ESSENTIAL SKILLS AND STRATEGIES IN HIGHER EDUCATION FOR THE FOURTH INDUSTRIAL REVOLUTION: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

The Fourth Industrial Revolution necessitates relevant initiatives to stay abreast. Higher education plays a pivotal role in providing nuanced opportunities for the future workforce and enabling students to address real-world problems in a complex world. Despite new developments, it is not clear how the Fourth Industrial Revolution will influence the educational sector. We followed a systematic review approach with the aim of providing a comprehensive view on crucial strategies and skills for the Fourth Industrial Revolution. We applied the processes of Evidence for Policy and Practice Information and Co-ordinating Centre as a guideline for conducting the systematic review and retrieved relevant articles published from 2017 to 2021. The results highlight that critical thinking is the most emphasised skill and student-centred teaching-learning strategies are essential for the Fourth Industrial Revolution and future demands. Implications for self-directed learning were also outlined.

Keywords: Fourth Industrial Revolution, higher-education, self-directed learning, skill development, teaching and learning strategies

INTRODUCTION

Numerous developments has led to the Fourth Industrial Revolution (4IR) as distinctive and comprehensive in terms of its impact on all facets of life. Klaus Schwab (2016, 3), chief executive of the World Economic Forum (WEF), argues that the 4IR is characterised by new technologies that will have an impact on humanity related to "velocity" (living in an interconnected world that is continuously evolving), "breadth and depth" (associated with the integration of technologies) and "systems impact" (directs and transforms organisations, systems and industries). The 4IR comprises various innovations such as cloud technology,

artificial intelligence (AI), robotics and genetics, big data and quantum computing (Azli et al. 2019; Schwab 2016). It is however not clear how the 4IR will influence higher education.

As a result of technological developments for the 4IR there has been "a tremendous demand for continuous, lifelong development ... integrating work and learning more tightly with each other" (WEF 2019, 18). Higher education (HE) plays a pivotal role in providing crucial and relevant learning opportunities for the future and it must be contextualised in terms of the requirements for the 4IR (Waghid 2019). It is therefore expected of HE to invest in relevant teaching and learning methods towards the acquisition of essential skills for the future workforce (Adhikari 2020; Kupe 2019). Development of such skills may provide opportunities for students to address real-world problems in a complex world. As a result, there is an urgent need for re-skilling since the skills possessed by students are not necessarily appropriate for the future (Chauke 2018; Kamaruzaman et al. 2019). Re-skilling firstly refers to the ability to equip university students with the appropriate skills for future demands and secondly it involves substituting outdated skills to meet the changing needs of the market (Education, Training and Development Practices Sector Education and Training Authority [ETDP SETA] 2020). Re-skilling can also be regarded as the process of developing relevant abilities that will enable university students to be competitive for the future job market (Kamaruzaman et al. 2019).

Essential skills for the successful operation in the 4IR involve digital literacy, communication and group skills, critical and analytical thinking, collaborative problem-solving and innovative skills among others (Chaka 2018; Onyilo et al. 2020). On this note, the WEF (2019, 18) emphasise the "importance of learning, intellectual curiosity, and taking responsibility for one's own learning journey". Scholars also accentuate the development of self-directed learning (SDL) abilities to be crucial for the 4IR (Briede and Popova 2020; Penprase 2018). Self-directed learners are passionate about their own learning, they drive their learning processes with clear objectives in mind, make decisions about relevant learning strategies, are curious about particular topics, select appropriate resources, direct their own learning and consequently determine whether the outcomes are achieved (Knowles 1975; Humaira and Hurriyah 2017). Although many studies have been done on self-directed learning, these are relatively limited regarding skills development for the 4IR (Geng, Law, and Niu 2019; Gleason 2018; Penprase 2018). In an attempt to fill the research gap, the objective was to conduct a systematic review on skill development for the 4IR based on the following questions:

1. What are the required skills to be developed for learning in the 4IR?
2. What teaching-learning strategies are used to develop SDL skills for the 4IR?

THEORETICAL FRAMEWORK

The theoretical aspects are outlined in this section.

