrooms, encompass both physical and digital learning environments, they are considered integral components of a smart campus for the purposes of this project. That is, smart campuses are considered to be the overarching concept, including SLEs/smart classrooms. Building on the found frameworks, models, concepts, and indices and developing a comprehensive tool to measure smart education dedicated to higher education, i.e., the SEI, all the mentioned components of smart education were proposed as the main indicators of the SEI, namely: Smart Campus, Smart Pedagogy, Smart Learner, Smart Teacher, and Governance of Smart Education. Each of the indicators is described in the following sections.

METHODOLOGY

The development of the smart education composite indicators follows the Organization for Economic Co-Operation and Development (OECD) methodology (OECD, 2008). The first stage is to develop the index model based on the analysis of previous studies and the involvement of subject experts.

The methodology employed to construct the Index consisted of three primary stages (Figure 1). The initial phase involved examining and evaluating prior pertinent research on the concept, components, frameworks, and indices of smart education. The purpose of this is to establish the foundation for the SEI, incorporating the most significant indicators. The review included literature gathered from reputable databases, including Springer and Education Resources Information Centre (ERIC), Google Scholar, and studies conducted by the UNESCO Institute for Information Technologies in Education. In addition, the Education and Training Quality Authority (BQA) (2024) national reports were used to determine the current level of technological integration in HEIs in the Kingdom of Bahrain. Out of the 96 papers that were assessed, 38 of them were found to be directly related to the purpose of this study. The studies covered in this project primarily focused on the characteristics and components of smart education, such as smart campus and smart pedagogy. The main emphasis was on higher education to ensure the project's objectives were met. Only scholarly research written in English and published between 2013 and 2023 was chosen to obtain the most up-to-date information on the subject.

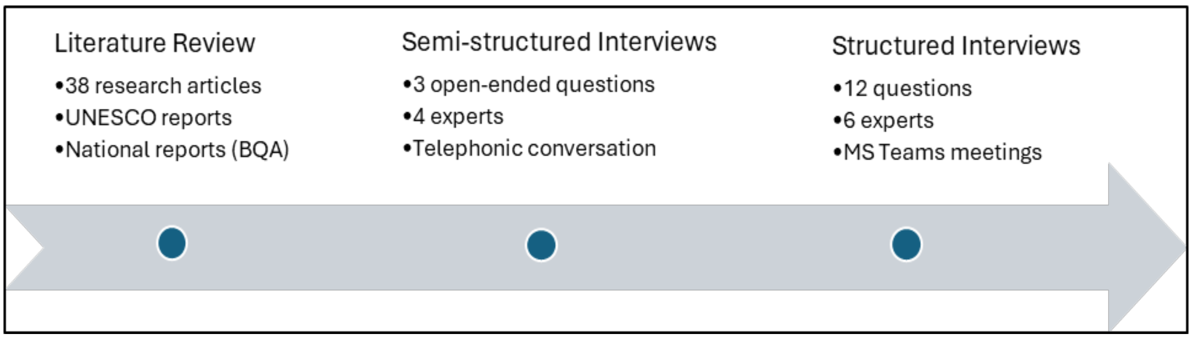

Figure 1. Methodology for developing the SEI

The second phase involved employing a qualitative methodology, specifically semi-structured interviews. This consisted of three open-ended generic questions. Semi-structured interviews are appropriate for collecting subjective opinions and detailed descriptions related to a certain subject (Cropley, 2021). Therefore, it was selected for this phase to obtain descriptive responses from educational experts located in the Kingdom of Bahrain. The aim was to gather their opinions on the current state of HEIs in the Kingdom regarding their efforts to implement smart education. The experts were also asked to identify potential indicators that could be used to measure the adoption of smart education. The questions also sought to elicit the experts' perspective on the need for an index to assess smart education, which would be utilized by HEIs in the Kingdom. The semi-structured interviews were conducted through telephone conversations with four educational experts (Table 2), who are primarily academics and possess substantial competence in quality assurance and the latest developments in higher education.

Table 2. Experience and position of experts participated in semi-structured interviews

Expert #	Specialization and current position	Years of experience	Sector
Expert 1	Education, educational technology, and quality of higher education. Associate Professor of Humanities, Director of Center for Teaching and Learning Excellence	33	Private
Expert 2	Digital communication, electrical and satellite engineering, audit of information systems, and higher education accreditation. Senior Academic Licenses Specialist	24 years (including 18 years in academia)	Public

Expert #	Specialization and current position	Years of experience	Sector
Expert 3	Director – higher education reviews, quality and higher education expert. Assistant Professor – Economics and Finance	26 years (including 18 years in academia)	Public
Expert 4	Director of Quality Assurance and Accreditation Center. Associate Professor in Sustainable Urbanism	14	Public

The third phase included the construction of the index, which involved identifying several indicators and sub-indicators derived from literature and semi-structured interviews, followed by determining the measuring items for each sub-indicator. After that, a set of 12 questions was devised to assess the relevance and appropriateness of the indicators, sub-indicators, and measurement items in the context of smart education. The questions were administered in a structured interview format and were responded to by a group of 6 experts (Table 3). At this stage, the structured interview method was utilized because it is the most suitable approach for obtaining accurate responses on a particular issue (Cropley, 2021), which in this case is attaining consensus on the structure and measurement items of the index. These experts have specialized knowledge in areas such as higher education excellence, strategic planning for higher education, and quality assurance. Additionally, experts were requested to include additional measurement items for each sub-indicator based on their expertise, if required. The third phase was the most important for evaluating the appropriateness of the index and ensuring its validity, comprehensiveness, and fitness for purpose.

