Smart Education System

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The requirement to develop a smart education system is critical in the era of ubiquitous technology. In the smart education environment, intelligent pedagogies are constructed to take advantage of technological devices and foster learners' competencies which undoubtedly assist learners in dealing with knowledge and handling issues in a dynamic society more effectively and productively.

collaborative learning e-mentoring smart education smart learning environment smart learners smart pedagogies

1. Introduction

Technology has had a positive impact on most aspects of society, including education and learning [1][2]. The technological transformation of education has not only had an impact on learning materials and classroom boundaries, but it also offers learners various opportunities to acquire a range of skills and knowledge by connecting to a wide professional learning network [2][3]. Educators and learners are no longer limited by learning borders due to advances in technology, which has made online learning and hybrid learning possible, giving learners greater flexibility, a wide selection of courses, accessibility, and cost-effective options [4]. Online and hybrid learning also open the door to learning communities around the world, where learners can build a network and develop an international mindset [4].

In particular, in the era of the fourth industrial revolution, known as Industry 4.0, the development of digitalisation and the increasingly convergent boundaries between humans and machines are expected to produce a qualified and highly educated workforce [5][6]. Learners are required to acquire holistic competencies, including technical and non-technical skills that cannot be attained by learning from books and lectures alone [5]. Hence, designing a smart education system is of critical importance to offer learners the opportunity to choose the learning pathway that is the most effective for them.

The smart education paradigm is one of the most effective and promising directions for educational development. The purpose of smart education is to cultivate a smart learner generation by immersing learners in intelligent pedagogies facilitated by smart environments with the support of technological advances [7]. There are three key factors contributing to a complete smart education system: smart learners, smart pedagogies, and smart environments. Smart learners not only possess sustainable hard skills, but also need to achieve the necessary soft skills, both in terms of personal skills (complex problem-solving, critical thinking, creativity, out-of-the-box thinking,

emotional intelligence, and cognitive flexibility), and social skills (communication, teamwork, negotiation, and leadership skills) [8]. A smart environment and smart pedagogy support smart learners on their learning pathways. A smart environment is shaped by both software and hardware technological support, digital resources, and the contribution of smart pedagogies that are designed based on a learner-centric paradigm to shape learners who have different backgrounds, levels, and interests to enhance their necessary knowledge skills [7]. Consequently, two major pedagogical strategies, collaborative learning and e-mentoring, are designed to improve learners' knowledge, experience, and skills by not only encouraging them to actively communicate and exchange valuable learning resources but also helping them connect with professional communities.

Collaborative learning encourages learners to develop their capabilities by exchanging knowledge and experience with peers [9]. The paradigm provides learners with the opportunity to build a group themselves with common goals or to search for an existing group which has the same goals as the learner [10]. They engage in the learning process using a joint workspace where they can share resources, learn new concepts, and discuss and deal with uncertain theories and construct ideas together, especially in the case of learners in disparate locations [9]. Moreover, collaborative learning applications enable them to learn in both synchronous and asynchronous ways using a range of multimedia and devices [11]. Since collaboration takes place between learners with different backgrounds and characteristics and diverse fields of specialisation, learners can acquire new knowledge and cultivate advanced skills, such as intensive judgment and negotiation skills, wise emotional intelligence, and effective communication skills, contributing to building a stronger learning community [7].

Another effective learning strategy is to study with mentors who are experts in their field, with unique experiences and skills. E-mentoring takes place between mentors and mentees who desire to achieve mutual growth [12]. This approach consists of a matching mentor–mentee stage and learning process with flexible curriculums. By connecting with professional communities, learners are able to search for suitable mentors who can guide them, develop ideas, build knowledge, and encourage and assist them in their learning development [13]. Mentors with valuable experience, knowledge and skills can develop suitable programs and activities that can be flexibly adjusted as the learners progress. Hence, learners gradually acquire competencies to deal with complex problem-solving and decision-making.

In a smart education environment, both collaborative learning and e-mentoring are supported by technological advances that are breaking the barriers of learning space and time. A more immersive environment has been created with various dynamic media: virtual classrooms, a huge number of digital resources, and flexible tools and systems have been employed to improve collaboration.

