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The effectiveness of innovative pedagogy in the industry 4.0: Educational ecosystem perspective

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ABSTRACT

Higher education institutions have been aware of the mutually beneficial interaction between Higher Education 4.0 (HE4.0), Industry 4.0 (I4.0), and Work 4.0 (W4.0). Teaching and learning (T&L) are best accomplished through the novel and blended approaches in today's smart manufacturing, services, and labor processes. The traditional T&L methods no longer complement the fourth industrial revolution and the future of work skills. Little research has focused on innovative pedagogies in Higher Education Institutions (HEIs) globally and especially in South Africa from the Learning Ecosystem Framework perspective. This paper begins to address this void via a review of academic literature, aiming to understand new pedagogies of teaching and learning in HEIs and their effectiveness as we move into HE4.0. The emphasis of higher education research worldwide should be on reviewing and synthesizing current research outputs rather than performing new studies since there are fewer systematic literature reviews and a blend of systematic-narrative literature review approaches published in higher education journals. In light of this, exhaustive systematic-narrative literature reviews have been conducted to aggregate research findings within the context of global higher education pedagogy. Combined, this encompasses an analysis of 138 papers across different academic databases. We concluded that integrating teaching and learning methodologies such as flipped classroom, SCALE-UP, and blended teaching and learning are the most effective, sustainable, and student-centered pedagogy. Combining these teaching and learning approaches will ensure that students receive dynamic support, hands-on activities, practical assessments, active collaboration, and inquiry-based learning. Overall, our findings revealed that we need all parts of the learning ecosystem to work together toward teaching and learning that is transgressive, innovative, transformative, diverse, and inclusive with the I4.0, HE4.0, and W4.0 in mind – that is, if we aim to achieve effective blended teaching and learning, and sustainable student-centered academic output. Here, we point out where these discoveries might take us in research and what policies should be revised.

1. Introduction

Higher Education 4.0 seeks not only teachers but also mentors, facilitators, trainers, educators, and motivators who will diversify innovative transgressive pedagogy practices that engage with sustainability-oriented and flexible learning rather than replicating unsustainable and static teaching and learning strategies that struggles to complement Industry 4.0 (I4.0) skills. The need for the education sector to meet the learning expectations of students (Hénard & Roseveare, 2012; Licite & Janmere, 2017), exploratory and multi-disciplinary approaches to education (Himmetoglu et al., 2021), internationalization, globalization, and technological advancement (Frank, 2021; Hénard & Roseveare, 2012; Ilori & Ajagunna, 2020), in the Fourth Industrial Revolution (4IR), necessitated the embracement of HE4.0 (Cabrita et al., 2020), which is reforming the educational panorama (Jung, 2022). HE4.0 is a purposeful approach to teaching and learning (T&L) that aligns with the 4IR (Hussin, 2018; Khine et al., 2021).

For centuries, formal education relied on the classroom approach, which requires the physical presence of teachers and their students in a designated classroom. However, there is a glaring shift from the traditional T&L practice toward the modern pedagogical models, including electronic-based learning (e-learning), blended teaching, and other learning approaches. As García-morales et al. (2021) reported, many HEIs want to explore new ways of teaching. The reason is that the

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transformation in the pedagogical landscape is being propelled by technological advancement, which has made available the enabling gadgets and software that facilitate remote, online, and face-to-face (f2f) pedagogy (Lim & Wang, 2016; Yusuf & Al-Banawi, 2013). Hence, tech-based, and innovative pedagogy as the way forward has become indispensable in modern T&L practices.

However, in most developing countries, adaptation to HE4.0 pedagogy remains dismal, and improvement is gradual. In South Africa (SA), aligning the T&L processes with the HE4.0 standard has not been impressive (Faiq, 2019). The antecedents of the HEIs in SA reveal a system where less attention is paid to the advancement in the global view (Hlatshwayo & Shawa, 2020). The problem might be that the education sector in SA is unprepared for the 4IR (Oke & Fernandes, 2020), despite a mutual symbiotic relationship between the education sector and I4.0 (Gleason, 2018). Yet, not many studies have discussed the importance of adopting an innovative system of T&L for the rapid transformation in the 4IR system (Omodan, 2019), and reflection on current teaching techniques promotes the implementation of novel educational initiatives (Hellmann et al., 2014).