Table 3. Experience and position of experts participated in structured interviews

Expert #	Specialization and current position	Years of experience	Sector
Expert 1	Education, educational technology, and quality of higher education. Associate Professor of Humanities, Director of Center for Teaching and Learning Excellence	33	Private
Expert 2	Inclusive education and special educational needs. Assistant Professor.	13	Public
Expert 3	Associate Professor of Management Studies. Executive Director for Strategy, Quality and Sustainability	15	Private
Expert 4	Nursing, education development, quality assurance of higher education. Director of Allied Health Sciences	17	Public
Expert 5	Information technology, interactive systems, cybersecurity, innovation, academic leadership, quality of higher education. Director of Unit for Teaching Excellence and Leadership	23	Public
Expert 6	Electrical engineering, quality assurance, teaching excellence, and leadership. Assistant Professor (electrical engineering), Associate of Advance HE	26	Public (retired)

RESULTS AND DISCUSSION

This section presents the outcomes of the semi-structured interviews carried out with the four experts before developing the SEI Model. Table 4 displays the responses of the experts to the three open-ended questions.

Table 4. Experts' responses to the open-ended questions (semi-structured interview)

Question	Answer	Experts			
		1	2	3	4
Q1: From your experience, do HEIs in the Kingdom of Bahrain implement smart education?	HEIs adopt smart education but in variation.	✓	✓	✓	✓
	Depending on the nature of the programs offered, HEIs may use advanced teaching and learning techniques, such as interactive learning, simulation, and advanced technologies.	✓		✓	✓
	Varying "individual" attempts to utilize the LMS features, which are usually limited to posting information, course content, posting announcements, etc.	✓	✓	✓	
	Some HEIs, to some extent, are improving their policies and procedures to regulate the use of technology in their educational processes efficiently.		✓	✓	
Q2: What could be the indicators to measure smart education in HEIs?	High-quality digital tools and platforms.	✓	✓	✓	✓
	Highly qualified ICT staff.	✓	✓	✓	✓
	Interactive learning through interactive tools and collaborative platforms.	✓	✓		✓
	Teacher competencies (digital literacy, pedagogical skills, and ability to create dynamic learning environments).	✓	✓	✓	
	Cyber resilience.		✓		✓
	Accessibility and inclusivity (equal access to quality education).	✓	✓		
	Effective policies and procedures for smart education.	✓	✓		
	Data-driven decision-making (utilizing data analytics).	✓	✓		
	Personalized learning paths (tailoring content, pace, and assessments based on students' needs).	✓			
Q3: Do you think that having an index to measure smart education is beneficial to HEIs? Why?	An index will offer a standardized instrument for HEIs to facilitate and encourage smart education.	✓	✓	✓	
	It would greatly assist HEIs in self-evaluation and enhancing their performance in delivering smart education.	✓	✓	✓	
	It would greatly assist in monitoring technological advancements in education and being up-to-date in responding to ongoing changes in the current digital era.	✓	✓	✓	✓
	It would promote sustainability in HEI operations.	✓		✓	✓

All four experts have unanimously affirmed the necessity of having an index, citing the advantages it would bring to the HEIs in the Kingdom. They commended the unique concept of the index. For instance, expert 1 indicated that the idea of the index is innovative and effectively encompasses the technological aspect, particularly in the context of the current digital era. When asked about the benefit of such an index, the experts highlighted that an index would serve as an incentive for HEIs in the

Kingdom to evaluate their current condition, identify any shortcomings, and accordingly pursue solutions for ongoing enhancements. Experts 1, 3, and 4 believe that an index is a great initiative, especially with the recent emphasis on promoting sustainability in different aspects. All four experts agreed that HEIs are currently adopting smart education, but in variation, where some HEIs are more advanced in their implementation than others. This is supported by the Education and Training Quality Authority (2024). The reports state that HEIs in the Kingdom have effective ICT policies, some implement hybrid learning, have effective LMSs, and regularly organize workshops to enhance their teachers' ICT skills. They added that it depends on the capacity of the HEI and the nature of the programs. For example, there is a considerable level of interactive learning, mainly using visual simulations and technology integration using digital devices and machinery in medical science and engineering programs, but not in other programs, such as humanities and social sciences. Experts 2 and 3 stated that HEIs are making efforts to adopt technological advancements, to some extent, with their LMSs serving as the fundamental tool to facilitate teaching, learning, and assessment. Additionally, they agreed that there are varying "individual" attempts to utilize the LMS features; however, this is usually limited to posting information, course contents, posting announcements, etc., which does not really constitute interactive learning of the type expected in smart education. In addition, experts 2 and 3 stated that HEIs are constantly improving their policies and procedures to efficiently regulate the use of technology in their educational processes. These efforts showcase their dedication to utilizing digital platforms and improving the overall educational experience for students. Therefore, the existence of such an Index will offer a standardized instrument to facilitate and encourage smart education, which was supported by the UNESCO IITE, BNU, & ISTE (2022b) report to ensure inclusive and quality education. Additionally, it will help detect any deficiencies and advocate for the implementation of additional initiatives.

Experts also listed several indicators that could be used to measure smart education in HEIs. They agreed that having high-quality ICT devices and learning resources, highly qualified ICT staff, innovative, digital, and interactive content, as well as teachers' ICT pedagogical skills are among the most important indicators.

THE PROPOSED COMPOSITE INDEX (THE SEI MODEL)

Based on literature and semi-structured interviews, the composite index is developed. A composite index is capable of quantifying multi-dimensional subjects that cannot be sufficiently represented by a single indicator (OECD, 2008). Smart education is an emerging and inclusive concept that is multifaceted and cannot be directly measured. It encompasses a wide range of concepts, aspects, and variables that could be measured qualitatively and/or quantitatively. When assessing indicators on a regular basis, they can show the direction of change over time and across different units. Thus, they can be used in benchmarking or performance monitoring, as well as in establishing policy priorities and decision-making based on generated results. When combining individual indicators into a single index using an underlying model, a composite indicator is created. Therefore, using a composite index that comprises several indicators is the most appropriate approach to measure smart education's different dimensions.