Fourth Industrial Revolution

To understand the 4IR, it must be informed by the previous three industrial revolutions, as each is characterised by significant developments. The 4IR involved mechanisation and the use of steam power. Electric power was used in the Second Industrial Revolution while the Third Industrial Revolution constitutes digital and information systems, and computer developments (Chung and Kim 2016). However, the 4IR is not an aggregate of the past industrial revolutions or certain developments, but rather requires an entirely different view of a connected and complex society with multiple facets and unknown challenges that will revolutionise the future. Schwab (2016) argues that the 4IR is characterised by new technologies that will impact on all facets of humankind (Schwab 2016). Scholars emphasise developments such as cloud technology, AI, machine learning and robot applications as essential for the 4IR (Ayandibu et al. 2021; Azli et al. 2019; Schulze 2019; Schwab 2016). Technological developments influence all aspects of our daily lives, for example, communicating with others by using smart watches, integrating systems with higher efficiency and increasing productivity that have an impact on how people work and live (Marwala 2020). One example of such a development that has a major impact on the world and HE is ChatGPT, developed by OpenAI and released at the end of 2022 (Sun and Hoelscher 2023). It is based on a neural network and generates text that on the one hand has an overwhelming impact on ethics, academic integrity and professionalism and on the other hand can also provide for new opportunities in the world of work.

With regard to personal and people skills, the 4IR is associated with abilities such as curiosity, decision making, cognitive flexibility, emotional intelligence, team coordination and negotiation abilities (Okebiorun 2020; WEF 2017b; WEF 2019). Tsiligiris and Bowyer (2021) also refer to the importance of ethical skills, business skills and soft skills to be considered essential for the future. Although Schwab (2016) outlined details on the 4IR, it is not clear what the 4IR entails regarding skill development in HE.

Skill development in higher education for the 4IR

As the 4IR involves rapid change to all sectors and the society (Schwab 2016), it is important to emphasise the acquisition of skills to prepare students for the future world of work. In their report on Commonwealth of Learning, Ally and Wark (2020) emphasise that although industry shifted to the 4IR, the majority of education environments/institutions continue to adopt Education 2.0 instead of Education 4.0. Consequently, HE faces the risk of having being “left

behind" (Fomunyam 2020, 27) if no substantive commitment is given to the challenges of the 4IR to prepare students for real-time knowledge, skills and values, and contribute to an integrated society of work. The White Paper of the World Economic Forum refers in particular to "Accelerating Workforce Reskilling for the Fourth Industrial Revolution" (WEF 2017a). Regarding the teaching and learning of students, the WEF highlights the notion of Knowles, namely that:

- students are expected to manage their own learning activities
- the application of experiential learning (active teaching-learning strategies) is essential
- learning must be contextualised by means of a real-word problem and
- learning must be meaningful to be applied to real-life circumstances.

Education 4.0 supports educational enrivonments with the application of relevant technologies, to provide learning opportunities for all and to personalise learning regardless of status (Qi 2020). Moreover, technologies such as AI and learning analytics, shift the process of teaching and learning toward individualisation and student-centred learning (Aker and Pentón Herrera 2020). The 4IR era requires a change in the role of educators by using the effective integration of technologies such as AI (e.g., virtual reality and robotics) in the classroom (Ally 2019; Bryant et al. 2020; WEF 2017b). This demands more emphasis on skill development such as complex problem solving, student collaboration and innovative thinking (Klarner et al. 2018). Lapawi and Husnin (2020) also mention the importance of high-level and computational thinking for the 4IR. Supportive abilities to thrive in the future involve active learning, the use of appropriate learning strategies, leadership, resilience, stress management and emotional intelligence (WEF 2018). In addition, the WEF 2018 report suggests that skills which include manual dexterity, endurance, precision, technology installation and maintenance, for example, will be declined in the future (WEF 2018). Deloitte (2018) distinguishes among four main types of skills for the future namely:

- Workforce readiness skills (e.g. time-management, group interaction, work discipline)
- Soft skills (e.g. collaboration and communication, cultural awareness, interpersonal skills)
- Technical skills (e.g. programming, project management)
- Entrepreneurial skills (build a work opportunity, initiative and innovation, curiosity)