2. Smart Education

To adapt to the changes and the requirements of the workforce in a digital and intelligent society, the key factors in the success of the new learner generation are classified into two categories: hard skills (analytical skills and research skills) and soft skills (critical thinking, problem-solving, decision-making, creativity, emotional intelligence, communication skills, teamwork skills, negotiation skills, ability to transfer knowledge, and leadership skills) [8].

Progressively, smart educational systems need to focus on creative, innovative, and communicative activities rather than routine activities with monitoring duties, which evolve and consider many promising trends, including opportunities to learn at diverse times and places, personalised learning based on students' capabilities, the use of technological advances and resources, the use of experiential and collaborative learning, student involvement in curriculum design, and increased mentoring approaches [14]. Zhu and He [7] proposed a research model in smart education with three essential elements: (1) smart learners; (2) smart environments; and (3) smart pedagogies (**Figure 1**), in which smart environments play a vital role in influencing smart pedagogies, and smart pedagogies are one of the key factors contributing to smart environments. The skills and knowledge enhancement of smart learners are supported by smart pedagogies and smart environments.

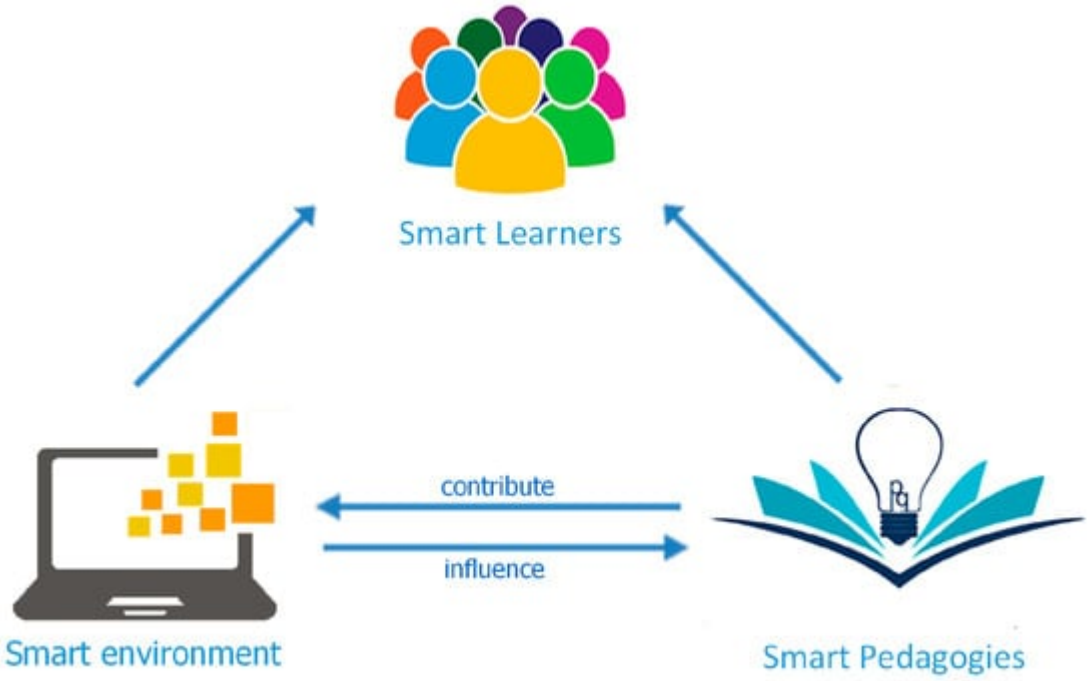

Figure 1. Smart education.

2.1. Smart Learners

Learners in a smart learning environment are demanded to learn smarter to acquire competencies to adapt to a modern and dynamic society. They are required to actively look for the knowledge and learning approaches that are appropriate for them [15] and build their own knowledge and skills by interacting with their peers, instructors, technological advancements, and learning resources [16]. Achieving success in a smart learning environment is difficult and depends heavily on learners' academic characteristics, such as collaboration, self-motivation, persistency, curiosity, and risk-taking, as well as the skills of time management, effective reading, creativity and innovation, and learning through co-operation [17]. Hence, to meet the needs of the smart education system, learners must master the following four skills [7]:

(1) Basic knowledge and core skills, which provide a foundation for skill development and setting future goals, and this is instrumental in the process of understanding concepts [18].

(2) Comprehension such as critical thinking and problem solving.

(3) Personalised expertise which challenges learners to think and suggest new ideas in studying and working to contribute to innovation.