Besides, academics are encouraged, more than ever, to participate in educational innovation to promote students' learning (Fraser, 2019; Kgwete & Malatji, 2021). Hence, the need to adopt good modern techniques of pedagogical approaches that are more flexible, inclusive, effective, and sustainable (Chiba et al., 2021; Chigbu & Nekhwevha, 2022; Frank, 2021; Masinde & Roux, 2020; Penprase, 2018) as a roadmap to transform HEIs in SA towards achieving the demands of 4IR (Masinde & Roux, 2020). Moreover, the promotion of transformative learning in HEIs in SA, its status and impact remain unclear, inconclusive, open to debate, and begging for further research (Guri-rosenblit, 2018; Majanja, 2020).

The issues pointed out above formed the justification for this research. Indeed, there is an opportunity for the education sector to harness the innovations associated with the 4IR through research and teaching to enhance students' T&L experiences. Consequently, this study aimed to evaluate the prospects and effectiveness of HE4.0 in the 4IR in SA through the lens of the Learning Ecosystem, to inform further educational research, policies, and practices. In addressing the critical aim of the study, we asked the following research questions.

- ✓ What are the new teaching pedagogies in HEIs as we move into HE 4.0?
- ✓ Which of the innovative teaching approaches are adopted by South African HEIs educators?
- ✓ In the South African context, which among the novel pedagogical techniques will be most effective in teaching students in consideration of research question 1 above?

In this paper, we impacted on five theoretical areas: 1) identified innovative models of macro T&L that support the transition to HE4.0 as a result of the 4IR; 2) sheds light on the novel teaching and learning methods in SA's HEIs; 3) explained the most effective and practical new pedagogy methods that align better with the micro education in SA; 4) pointed out various challenges facing blended pedagogy in SA, and 5) emphasized the need for change in the pedagogical ecosystem and its importance to the future of work associated with the 4IR. This study bridges ground-breaking global education research and the application of novel pedagogies in HEIs.

The paper proceeds as follows: Section 2 looks at the framework of this study. Section 3 describes the systematic review method. Section 4 presents our results and discussions. Section 5 gives extensive conclusions.

2. Learning ecosystem framework

A learning ecosystem framework (LE) involves pedagogical requirements formed by a wide range of stakeholders working toward the same goal – "student-centered learning," as depicted in Fig. 1 below. As explained by 21CLEO (2019), the ecosystem comes from ecology, the study of organisms and their surroundings. Living and nonliving elements interact as a system in their environment, and a change in one part may affect the entire system. Social sciences and education use the ecosystem notion to understand how the human experience fits together, and the interplay between multiple learning environment components is called a 'learning ecosystem.'

LE can be grouped into two components. First are the living components that comprise academic stakeholders, including policymakers, instructors, institutional staff members, and students. Second, the nonliving components of the LE ecosystem, which include the natural environment as it relates to T&L, consist of the technology, internet, course content, educational policy, structures, culture, strategies, and digital learning tools (21CLEO, 2019), all of which influence the formal and informal learning of students in the HEIs (Jamaludin et al., 2020). In an educational ecosystem, all stakeholders are expected to know that they should learn, unlearn, relearn and co-learn for self-improvement (Jamaludin et al., 2020).

The importance of the application of learning ecosystem concepts in the HE 4.0 is made relevant by the need to improve the education system with modern pedagogical models that reflect the conditions of I4.0. Thus, the notion of a learning ecosystem is connected to the need to comprehend and conceptualize the dynamic, diversified, and interactive character of the interaction between educational institutions and digitally enabled activities (Díaz-Gibson et al., 2020; Virolainen et al., 2021). For example, a policy change can influence a difference in the pedagogical model, as the introduction of digital pedagogical tools has facilitated the leap in blended learning and other technology-facilitated pedagogical approaches, which have further expanded the learning space, and the mode of T&L processes (Belias et al., 2013).

According to Díaz-Gibson et al. (2020), the weaving of the learning ecosystem in the new pedagogical framework is to ensure improvement in educational action, owing to the need to improve "the quantity and quality of social relationships" among stakeholders (Díaz-Gibson et al., 2020). We need a collective system considering that HE4.0 is the education for the future (World Economic Forum, 2020). The emergence of I4.0 has prompted education to evolve and shift its delivery perspective (Nayar & Koul, 2020) to meet its students' needs (Ayinde & Kirkwood, 2020; Monaco & Martin, 2007). To that end, to adapt to the expectation of I4.0, HE4.0 has built a new interface for each stakeholder (Nayar & Koul, 2020), which will, in turn, influence the way a new-age student studies (Nayar & Koul, 2020; Scepanovič, 2019) from every aspect of the twenty-first century's studying environment (Elayyan, 2021; Eudy, 2018).