The model for the SEI (Figure 2) was developed after analyzing past research on components of smart education and relevant theoretical frameworks. The development of the model followed a sequential approach, considering the insights gained from the analysis. The model is constructed according to the following hierarchy: index, indicators, and sub-indicators. The model includes five main indicators and 12 sub-indicators, encompassing 67 measurement items. Tables 5 to 9 show that the sub-indicators encompass a range of elements derived from literature, author identification, and expert input, which are subsequently converted into "measurement items." The identification of the five main indicators of the SEI is based on the smart education components outlined in the literature. Following that, relevant sub-indicators were determined. Titles of the sub-indicators were self-identified based on the relevant group of items highlighted in previous research. Due to the absence of comparable studies and indices, the validation of the proposed set of indicators and sub-indicators for the SEI relied on input from subject matter experts during the structured interviews.

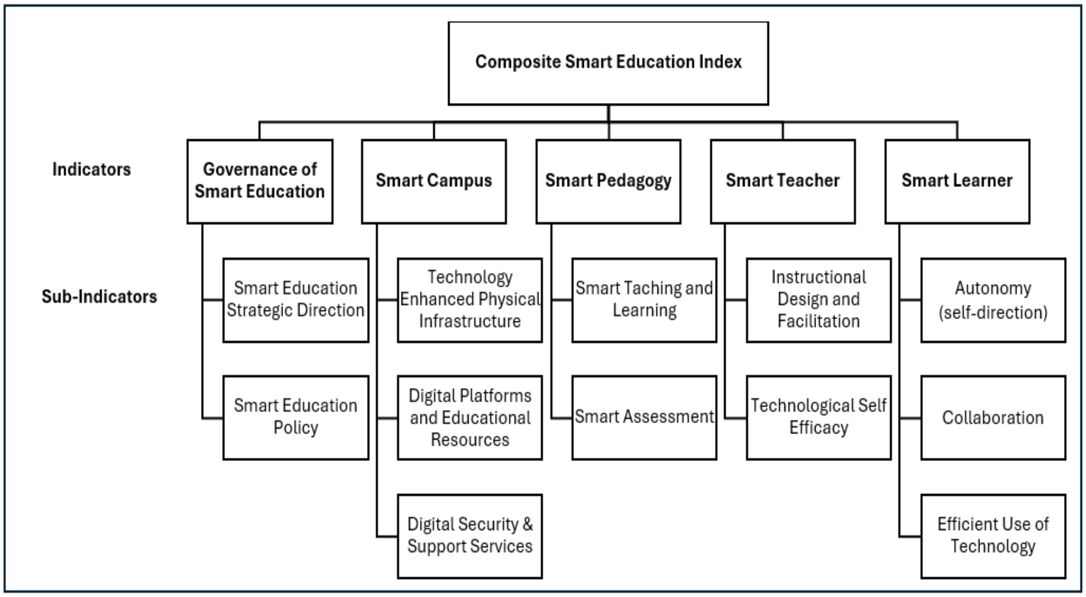

Figure 2. SEI model (hierarchy)

Describing the SEI

The main indicators of the index were decided and guided by the smart education components identified in the literature. These are Smart Campus, Smart Pedagogy, Smart Learner, Smart Teacher, and Governance of Smart Education. The model was then proposed, including relevant sub-indicators for each indicator, which were then given to experts to validate. This section provides a detailed explanation of the indicators, sub-indicators, and the specific items used to measure them. These measurement items can gather either quantitative or qualitative data, such as numbers, percentages, ratios, or rating scales, to assess the current state of the HEI.

Additionally, the section presents the results of structured interviews conducted to evaluate the suitability of the proposed measurement items for each of the 12 sub-indicators. The tables below present the final set of measurement items, which have been approved by six experts. The experts have also rated each item in terms of its importance and contribution to both the specific sub-indicator and smart education in general. Ratings range from 1 (least important) to 5 (most important). The tables display the average rating for each item under each sub-indicator.

Findings of the Structured Interviews

Overall confirmation of the appropriateness of the SEI Structure. Experts have verified that the proposed index is comprehensive since it covers all the essential elements of smart education. Moreover, all six experts have affirmed that the indicators and their sub-indicators are appropriate for evaluating smart education in HEIs in the Kingdom of Bahrain. They are considered valid and fit for their intended purpose, and no further indicators or sub-indicators should be included at this stage. However, some experts have proposed additional measurement items to enhance the comprehensiveness of the evaluation for each sub-indicator. This is explained in the following sections.

Indicator 1: Smart Campus. This indicator will be assessed using three sub-indicators, as shown in Table 5. The objective is to assess the degree to which HEIs possess the appropriate physical and digital infrastructure, technical support, and security measures necessary for the implementation of smart education (Ghanem & Al-Ammary, 2024). In terms of suitability, all six experts confirmed the suitability of the measurement items proposed for the three sub-indicators of Smart Campus. They also confirmed the appropriateness of the measurement units. In terms of rating the items for their importance and contribution to the smart campus indicator, all six experts rated most of the items either important or highly important, resulting in an average of 4.5, 4.6, and 4.7 per sub-indicator, respectively. Additionally, experts 3, 5, and 6 highlighted the importance of implementing cybersecurity measures and organizing capacity-building workshops by HEIs in a constantly evolving digital world. Hence, they recommended adding item 3.3 and enhancing item 3.6 to cover cybersecurity as part of sub-indicator 3.