(4) Collective intelligence refers to the abilities of a group of individuals to share and gather their knowledge and skills to perform tasks or deal with problems. This collective intelligence can be constructed by accumulating, arranging, and refining individual learning content followed by communication and collaboration between the learners [19].

2.2. Smart Pedagogies

Pedagogy is defined as a science that is constantly evolving and looking for a better way to teach and engage learners in the process of knowledge building. SMART stands for Self-Monitoring Analysis and Reporting Technology. In the contemporary society, wherein technology is integrated into education, smart refers to smart devices [20]. Zhu et al. [7] argue that, if the goal of the educational process is learners, then, for smart pedagogies, which focus on smart learners, technology is a supporting factor influencing the learning environment. A dynamic and intelligent society requires the future workforce to possess holistic competencies, such as strong logical thinking and decision-making, judgment and negotiation skills, organisational leadership and management qualities, and interpersonal and high-level communication skills, which are fostered by practice and problem-based learning approaches. Learners should be experienced in applying effective learning strategies, namely, having the ability to actively use theoretical knowledge in practice, engage in open discussion, understand problems from different perspectives, and learn from more experienced people; moreover, within interdisciplinary groups, with teamwork and practice, develop the soft skills needed for cooperation and communication in solving common tasks. Furthermore, each individual learner with a different background, education level, and interest deserves suitable and flexible curriculums which ignite their passion and promote their understanding [21]. Hence, learning collaboratively and mentoring are the two most important learning strategies that provide opportunities for learners to broaden their views and gain comprehensive knowledge.

2.2.1. Collaborative Learning

In a smart learning environment, facilitators are required to design their teaching strategies flexibly, enhance the quality of the teaching content, and evaluate the impact of the learning process on students' outcomes [22] to motivate learners to study actively. Therefore, collaborative learning has become one of the most effective pedagogical approaches in the design of a smart learning environment. Knowledge acquired from lectures is a key fundamental of core knowledge and the basic skills required for learners in their learning pathway. However, in higher education, to develop core knowledge, enhance advanced comprehension abilities, and, especially, engage in flexible problem-solving, learners need to step out of their comfort zones by actively exchanging knowledge and skills and studying with their peers.

As shown in **Figure 2**, collaborative learning is an educational strategy where learners are encouraged to study and work in a group to perform tasks together and achieve common goals. Karin et al. [9] stated that this kind of study provides an opportunity for learners to develop both cognitive skills, such as analytical skills, research skills, critical thinking, problem-solving, and decision-making, and pro-social behaviour, like understanding, communicating, negotiating, helping, sharing, and cooperating. Moreover, learners who study in a group achieve a significantly better understanding in comparison with those who study individually. In the group learning context, learners engage in high-quality social interaction, such as discussing contradictory information, explaining and questioning one another critically, recognizing misconceptions, and strengthening the connections between new information and previously learned knowledge. Additionally, it is an advisable strategy that helps facilitators recognize a poor-performing student and help them find a solution to improve their learning performance and engagement.