Graduates in HE need to embrace these skills to ensure they meet the demands of the labour

market and industry (Gang et al. 2020). Developing such skills should be part of higher education's mission and vision to provide for effective teaching and learning for future demands. Skill development is crucial with the aim of:

- preparing students and future workers for relevant knowledge, an integerated skill set for the 4IR and appropriate capabilities for a dynamic and continuous changing world of work (Yusuf, Walters, and Sailin 2020; WEF 2019);
- developing integrated, novel and "coss-functional skills" to address complex problems and improve human life and society (Ysuf et al. 2020, 96); and
- being able to work effectively and work with experts to achieve specific goals and contribute to economic development and progress (Gang et al. 2020; Yusuf et al. 2020).

The prominence of relevant skill development in HE is further encapsulated in the vision statement of Stanford Graduate School of Education: "Now is a transformational time in education. We are on the cusp of imminent breakthroughs that will change our ability to improve teaching and learning for all." (Standford Graduate School of Education, No date). The vision is also important to promote skill development in African countries where students do not necessarily have the opportunity to develop such skills. For example, the integration of digital technology and robotics has been considered crucial "tools of transformation" to provide opportunities for rural and urban-based HE institutions to develop essential skills for a challenging society (Yende 2021, 70).

Teaching and learning strategies to enhance skill development for the 4IR

A strategy constitutes activities that impact on and enhance the learning process and as such it can be seen as an essential part of the "personal repertoire" of the student to develop necessary abilities for the future (De Smul et al. 2018, 215). Teaching-learning strategies aim to involve students as responsible contributors to their learning and enable them to make decisions, manage their thinking and reflect independently (De Smul et al. 2018). Several examples of student-centred strategies are problem-based learning, project-oriented learning, cooperative learning, blended learning, service learning and game-based learning (Abdullahi, Jabor, and Akot. 2020; Jordaan, Havenga, and Bunt 2021). Employing teaching-learning strategies allows students to develop learner autonomy and self-directed abilities (Akor et al. 2018; Zainuddin and Perera 2018). For example, problem-based learning requires student engagement in identifying and analysing a problem, gathering relevant resources, developing a suitable

solution, and consequently enhancing self-directed learning skills (Latada and Kassim 2017; Savery 2015). Such strategies allow for the application of knowledge in real-world contexts for the development of skills needed by society (Akor et al. 2018).

It is obvious that the development of 4IR skills cannot be achieved through conventional teaching-learning methods. Based on the skills and strategies emerged from the literature, we compiled an integrated framework to outline the competences for the 4IR in Table 1.

Table 1: Integrated competences for the Fourth Industrial Revolution

Integrated competences	Reference
Learning competences Set clear objectives, learner autonomy and self-directed learning, continuous and lifelong learning, intellectual curiosity, initiative for learning	Akor et al. (2018), Briede and Popova (2020), Deloitte (2018), Kamaruzaman et al. (2019), Penprase (2018), WEF (2019), Zainuddin and Perera (2018),
Cognitive and reflective competences Higher-order thinking, computational and innovative thinking, construction of own knowledge, entrepreneurial skills and business skills. Reflective thinking and metacognitive skills	Aoun (2017), Chiaka (2018), De Smul et al. (2018), Lapawi and Husnin (2020), Onyilo et al. (2020), Penprase (2018), WEF (2019)
Valued human competences Emotional intelligence and mental flexibility, ethical behaviour, leadership, resilience, time management, cultural awareness and agility, work discipline	Aoun (2017), Deloitte (2018), Tsiligiris and Bowyer (2021), WEF (2018),
Cooperative competences Group cooperation and coordination, negotiation and group dynamics, effective communication and interpersonal skills	Deloitte (2018), Schwab (2016)
Technological competences Technological competences and digital literacies, integration of technologies and systems thinking. Application of competences such as AI, 3D printing and cloud computing.	Aker and Pentón Herrera (2020), Aoun (2017), Ayandibu et al. (2021), Azli et al. (2019), Marwala (2020), Schulze (2019), Schwab (2016)
Active strategies to develop essential skills Some examples of student-centred and active learning strategies are problem-based learning, project-oriented learning, cooperative learning, experiential learning, discovery learning, play-based learning and game-based learning	Abdullahi, et al. (2020), Aoun (2017), Jordaan et al. (2021)

The next section outlines the research methodology and processes involved in the systematic literature overview.