Table 5. Smart campus sub-indicators and measures (items description adapted from Ghanem & Al-Ammary, 2024)

Item description	Source	Measurement item	Unit
Sub-indicator (1) technology-enhanced physical infrastructure			**Average rating: 4.5**
Updated digital devices, including handheld and internet-enabled devices for students and teachers	(CNAES, 2023; Dong et al., 2020; Heinemann & Uskov, 2018; Pandey et al., 2022; UNESCO IITE, HSE University, & BNU, 2022)	1.1. Number of updated, fit-for-purpose computers and digital devices available to students	Number
		1.2. Number of updated, fit-for-purpose computers and digital devices available to faculty	Number
Laboratories equipped with smart instruments that use AI and IoT technologies	(Dong et al., 2020)	1.3. Number of cutting-edge laboratories (e.g., AI-equipped, innovative labs, augmented reality)	Number
Smart and digital boards, various types of speakers and microphones, and fixed projectors with big screens to display main activities in actual classrooms for seamless process to remote/online students	(CNAES, 2023; Díaz-Parra et al., 2022; Heinemann & Uskov, 2018; Pandey et al., 2022)	1.4. Percentage of classrooms with multimedia devices (e.g., smart boards, projectors)	Percentage
Internet coverage on campus	(CNAES, 2023; Dong et al., 2020; Heinemann & Uskov, 2018; Indrawati et al., 2018; Pompei et al., 2018; UNESCO IITE, HSE University, & BNU, 2022; Zhu, Sun, & Riezebos, 2016)	1.5. Percentage of fixed broadband connection coverage on campus	Percentage
		1.6. Percentage of mobile broadband (Wi Fi) connection coverage on campus	Percentage
Smart devices to support students with disabilities	(Heinemann & Uskov, 2018; Pandey et al., 2022)	1.7. Availability/usage of technological facilities to support students with special needs (e.g., auto doors, smart devices, etc.)	Rating scale

Item description	Source	Measurement item	Unit
Sub-indicator (2) digital platforms and learning resources			**Average rating: 4.6**
Active digital platforms, including LMS, MIS, SIS, etc., and digital learning applications with advanced features fostering student-centered learning	(CNAES, 2023; Pandey et al., 2022; UNESCO IITE, COL, & BNU, 2022; UNESCO IITE, HSE University, & BNU, 2022; Zhu, Sun, & Riezebos, 2016)	1.8. Overall utilization (%) of Learning Management System (Moodle, Blackboard, … per institution	Percentage
High-quality digital learning content and OERs with verified content for teaching and learning	(CNAES, 2023; Daniela, 2019; Heinemann & Uskov, 2018; Hwang, 2014; UNESCO IITE, COL, & BNU, 2022; UNESCO IITE, HSE University, & BNU, 2022; Zhu, Sun, & Riezebos, 2016)	1.9. Percentage of traditional/face-to-face courses using digital content per program (such as videos, games, smartbooks, simulation, etc.)	Percentage
		1.10. Percentage of courses using Open Educational Resources per program	Percentage
Virtual classroom(s)	(Díaz-Parra et al., 2022; Indrawati et al., 2018)	1.11. Utilization (%) of virtual classrooms (synchronous learning) per institution	Percentage
Active digital libraries covering all programs' specializations	(Pompei et al., 2018; UNESCO IITE, COL, & BNU, 2022; UNESCO IITE, HSE University, & BNU, 2022; Zhu, Sun, & Riezebos, 2016)	1.12. Utilization (%) of digital library covering all program specializations (e-journals, e-books, e-catalogs, etc.)	Percentage
The platform performs learning analytics and pursues predictive analytics based on learning preferences and behavior	(Heinemann & Uskov, 2018; Hwang, 2014; Indrawati et al., 2018; Zhu, Sun, & Riezebos, 2016)	1.13. Utilization of learning analytics (students' performance tracking) feature (% per institution)	Percentage
Software systems/ applications to support students with disabilities	(Heinemann & Uskov, 2018; Pandey et al., 2022)	1.14. Availability of software systems/ applications to support students with special needs (disabled students), such as: color-coded notes, voice recognition software, text-to-speech software, word prediction software, graphic organizers)	Rating scale

Item description	Source	Measurement item	Unit
Sub-indicator (2) digital platforms and learning resources			Average rating: 4.7
Physical security systems, such as automatic door locks, surveillance cameras	(Díaz-Parra et al., 2022; Dong et al., 2020; Pandey et al., 2022; UNESCO IITE, BNU, & ISTE, 2022b)	1.15. Coverage rate of physical security measures, such as automatic door locks, surveillance cameras, etc. (from the total campus area)	Percentage
Digital security systems, such as smart cards, Radio Frequency Identification (RFID), sensors for data protection	(Díaz-Parra et al., 2022; Dong et al., 2020; Heinemann & Uskov, 2018; Pandey et al., 2022; UNESCO IITE, BNU, & ISTE, 2022b)	1.16. Utilization (%) of digital security measures (e.g., RFID, smart card, passwords) on campus	Percentage
	Identified by experts	1.17. Utilization (%) of cybersecurity measures for data protection	Percentage
Online support services for students	(CNAES, 2023)	1.18. Utilization (%) of online educational and support services (e.g., troubleshooting, advising, counseling, loans, chatbots, support requests, etc.)	Percentage
Technical support for teachers and students	(Díaz-Parra et al., 2022; Indrawati et al., 2018; UNESCO IITE, BNU, & ISTE, 2022b; UNESCO IITE, HSE University, & BNU, 2022)	1.19. Specialized technical staff (technicians) per institution (technicians to laboratories ratio)	Ratio
Enhancing the skills and knowledge of staff and students in digital literacy	Self-identified	3.1 Number of workshops/trainings conducted by the HEI to its staff on advanced digital tools used in education and cybersecurity measures over the last year	Number
	Self-identified	3.2 Number of workshops /trainings by the HEI for learners on how to use different available learning and administrative platforms available in the HEI (e.g., newly introduced tools/software, etc.) over the last year	Number

Indicator 2: Smart Pedagogy. This indicator seeks to assess the level of implementation of smart pedagogy in HEIs using two sub-indicators (Table 6), namely smart teaching and learning and smart assessment.