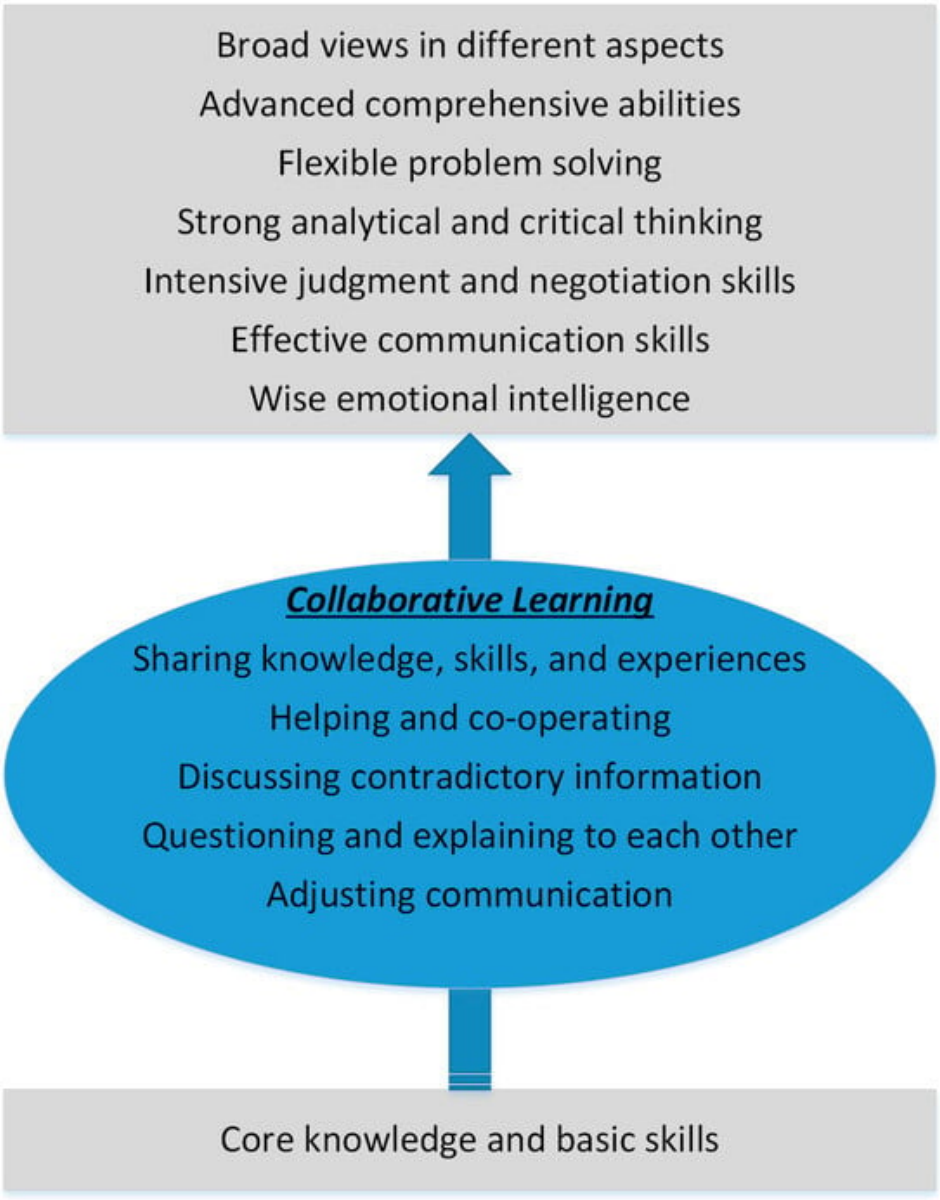

Figure 2. Collaborative learning enhances knowledge and skills.

2.2.2. E-Mentoring

Mentoring is mostly conceptualised as a learning process where the experienced mentor provides guidance, instruction, encouragement, role modelling, and emotional support to a younger person [23]. Mentoring is also defined as a collaborative learning and mutually beneficial relationship where both mentors and mentees foster their personal and professional development by engaging in professional activities [12]. In higher education, the role of mentors is critical because they direct mentees on the path to success, enhance their academic achievements, reduce their stress, and inspire them to engage in a cycle of learning [3]. There are many types of mentoring relationships, such as traditional mentoring, peer mentoring, group mentoring, reserve mentoring, and situation mentoring, which depend on many factors, such as the purpose and goal of learning, the organisation's circumstances, willingness, availability, and appropriateness according to the individual's situations, as well as the length of the learning time [24]. The key factor to success in an e-mentoring program is the establishment of a strong personal relationship based on trust, self-motivation, flexibility, communication skills, and technological skills. Two important elements need to be considered: (1) matching appropriate mentors and mentees [25] and (2) building a strong relationship between mentors and mentees [26].

E-mentoring is a process where a virtual platform is used to facilitate mentoring relationships. Participants not only engage in synchronous and asynchronous online dialogue through various aspects of the course but can also be introduced to social and professional networks, providing a valuable opportunity to connect to a pool of mentors and mentees [26]. However, Colky and Young [27] suggested that understanding the mentoring process established in a traditional learning environment is necessary for effective mentoring in a virtual environment. There are four phases to a mentoring relationship: (1) initiation, which involves identifying and matching mentors-mentees; (2) training, where the success of a mentoring program is dependent on the training given to both the mentors and mentees and aims to familiarise all the partners with the techniques and the overall goals of the mentoring program; (3) monitoring, to assess if the mentoring process is working well or if there is a need for retraining; (4) evaluation, which involves evaluating the mentoring results and obtaining recommendations to improve the first three steps [28].