RESEARCH METHODOLOGY

This systematic review research design used in this study involves searching for relevant articles with the aim of answering the research questions. According to the Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre 2010), a systematic review uses a comprehensive set of procedures and steps that can be replicated. Specifically, this review followed the EPPI-Centre guidelines since it is based on clear processes to assure quality and credibility. These are summarised as follows (EPPI-Centre 2010):

1. develop the inclusion and exclusion criteria,
2. search the electronic databases for research that meets the study parameters and is aligned

with the inclusion criteria,

3. describe and map the findings in a particular scope,
4. provide for relevance by checking the credibility and appropriateness of studies to address the research questions. (Both researchers contributed by extracting and cross-checking the data),
5. This step, refines and synthesises the findings, where the selected studies were described and analysed,
6. The last step comprises drawing conclusions.

Study selection and protocols followed

A clear standard was set and adopted to form the criteria for inclusion of papers. A Boolean search strategy was applied. The search terms consist of various combinations of keywords as outlined in Table 2. This systematic review was conducted using Google Scholar to retrieve the relevant articles published from 2017 to 2021 and were cross-checked against other databases such as ERIC and Mendeley.

Table 2: Eligibility criteria for this study

Inclusion criteria	Exclusion criteria
Peer review journal articles. Search strategy used in this study Topic must include: #1: (descriptor = (higher education)) #2: (descriptor = (skill(s) development) or (essentials skills)) #3: (descriptor = ((Fourth Industrial Revolution) or (4IR)) #4: (teaching-learning) or (teaching and learning) #5: (descriptor = (self-directed learning) #6: (descriptor = (teaching learning strategies) Search strategy: #1 and #2 and #3 and #4 and #5 and #6	Primary and secondary education Articles which had not mentioned skill development, or development of SDL skills and the 4IR. Studies not originally written in English language. Studies whose full text is not available online. Articles published before 2017

To manage the filtering process, the relevant articles were saved in the researchers' Google Scholar library and were later exported into Excel as a CSV file before proceeding with the analysis. The initial search of databases yielded 7190 articles. After the articles passed additional screening based on the titles, 295 were chosen for further investigation. Thereafter, 98 articles were selected according to relevance and accessibility. This was done by using excel and Publish or Perish software (Harzing 2007). After removing the duplicates and articles that were not in line with research objectives, 62 articles remained and were included in the review. The remaining articles were carefully read and synthesised to answer the research questions. This was crossed checked several times by the researchers to ensure reliability.

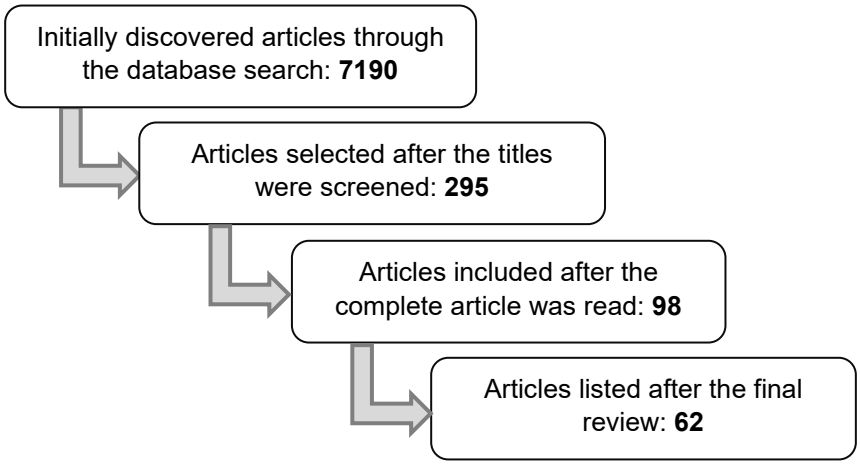

Figure 1: A process flow diagram for selecting articles

Extraction and data analysis

Data were extracted and entered in Table 3 and Table 4. Data gathered from the systematic review process were analysed by section, coding and content review analysis. The following process was followed in order to extract the data from the articles: author information, year, skills, country and method/approach for Table 3 while author, year, strategy, country and method/approach were used for Table 4.