Table 6. Smart pedagogy sub-indicators and measures (items description adapted from Ghanem & Al-Ammary, 2024)

Item description	Source	Measurement item	Unit
Sub-indicator (4) smart teaching and learning			**Average rating: 4.6**
Digital pedagogical practices, including online and/or hybrid learning that are accessible by all learners, including those with disabilities	(CNAES, 2023; Dong et al., 2020; Pandey et al., 2022; UNESCO IITE, BNU, & ISTE, 2022b; UNESCO IITE, COL, & BNU, 2022; UNESCO IITE, HSE University, & BNU, 2022)	4.1 Percentage of programs implementing hybrid modes of teaching and learning in the institution	Percentage
		4.2 Percentage of online delivery per course	Percentage
Collaborative learning (group-based learning), design-based learning (integrating design thinking principles, investigation, prototyping, and evaluation into the educational experience to enhance students' creativity and innovation), and project-based learning with real-world cases requiring practical and evidence-based solutions	(CNAES, 2023; Dong et al., 2020; Pandey et al., 2022; UNESCO IITE, BNU, & ISTE, 2022b; UNESCO IITE, COL, & BNU, 2022; Zhu, Sun, & Riezebos., 2016)	4.3 Percentage of courses implementing various teaching and learning approaches (such as collaborative/ group-based learning, design-based learning, and problem-based learning with real-world cases)	Percentage
Inclusion of innovative and interactive learning activities	(Dong et al., 2020; Heinemann & Uskov, 2018; Pandey et al., 2022; Uskov, 2022)	4.4 Percentage of courses designed with smart learning activities (such as game-based learning and hands-on demonstration) per program	Percentage
Sub-indicator (5) smart assessment			**Average rating: 4.8**
Online assessment that is accessible by all learners, including those with disabilities	(CNAES, 2023; Dong et al., 2020; Pandey et al., 2022; UNESCO IITE, BNU, & ISTE, 2022b; UNESCO IITE, COL, & BNU, 2022)	5.1 Percentage of digitalized online assessment per program (e.g., AI-based assessment, ICT-based formative assessment, etc.)	Percentage
Various assessment methods to measure different skills and competencies, such as competency-based assessment, digital portfolios, peer feedback, and multimedia presentations	(UNESCO IITE, BNU, & ISTE, 2022b; UNESCO IITE, HSE University, & BNU, 2022; Uskov, 2022; Zhu, Sun, & Riezebos, 2016)	5.2 Percentage of courses incorporating a variety of assessment methods used to measure different skills and competencies, such as competency-based assessment, digital portfolios, peer feedback, and multimedia presentations per program	Percentage

Item description	Source	Measurement item	Unit
Automated evaluation of assessment	(Saini & Goel, 2019)	5.3 Percentage of courses using automated evaluation system (automatic marking)	Percentage
Digital platforms to provide online access to grades and feedback on assessment	Identified by experts	5.4 Percentage of programs providing students with online access to their grades and clear and timely feedback on their assessments	Percentage
Digital controlling and online examination and invigilation systems	Identified by experts	5.5 Utilization (%) of digital controlling and management of online examination and invigilation	Percentage

All six experts confirmed the suitability of the measurement items proposed for the two sub-indicators of Smart Pedagogy. In terms of rating the items for their importance and contribution to the smart pedagogy indicator, all six experts rated most of the items either important or highly important, resulting in an average of 4.6 and 4.8 per sub-indicator, respectively. Experts 1, 2, and 5 rated item 4.3 highly important, although they emphasized that the inclusion of various teaching and learning methods depends on the nature of the program. For example, they said that theoretical programs may not necessitate a design-based learning methodology. However, having the item generally articulated, with examples provided, allows the HEI to reply in a way that is most appropriate for its needs.

For the Smart Assessment sub-indicator, experts recommend adding items 5.4 and 5.5. Experts 1, 3, 4, and 5 emphasized the significance of including a new item related to online access to assessment grades and feedback. They further clarified that providing this feature through the LMS/digital platform supports flexibility and indicates smartness. Another recommendation was made by experts 4, 5, and 6 regarding the systems to manage online examinations and detect cheating. The two added items were confirmed by the other experts and rated as highly significant.

Indicator 3: Smart Learner. This indicator aims to measure to what extent learners in HEIs are autonomous, collaborative, and master ICT skills (Demir, 2021; Zhu, Sun, & Riezebos, 2016), hence, are considered smart learners, using three sub-indicators, as shown in Table 7.