2.3. Smart Learning Environment

Huang et al. [29] pointed out that the objective of a smart learning environment is to promote easy learning, engaged learning, and effective learning. Consequently, it is necessary to design a smart learning environment technically and pedagogically. It should be expanded in space, time, technology, interaction, and control [8] to facilitate and engage learners to experience a seamless learning process and perform tasks in an easy and natural way. Technology covers both hardware and software. Hardware includes tangible technological devices such as IQ boards, projection screens, interactive LCD/LED touchscreens using cloud computing, ubiquitous computing, IoT technology, and smart audio–visual systems. Software includes learning tools, online resources, new supporting applications using virtual reality technology, and learning analytics. From a pedagogical perspective, a learning environment is implemented to assist facilitators in designing and conducting lessons and learning activities

effectively and supports learners to enhance their knowledge and skills with the additional flexibility and diversity of the learning practice [6].

Many researchers have found that a smart learning environment has considerably changed the way learners and facilitators interact with each other, enabling collaboration in a flexible environment [10][30][31][32]. Learning processes are maintained from building groups to monitoring students' progress and adjusting curriculums accordingly to suit the student's needs. A smart learning environment supports learners to form the right group by finding suitable partners in a wide range of learning communities. Learners receive opportunities to experience virtual learning environments where they can study both asynchronously and synchronously, have access to shared repositories with diverse valuable resources, and join in common learning workspaces. The learning progress is monitored and evaluated to identify the strengths and weaknesses of the learners and the curriculum for improvement (as shown in **Figure 3**).

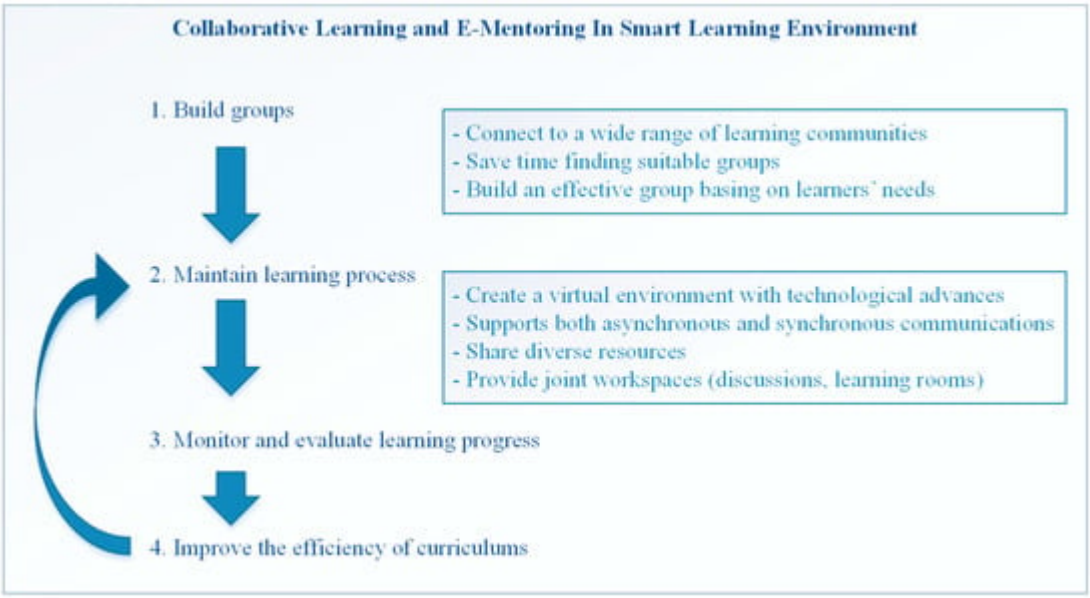

Figure 3. Collaborative learning and e-mentoring in a smart learning environment.

Smart education is becoming a promising trend to ensure the development of a new generation of the smart workforce who need to be equipped with valuable competencies, involving sustainable knowledge and flexible skills. Smart pedagogies are designed to focus more on learners, influencing a learning environment that is supported by technology and intelligent devices to be flexible, diverse, and smart [7]. As a result, two learning approaches, collaborative learning and e-mentoring, are considered as effective learning strategies for learners to adapt to future requirements. To further explain the theory, the next section proposed a model to show how collaborative learning and e-mentoring help learners reach their goals effectively in a smart education environment.

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