More so, the integration of the digital components of the learning ecosystem in the prevailing pedagogical methods to improve the standard and quality of education is in line with the South African National Development Plan 2030 (NDP), tagged "Our Future – Make it Work," which includes to "improve the quality of education, skills development, and innovation." The takeaway here is that if we want SA's HEI teaching and learning to be successful, we need to pay attention to the entire learning ecosystem and reflect strategically on their pedagogical models to achieve their set objectives (Eudy, 2018), which is to improve the academic output of the students (Chigbu & Nekhwevha, 2021a). The fact is that learning must become more relevant and contextualized for students to be adequately prepared for the 4IR (Elayyan, 2021). Therefore, it is vital for HEIs to partner with multiple stakeholders to create the most effective type of academic environment (Dos Reis & Braund, 2019) and T&L methods.

In conclusion, the primary reason for the institution's existence is to facilitate student learning. Consequently, students are dependent on and influenced by the learning ecosystem, which includes instructors. Students are the most critical stakeholders in education because they need a quality education to acquire the information and skills necessary for job success. As stakeholders in education, instructors are vested in ensuring

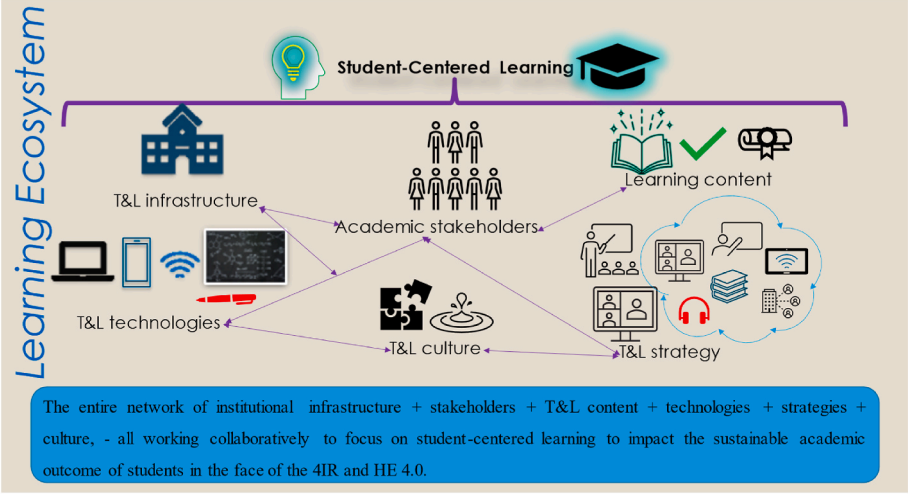

Fig. 1. Shows the connected learning ecosystem that influences student-centered learning. Source: authors.

students' learning; however, to ensure student-centered learning, teachers must take personal responsibility for determining the teaching strategy for their students to learn the curriculum materials most effectively. Nonetheless, instructors rely on the administrative staff and policymakers in the learning environment to ensure that the necessary resources for various T&L methodologies are readily available for adoption and implementation.

Consequently, university institutional staff members have a vested interest in the success of the educational environment by ensuring that all administrative responsibilities are carried out effectively and with a focus on the success of students learning. In addition, policymakers play a crucial role in the education environment. Their decisions determine the implementation of every system component, including teaching methods, culture, curricular content, university infrastructure investment, innovation, and the quality of students' academic achievement. All learning ecosystem stakeholders generally have relational ties that pursue student-centered learning and students learning sustainability.

3. Materials and methods

Notwithstanding that systematic literature reviews (SLRs) are regarded as a valuable and effective way to summarize research evidence in HE research (Bearman et al., 2012), fewer SLRs techniques are published in journals of higher education (Bearman et al., 2012; Chong et al., 2022). Progressively, HE researchers are recognizing the need to pool existing research results to map research landscapes (Chong et al., 2022). Specifically, the use of a systematic-narrative literature review technique capitalizes on the strengths of both systematic and narrative reviews. It lays the groundwork for an effective methodology without overburdening scholars. Importantly, SLRs require a well-developed method that describes the search strategy, literature sources, scope, limitations, and information synthesis techniques used to bolster the arguments and findings presented to the reader (Turnbull et al., 2023).