Table 7. Smart learner sub-indicators and measures (items description adapted from Ghanem & Al-Ammary, 2024)

Item description	Source	Measurement item	Unit
Sub-indicator (6) autonomy (self-direction)			**Average rating: 5**
Learners' ability to evaluate their own capabilities and needs, independently plan, manage, and customize their own learning, and develop self-awareness, self-management, and motivation competencies	(Budhrani et al., 2018; International Society for Technology in Education (ISTE), n.d.; Tikhomirov et al., 2015; UNESCO IITE, COL, & BNU, 2022; Zhu, Sun, & Riezebos, 2016) *Measurement Items 6.1 and 6.3 are Self-identified, and Item 6.2 is identified by Experts*	6.1 Percentage of programs with learning outcomes on autonomy (PILOs) (such as independent planning, independent learning, and self-management) per program	Percentage
		6.2 Percentage of attainment of learning outcomes related to autonomy (such as independent planning, independent learning, self-management) per program	Percentage
		6.3 Percentage of independent learning activities per program	Percentage

Item description	Source	Measurement item	Unit
Sub-indicator (7) cooperation			**Average rating: 4.8**
Learners' ability to engage and participate in a learning community, develop relationships with learners from various backgrounds and cultures, and use collaborative technologies and learning platforms to interact, participate, and work with colleagues in group activities and assignments through collaborative learning environments	(Demir, 2021; ISTE, n.d.; Pandey et al., 2022; UNESCO IITE, COL, & BNU, 2022; Zhu, Sun, & Riezebos, 2016) *Measurement Item 7.2 is identified by Experts, while other items are Self-identified*	7.1 Percentage of programs with learning outcomes on collaboration, interaction, and teamwork (PILOs) from total number of programs	Percentage
		7.2 Percentage of attainment of collaboration and teamwork learning outcomes per program	Percentage
		7.3 Percentage of learner utilization of the functions enabled by the different digital platforms (e.g., LMS, MS Teams, Zoom, etc.) for communication and interaction with teachers and colleagues	Percentage
		7.4 Percentage of group-based activities and assessment per program enabled through the digital platforms	Percentage
Sub-indicator (8) efficient use of technology			**Average rating: 4.7**
Learners' ability to use all functions of the LMS and learn how to use new technologies to acquire and transfer knowledge in an ethical manner	(CNAES, 2023; ISTE, n.d.; UNESCO IITE, COL, & BNU, 2022; Zhu, Sun, & Riezebos, 2016) *All Measurement Items are Self-identified*	8.1 Learner utilization (%) (per year) of the HEI platform (LMS) to conduct different activities (i.e., upload and download material, class attendance, assignment submission, plagiarism check, etc.)	Percentage
		8.2 Learner utilization (%) (per year) of the HEI platform (SIS) for course registration, advising requests, transcript requests, course withdrawal, appeal, etc.	Percentage
		8.3 Learner utilization *(%)* of digital tools (such as chatbots, Chat GPT, etc.) in an ethical manner as part of informal learning	Percentage

Due to the absence of specific measuring tools for a smart learner, the measurement items for the Smart Learner indicator were determined based on self-identification, led by the features of the smart learner component found in the research and frameworks analyzed. All six experts unanimously agreed that the inclusion of relevant program learning outcomes and learning activities that promote the growth of learners' autonomy and collaboration is suitable as measurement items. Experts 1, 3, and 5 highlighted that when learners attain these learning outcomes to a high degree, it ensures that they acquire the necessary qualities of autonomy and collaboration and, hence, are considered smart learners. Therefore, they recommended adding items 6.2 and 7.2. The items regarding the utilization of HEI digital platforms/applications in various learning operations were also highly supported by experts, as they were deemed appropriate for evaluating the learners' effective use of technology. All six experts confirmed the suitability of the measurement items proposed for the three sub-indicators of Smart Learner. Experts rated the items as highly important in terms of their importance and contribution to smart education, resulting in an average of 5, 4.8, and 4.7 for each sub-indicator, respectively.

Indicator 4: Smart Teacher. This indicator aims to measure to what extent teachers in HEIs can utilize relevant advanced technologies to creatively create interactive learning content and personalize learning paths and instructions to suit learners' different capabilities through two sub-indicators (Table 8).

Table 8. Smart teacher sub-indicators and measures (items description adapted from Ghanem & Al-Ammary, 2024)

Item description	Source	Measurement item	Unit
Sub-indicator (9) instructional design and facilitation			**Average rating: 5**
Teachers' ability to develop and apply flexible and innovative teaching and learning methods and new instructional models that engage learners, create student-centered and collaborative learning environments, and facilitate the learning process by promoting interactions and providing direct instructions	(Demir, 2021; Dong et al., 2020; ISTE, n.d.; UNESCO IITE, BNU, & ISTE, 2022a; Zhu, Sun, & Riezebos, 2016) *Both Measurement Items are identified by experts*	9.1 Percentage of faculty who pursued professional development opportunities to remain updated with innovative pedagogies and the latest technologies during the last year	Percentage
		9.2 Percentage of faculty using a variety of teaching methodologies in their courses (such as traditional lecturing, interactive teaching & learning methods, etc.) per program	Percentage
Develop personalized learning paths that cater to individual variations	(CNAES, 2023; Dong et al., 2020; ISTE, n.d.; Pandey et al., 2022; UNESCO IITE, BNU, & ISTE, 2022b; UNESCO IITE, COL, & BNU, 2022; UNESCO IITE, HSE University, & BNU, 2022; Zhu, Sun, & Riezebos., 2016)	9.3 Percentage of teachers providing personalized learning paths, including differentiated activities, content, and support based on student's progress (per program)	Percentage
Sub-indicator (10) technological self-efficacy			**Average rating: 4.7**
Teachers' ability to conduct online and/or hybrid learning	(CNAES, 2023; Dong et al., 2020; Pandey et al., 2022; UNESCO IITE, BNU, & ISTE, 2022b; UNESCO IITE, COL, & BNU, 2022; UNESCO IITE, HSE University, & BNU, 2022)	10.1 Percentage of teachers who are qualified/skilled to design, develop, and implement digital education (per college)	Percentage
	Self-identified	10.2 Percentage of teachers effectively utilizing the LMS for online teaching, assessment, and feedback (per college)	Percentage