RESULTS AND DISCUSSION

The findings are discussed to address the research questions.

Required skills to be developed for learning in the 4IR

Table 3 shows the required skills as emerged from the systematic literature overview (arranged alphabetically by country, numerically by year and then alphabetically by author).

Table 3: Required skills to be developed for the 4IR

Nr	Author(s)	Year	Skills	Country	Method/approach
1.	Tsiligiris and Bowyer	2021	Ethical and soft skills, digital skills, business skills	Australia	Systematic review
2.	Mitsea et al.	2021	Groupwork and collaboration, decision-making, critical thinking, problem solving, time management	Greece	Theoretical overview
3.	Chitra et al.	2020	Creativity, critical thinking and authentic problem solving	India	Quantitative study
4.	Singh and Tilak	2020	Interpersonal, communication, teamwork skills	India	Mixed method
5.	Sudan	2021	Communication, teamwork, problem solving, critical thinking	India	Qualitative study
6.	Ruminar and Gayatri	2018	Communication, creativity, critical thinking, collaboration	Indonesia	Theoretical overview
7.	Abdurrahman	2019	Creative thinking, critical thinking, problem solving	Indonesia	Quasi-experimental study
8.	Kamaruzaman et al.	2019	Active learning and learning strategies, initiative. Analytical thinking, creativity and innovation	Malaysia	Systematic review

Nr	Author(s)	Year	Skills	Country	Method/approach
9.	Shafie et al.	2019	Communication, collaboration, critical thinking	Malaysia	Quantitative study
10.	Sohimi et al.	2019	Critical thinking, communication, behavioral skills	Malaysia	Qualitative study
11.	Abdullahi et al.	2020	Problem solving, critical thinking, communication	Malaysia	Conceptual overview
12.	Akor et al.	2020	Problem solving, teamwork, creativity, critical thinking	Malaysia	Content analysis
13.	Gang et al.	2020	Critical thinking, communication, collaboration	Malaysia	Quantitative study
14.	Khuraisah et al.	2020	Information literacy, media literacy, ICT literacy	Malaysia	Systematic review
15.	Saari et al.	2021	Teamwork, communication, decision making	Malaysia	Qualitative study
16.	Briede and Popova	2020	Problem solving, critical thinking, time management	Russia	Quantitative study
17.	Oke and Fernandes	2020	Analytical thinking, innovation, active learning strategies, creativity, originality, initiative	Scotland	Exploratory study
18.	Chaka	2018	Creativity, problem solving, empathy, critical thinking, teamwork, leadership	South Africa	Systematic review
19.	Nhede	2018	Novel and adaptive thinking, computational thinking, transdisciplinary	South Africa	Qualitative study
20.	Du Toit-Brits and Blignaut	2019	Creative thinking, critical thinking, problem solving	South Africa	Qualitative study
21.	Karsten et al.	2020	Self-awareness, assertiveness, creativity, problem solving, self-advocacy skills	South Africa	Exploratory study
22.	Mamabolo and Myres	2020	Management skills, social intelligence, complex problem solving, contextual intelligence	South Africa	Qualitative study
23.	Mtshali and Ramaligela	2020	Problem solving, creative, innovative thinking	South Africa	Sequential mixed method
24.	Sutcliffe and Bannister	2020	Creativity, complex problem solving, communication, collaboration, critical thinking	South Africa	Document analysis
25.	Van den Berg	2020	Creativity, originality, critical reasoning, problem solving, analysis skills	South Africa	Exploratory study
26.	Adegbite and Adeosun	2021	Management skills, negotiation, creative thinking	South Africa	Quantitative study
27.	Barac et al.	2021	Analytical, creative, critical thinking, communication	South Africa	Qualitative study
28.	Landsberg	2021	Problem solving, analytical skills, communication skills	South Africa	Qualitative study
29.	Maisiri and Van Dyk	2021	Digital skills, domain skills, soft skills, entrepreneurial skills	South Africa	Qualitative study
30.	Ramraj and Marimuthu	2021	Communication, collaboration, problem solving	South Africa	Quantitative study
31.	Diaz and Halkias	2021	Critical thinking, creativity, communication, analytical skills	Spain	Qualitative study
32.	Penprase	2018	Creativity, collaborative skills	Switzerland	Theoretical overview
33.	World Economic Forum (WEF)	2018	Analytical thinking, innovation, active learning, learning strategies, complex problem solving, critical thinking	Switzerland	–
34.	Ada et al.	2021	Workforce readiness, soft skills, technical skills, entrepreneurship	Turkey	Literature review (Fuzzy ANP)
35.	Reaves	2019	Flexibility, adaptability, observation, empathy, creativity, innovation	USA	Theoretical overview
36.	Webster and Andre	2018	Critical thinking, creativity, communication, collaboration	Vietnam	Reflective and participative approach (RAPAL)