Item description	Source	Measurement item	Unit
Creatively design and develop interactive learning content and material	(UNESCO IITE, COL, & BNU, 2022; Zhu, Sun, & Riezebos, 2016)	10.3 Percentage of teachers creating interactive material and content (per college)	Percentage
Design and implement a variety of online formative and summative assessments	(ISTE, n.d.)	10.4 Percentage of teachers designing and constructing online assessments (per college)	Percentage
Monitor ethical use of technology and provide technological support and guidance to learners	(ISTE, n.d.; Zhu, Sun, & Riezebos, 2016)	10.5 Teachers' utilization (%) of technology (LMS/ applications) to provide support to students (per college)	Percentage
		10.6 Teachers' utilization (%) of academic misconduct tools to monitor ethical use of technology (per college)	Percentage

The Instructional Design and Facilitation sub-indicator was originally designed with one measurement item (9.3). Then, during the Structured-Interviews, the experts recommended adding both measurement items 9.1 and 9.2. They explained that since the Smart Teacher indicator mainly aims to measure the teachers' ability to cope with teaching in the digital era, they need them to continuously update their knowledge and skills in digital pedagogies. This will enable them to apply a variety of teaching and learning methods, including interactive and innovative learning. Additionally, out of 6 experts, 5 evaluated item 9.3 as highly important because personalized learning, which focuses on the learners' needs, is a key objective of smart education. For the Technological Sefl-Efficacy sub-indicator, all six experts confirmed the suitability of the measurement items proposed. Experts rated the items of the Smart Teacher indicator as highly important in terms of their importance and contribution to smart education, resulting in an average of 5 and 4.7, respectively, for each sub-indicator.

Indicator 5: Governance of Smart Education. This indicator aims to measure to what extent HEIs have the appropriate base of rules, regulations, policies, and strategies to govern the development and implementation of smart education and ensure continuous improvement through two sub-indicators (Table 9).

Table 9. Governance of smart education sub-indicators and measures (items description adapted from Ghanem & Al-Ammary, 2024)

Item description	Source	Measurement item	Unit
Sub-indicator (11) smart education strategic direction			**Average rating: 4.9**
Vision and mission promote smart education, and mission covers sustainable use of technology in education	(UNESCO IITE, BNU, & ISTE, 2022b)	11.1 The institution promotes smart education through its vision	Rating scale
		11.2 The institution promotes smart education through its mission by covering the sustainable use of technology in education	
HEI has a framework for smart education, and there are plans and standards allowing learner-centric and personalized education	(UNESCO IITE, HSE University, & BNU, 2022)	11.3 There are plans, standards, and monitoring of the implementation of learner-centric and personalized education	

Item description	Source	Measurement item	Unit
Educational governance can be enhanced through the utilization of AI and big data analytics, which provide valuable insights for decision-making	(CNAES, 2023; UNESCO IITE, BNU, & ISTE, 2022b)	11.4 Educational governance is supported by artificial intelligence and data analytics for decision-making	
	Identified by experts	11.5 There is technological leadership in the HEI supporting smart education	
HEI has dedicated financial resources for smart education	Identified by experts	11.6 There is a financial budget linked to the strategy allocated to support smart education	
Sub-indicator (12) smart education policy			**Average rating: 4.9**
Designing and managing smart pedagogies and assessment systems	(UNESCO IITE, COL, & BNU, 2022)	12.1 There is a policy on designing and managing smart pedagogies and assessment systems with the support of advanced ICT	Rating scale
Creating high-quality digital material and curricula	(UNESCO IITE, BNU, & ISTE, 2022b)	12.2 The institution established criteria for creating high-quality digital education and curricula	
Digitalization of education using cloud computing, augmented and virtual reality, and IoT	(Heinemann & Uskov, 2018; Indrawati et al., 2018; UNESCO IITE, BNU, & ISTE, 2022b)	12.3 The institution's education system covers the digitalization of education (such as using cloud computing, augmented and virtual reality technology, and IoT)	
Managing the educational platforms and OERs	(UNESCO IITE, COL, & BNU, 2022)	12.4 There is a policy to manage the educational platforms and open educational resources used by the institution	
Providing, maintaining, and updating the necessary facilities, devices, and ICT infrastructure to ensure sustainable implementation and continuous improvement	(CNAES, 2023; UNESCO IITE, BNU, & ISTE, 2022b)	12.5 The institution's policy ensures providing, maintaining, and updating the necessary facilities, devices, and ICT infrastructure to ensure sustainable implementation and continuous improvement	
Developing the required qualified human resources with the proper digital skills and competencies	(UNESCO IITE, BNU, & ISTE, 2022b; UNESCO IITE, HSE University, & BNU, 2022)	12.6 The institution's policy ensures the development of the required qualified human resources with the proper digital skills and competencies	
Identifying digital competencies for academic staff, including digital pedagogy	(UNESCO IITE, BNU, & ISTE, 2022b)	12.7 The institution identifies digital competencies for academic staff and ensures that they are prepared for teaching in the digital age, including digital pedagogy	
Codes of ethics in the digital environment	(UNESCO IITE, HSE University, & BNU, 2022)	12.8 There are codes of ethics in the digital environment at the institutional level	
A mechanism for privacy and security of records in	(CNAES, 2023; Pandey et al., 2022; UNESCO IITE,	12.9 There is a mechanism for producing and keeping privacy and security of records in the educational	

Item description	Source	Measurement item	Unit
the digital learning environment	HSE University, & BNU, 2022)	digital environment at the institutional level	
Tools for tracking attendance and learning progress to facilitate decision-making and personalized learning	(Hwang, 2014; Koper, 2014; Pandey et al., 2022; UNESCO IITE, COL, & BNU, 2022)	12.10 There is a smart tracking and monitoring system (to track students' attendance, monitor students' performance, record assessment records, etc.)	
Interoperability (the exchange of data through seamless, secure, and controlled protocols and shared standards)	(Indrawati et al., 2018; UNESCO IITE, BNU, & ISTE, 2022b)	12.11 The institution's different systems are connected and integrated, which allows for data exchange through seamless, secure, and controlled protocols and shared standards	
Conducting data analytics (qualitative data, educational results, surveys, platform logs) for continuous improvement	(CNAES, 2023; UNESCO IITE, HSE University, & BNU, 2022)	12.12 The institution has a mechanism for using and analyzing data "data analytics" (qualitative data, educational results, records, surveys, platform logs, etc.) for continuous improvement	

Most of the chosen items to measure the fifth Indicator, "Governance of Smart Education," are sourced from the governance base outlined in the UNESCO Reports as a prerequisite for designing and implementing effective governance and policy initiatives for smart education (UNESCO IITE, BNU, & ISTE, 2022b UNESCO IITE, COL, & BNU, 2022, UNESCO IITE, HSE University, & BNU, 2022). While the UNESCO Reports did not specifically label these as indicators to measure smart education, they were suggested as measuring items in this project to emphasize, promote, and facilitate the criteria for the HEIs in the Kingdom of Bahrain. Experts 1 and 3 stressed the need for supportive leadership that is knowledgeable about current technology and trends in education, which resulted in the addition of item 11.5. Additionally, experts 3 and 4 recommended adding item 11.6 to ensure that the HEI has a dedicated financial budget allocated for the development and implementation of smart education. All six experts confirmed the suitability of the items. They also agreed that using the "rating scale" method to measure the extent to which an HEI covers smart education in its strategy is appropriate since the availability of such policies/criteria cannot be measured quantitively. All items were rated as important and highly important in terms of their significance and contribution to the governance indicator, resulting in an average of 4.9 for both sub-indicators.

CONCLUSION

Higher education must undergo digital transformation to keep up with the ongoing technological progress. Educational experts in the Kingdom of Bahrain have stated that HEIs are implementing digital transformation and facilitating smart education. However, the rate of adoption varies depending on the institutions' capabilities. Furthermore, there is a lack of mechanisms to effectively monitor their development and advancement. Moreover, the indices recently introduced by UNESCO and China are not explicitly tailored for higher education and may not be congruent with the educational frameworks and requirements of Arab countries. Consequently, it was necessary to create a comprehensive index that would serve as a tool for assessing the current state of smart education at HEIs and provide guidance for future developments. This is corroborated by experts throughout the semi-structured interviews, who praised the idea of establishing a unique national index for HEIs in the Kingdom of Bahrain, which is the first in the Arab Region. The proposed index has the potential to significantly elevate the Bahraini higher education system. It aligns with the government's Digital Transformation Strategy. However, since there are currently no mechanisms or tools in place for monitoring and facilitating digitalization and the implementation of smart education locally or regionally, this index is a significant initiative. Utilizing the established index, a standardized index throughout the countries of the Gulf Cooperation Council (GCC) can be constructed to guarantee uniformity and to ensure that higher education is continually advanced and elevated throughout the GCC. In terms of quality assurance of higher education, the identified set of indicators and their sub-indicators can be integrated into the quality assurance standards to advance higher education in collaboration with the BQA locally and the Arab Network for Quality Assurance in Higher Education regionally.

This article discusses the development of a composite index to assess the level of smart education at HEIs in the Kingdom of Bahrain. The development of a composite index is crucial as it enables the consolidation of a substantial volume of data into a comprehensible format, facilitating the comparison and evaluation of performance and advancement of HEIs for future enhancements. The SEI consists of 5 primary indicators and 12 associated sub-indicators, which collectively cover 67 measurement items. The purpose of the SEI is to evaluate the degree to which HEIs possess suitable infrastructure, planning, and implementation processes for smart education, thereby enhancing their ability to withstand challenges and maintain a sustainable future. The indicators encompass the fundamental elements of smart education, including smart campus, smart pedagogy, smart learners, smart teachers, and governance. SEI was created using the OECD methodology for composite indicators, resulting in a well-developed model that has been evaluated by subject matter experts by adopting structured interviews. This work is a component of an extensive pioneering initiative aimed at providing assistance and guidance to HEIs and education policymakers in order to advance and improve the national education system. The established SEI is adaptable and may be customized for use in different countries, enabling accurate assessment of the current condition of their HEIs regarding smart education.

The next phase of the project involves implementing the index in several HEIs in the Kingdom of Bahrain, normalizing the data, and assigning weights to the indicators. Although implementation remains a planned initiative and is contingent upon approval from local educational regulators, the last phase of piloting the SEI in choosing HEIs in the Kingdom of Bahrain may assist in assessing the costs and training required for SEI implementation. Assessing the financial requirements for implementing SEI is a challenging task. It requires consideration of multiple variables, including technological infrastructure, the creation of digital tools, and professional development for educators. The costs related to the implementation of SEI include hardware, software expenses for platform development, the efficacy of digital learning tools, maintenance, and content creation. This might be streamlined by a prospective participant in government funding to enhance and sustain this program in the Kingdom of Bahrain.

The analysis of prior studies on smart education revealed significant gaps in various domains, presenting opportunities for further research. Numerous countries worldwide have initiated digital transformation efforts; hence, performing a comparative analysis will facilitate the identification of the positive and negative aspects of these projects, as well as highlight gaps and potential areas for improvement. Another research field is to assess the impact of such initiatives on the education sector. Exploring how smart education may assist students with disabilities and promote inclusivity, together with the impact of such support concerning the SDGs, constitutes another important study topic.

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