Both research questions are addressed in this section: What are the required skills to be developed for learning in the 4IR, and what teaching-learning strategies are used to develop self-directed skills for the 4IR?

With regard to the research question one, 36 relevant papers were selected to investigate the required skills to be developed for the 4IR. Table 3 shows that 2020 had the highest number of publications (36%), followed by 2021 (30%), 2019 (17%) and 2018 (17%). The reviewed studies were carried out within 13 different countries. It appeared that South Africa has the highest number of studies (13), followed by Malaysia (8), India (3), Indonesia (2) and Switzerland (2), while Australia, Greece, Russia, Scotland, Spain, Turkey, United States of America and Vietnam were each represented by one study. The findings revealed that critical thinking is the most emphasised skill followed by creativity, problem solving, communication, collaboration, analytical thinking, teamwork, innovation, management skills, active learning and the use of learning strategies and entrepreneurship. Decision-making skills, originality, financial management skills and other were the least emphasised skills (Table 3).

The review further revealed that South African and Malaysian researchers emphasised critical thinking, communication, creativity and problem-solving skills as the skills required to be developed by students in the 4IR (Table 3). Moreover, critical thinking skills were emphasised by the majority of the scholars. This finding supports scholars' views who suggested that critical thinking is an essential ability that should be developed in the era of 4IR (Hidayati et al. 2020; Wilson and Narasuman, 2020). Mamabolo and Myres (2020) as well as the WEF (2020) argued that critical thinking is highly essential to succeed in the future work environment. Akor et al. (2019) further argued that the application of 4IR technologies in education would lead to the development of critical thinking skills. Lecturers play an important role by facilitating students to develop the mentioned skills. The lecturers are also expected to create an environment that is conducive to active learning and skill development. Moreover, the lecturer's role changes from instructor to a facilitator of learning to guide students in constructing their own knowledge (Akor et al. 2019).

Teaching-learning strategies used to develop self-directed learning skills

Essential teaching and learning strategies for the 4IR are outlined in Table 4 (arranged alphabetically by strategy, numerically by year, alphabetically by country and then alphabetically by author)

Table 4: Strategies to enhance skill development for the 4IR

Nr	Author(s)	Year	Strategy	Country	Method/approach
1.	Akor et al.	2018	**Blended learning**	Malaysia	Qualitative study
	Uz and Uzun	2018		Turkey	Mixed method
	Noh and Kim	2019		Korea	Quasi-experimental study
2.	Buitrago	2017	**Collaborative learning**	Colombia	Mixed method
	Lasfeto	2020		Indonesia	Quantitative study
3.	Mentz and Van Zyl	2018	**Cooperative learning**	South Africa	Explorative study
	Adefila and Pillay	2019		South Africa	Document analysis
	Bosch and Laubscher	2019		South Africa	Systematic review
	Bosch and Pool	2019		South Africa	Qualitative study
4.	Chitra et al.	2020	**Design thinking**	India	Qualitative study
	Satpathy et al.	2020		India	Qualitative study
5.	Chitra et al.	2020	**Experiential learning**	India	Qualitative study
6.	Liu et al.	2018	**Flipped classrooms**	China	Meta-analysis
	Borzova	2018		Russia	Theoretical overview
	Ceylaner and Karakus	2018		Turkey	Mixed method
	Shrivastava and Shrivastava	2019		China	Theoretical overview
	Zainuddin et al.	2019		Hong Kong	Qualitative study
7.	Chitra et al.	2020	**Gamification**	India	Qualitative study
8.	Kershaw et al.	2017	**Problem and project-based learning**	United Arab Emirates	Quantitative study
	Saleh et al.	2017		United Arab Emirates	Quasi-experimental study
	Akor et al.	2018		Malaysia	Qualitative study
	Golightly	2018		South Africa	Mixed method
	Lieu et al.	2018		Vietnam	Document analysis
	Shimizu et al.	2019		Japan	Quantitative study
	Abdullah et al.	2019		Malaysia	Quantitative study
	Azli et al.	2019		Malaysia	Theoretical overview
	Ginaya et al.	2020		Indonesia	Quantitative study
	Benadé	2020		South Africa	Mixed method
	Larson et al.	2020		USA	Qualitative study
9.	Azli et al.	2019	**Project-oriented learning**	Malaysia	Theoretical overview
	Akor et al.	2020		Malaysia	Content analysis
10.	Chitra et al.	2020	**Self-learning**	India	Qualitative study

The articles highlighted in Table 4 were chosen in accordance with the inclusion criteria listed in Table 2. The studies ranged from 2017 to 2021. The highest number of outputs were published in 2019 (taking duplicate articles into account), followed by 2018, 2020 and 2017. The examined studies were conducted in 14 different nations.

Malaysia, Turkey and Korea emphasised that the *blended-learning* strategy promotes

development of SDL skills (Akor et al. 2018; Uz and Uzun 2018; Noh and Kim 2019). For instance, Uz and Uzun (2018) argued that SDL of students were improved when they were exposed to a blended learning context.

The use of *collaborative learning* was mentioned by studies from Colombia and Indonesia (Buitrago 2017; Lasfeto 2020). In this regard, Buitrago (2017) indicated that group collaboration provided opportunities for students to engage emotionally in the learning process and to monitor and adjust their learning accordingly. In addition, four studies from South Africa reported that cooperative learning is crucial for the future, and it also promotes students' SDL skills. Cooperative learning, grounded in the Social Interdependence Theory, involves specific principles with the aim of enhancing students' responsibility in learning (Johnson and Johnson 2014). For example, Bosch and Laubscher (2019) mentioned that students helped each other achieve the outcomes by working in group without waiting for their facilitator to assist.

Two separate studies conducted in India argued that *design thinking* can be used to develop 4IR skills of students (Chitra et al. 2020; Satpathy et al. 2020). Satpathy et al. (2020) claimed that fifth semester engineering students' skills were developed after the Summer Internship Programme (SIP) and participation in industrial contexts designed to make them relevant in global competitive corporate careers through partnerships between industry and academia. Satpathy et al. (2020) assert that design thinking also encourages engineering students to develop soft skills such as English language proficiency, communication, critical thinking and problem-solving, leadership as well as team-building abilities. These skills are required to meet the demands of future employers.

Experiential learning, gamification and self-learning are important teaching methodologies required in the future. Chitra et al. (2020) noted that students were equipped with 4IR skills by using experiential learning when they were requested to work on assignments related to real-life challenges and be actively involved in solving problems. Self-learning enables students to develop essential skills by motivating them to learn on their own (Chitra et al. 2020). Gamification also promotes SDL by motivating students through the use of video game design and game features where they are encouraged to take ownership of their own learning (Chitra et al. 2020).

Studies from China, Russia, Turkey and Hong Kong focused on how a *flipped classroom* (FC) improves students' SDL (Liu et al. 2018; Borzova 2018; Ceylaner and Karakus 2018; Shrivastava and Shrivastava 2019; Zainuddin et al. 2019). For example, Liu et al. (2018) indicated that SDL skills of nursing students were improved using the FC approach compared to the conventional approach. Similarly, Zainuddin et al. (2019) claimed that the SDL skills of English students were enhance by the FC approach through video-enabled instructional

practices. Flipped classrooms require the lecturers to develop teaching and learning activities in accordance with individual students' pace of learning, and allow for practical tasks and critical discussions in class (Noh and Kim 2019; Chitra et al. 2020).

Studies from the United Arab Emirates, Malaysia, South Africa, Vietnam, Japan Indonesia and the USA indicated that *problem and project-based learning* (PBL) are effective teaching-learning strategies in assisting students to develop essential skills for the future (Kershaw et al. 2017; Saleh et al. 2017; Akor et al. 2018; Golightly 2018; Lieu et al. 2018; Shimizu et al. 2019; Abdullah, Mohd-Isa, and Samsudin 2019; Azli et al. 2019; Ginaya et al. 2020; Benadé 2020 and Larson et al. 2020). For example, Ginaya et al. (2020) viewed PBL as the integration of problem-solving activities, which enables students to master critical thinking, collaboration and soft skills, and hence facilitate students' SDL. Applying PBL as an effective strategy promotes SDL by inspiring students to take control and manage their own learning. Golightly (2018) revealed that Geography students' SDL improved when they were exposed to PBL experiences for a period of more than three-years. Furthermore, Larson et al. (2020) claimed that SDL skills of engineering students were facilitated when a course was based on project-based learning.

Moreover, studies from Malaysia claimed that *project-oriented problem-based learning* (POPBL) has potential to assist students in aquiring crucial skills for the 4IR (Azli et al. 2019; Akor et al. 2020). (POPBL mainly refers to the development of an artifact based on a project). For example, Akor et al. (2020) indicated that the application of POPBL in electronic engineering enables students to develop critical thinking, problem solving, creativity, innovation, service orientation, technological skills, emotional intelligence, negotiation and the ability to work together in teams.

It is reasonable to conclude from the studies that have been reviewed that teaching-learning methods including blended learning, collaborative and cooperative learning, design thinking, experiential learning, gamification and flipped classrooms, PBL, POPBL and self-learning is capable of assisting in acquiring important skills for the 4IR. Based on the systematic literature review, the essential skills that emerged from this study (Tables 3 and 4) are also aligned with some competences for the 4IR, as outlined in the theoretical framework (Table 1), for example:

- cognitive and reflective competences (critical and creative thinking, problem solving, analytical thinking, innovation and decision making, entrepreneurial skills and self-awareness),
- human competences (active learning, behavioral skills, time management skills, empathy, ethical skills, leadership, flexibility and adaptability, soft skills),

- cooperative and collaborative competences (interpersonal communication and teamwork skills, social intelligence, negotiation),
- technological competences (technical skills, ICT literacy skills, digital skills), and
- self-directed learning skills (initiative, self-advocacy skills, self-awareness).

As emerged from the systematic research overview, crucial skills for the 4IR include critical thinking, creativity, problem solving, communication, collaboration, analytical thinking, groupwork, management skills, active learning and the use of learning strategies (Tables 3 and 4). This study has implications for the development of SDL abilities for the future as emphasised by Briede and Popova (2020) and Penprase (2018). Another implication drawn from these findings is development of SDL is dependent on appropriate planning and implementation of the mentioned teaching-learning strategies.

CONCLUSION

A systematic review was conducted to determine essential skills and strategies required in higher education for the 4IR and its implication for SDL. The findings revealed that there is a need for re-skilling and critical thinking is the most emphasised skill followed by supportive skills such as complex problem solving, groupwork and active learning. With respect to active teaching-learning strategies, the findings revealed that several student-centred strategies are used to develop essential skills for the 4IR. Moreover, results were also aligned with some competencies as indicated in the theoretical framework. It is also worth noticing that the number of studies covering the topics under investigation is relatively low, indicating a need for more studies on these topics. Based on these findings, it is suggested that the adoption of the mentioned strategies may promote the development of students' SDL abilities.

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