Through systematic-narrative literature reviews, we collated, summarized, and reported the results and provide a narrative account of existing literature through interpretative content analysis (Chong et al.,

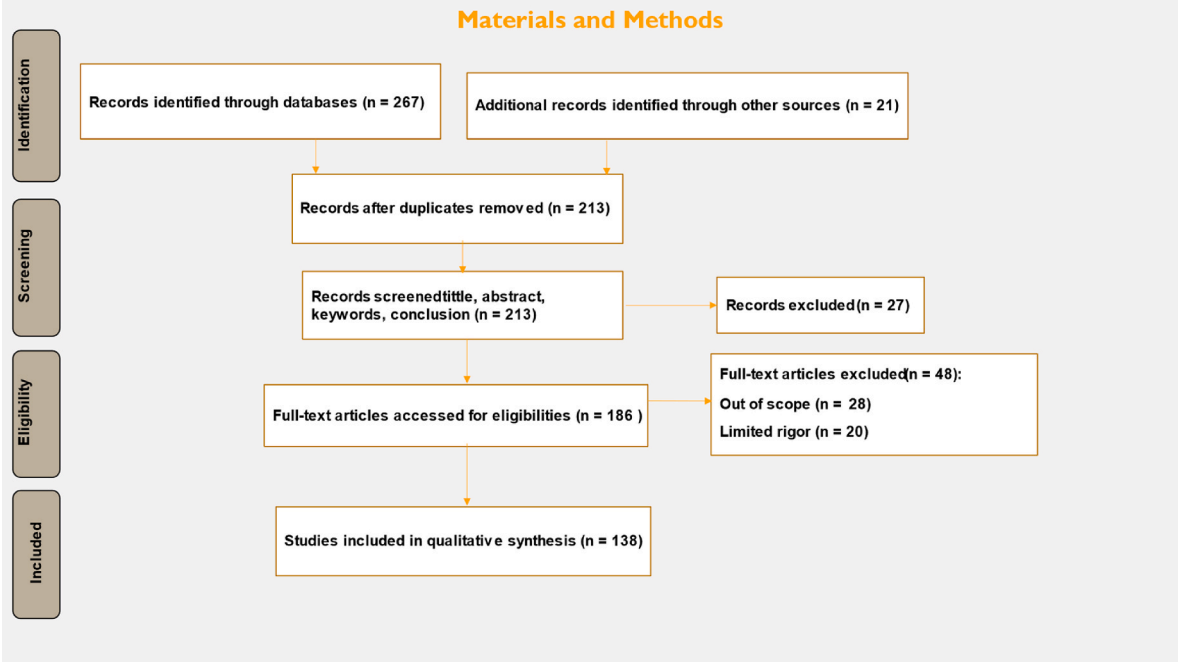

Fig. 2. Diagram of the systematic review and screening method. Source: authors.

2022). The systematic narrative reviews were performed per the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines and flow chart shown in Fig. 2.

The diagram shows how the studies were picked from the preliminary database search to the final included studies. The databases searched were electronic and concerned the areas of HEI pedagogy and social sciences. The databases searched were PsychINFO through Ebscohost, ERIC via Ebscohost, and Academic Search Complete. Also, Google Scholar and Google were used to search for grey and relevant literature. In each database, we searched key terms such as 'innovative pedagogies,' 'teaching and learning strategies,' '4IR and HEIs,' 'blended learning,' 'flipped classroom,' 'students-centered pedagogy,' 'global teaching and learning approaches,' 'South Africa,' and 'learning ecosystem.' We did not geographically limit our searches; the context was done on micro (global) and macro (South Africa) based on the research objectives. To be included in this review, studies needed to be published between 2007 and 2022.

Eligible studies also needed to be published in English. We screened for criteria such as titles, purposes, objectives, abstracts, highlights, keywords, results, and conclusions. This was done to ensure that most of the articles in the sample put considerable focus on innovative teaching and learning methodologies and their effectiveness rather than just mentioning each word in passing. As a result, we sampled and analyzed 138 existing documents on innovative teaching and learning strategies in HEIs. Thematic analyses were used to identify, analyze, and report patterns within the data. Each theme was meant to capture important information about the study, coded based on the research objectives. Reports were produced from the articles by relating them to the research objectives. The findings in each theme were based on a methodology that includes a set of transparent procedures, synthesis elements from collective repositories of credible existing research, reasonings, and analyses of exclusive perspectives from the literature analyzed in the study.

4. Analyses and discussions

Emerging technologies and the digital revolution of societies have transformed T&L (Scepanovič, 2019; Yawson & Yamoah, 2020) and have affected the classroom and student expectations in any learning setting (Burke, 2015; Chigbu & Nekhwevha, 2022). With the onset of the 4IR (Eberhard et al., 2017; Elayyan, 2021; Leopold et al., 2016), students are expecting their HEIs to develop their independent thinking, decision-making skills, savvy technological skills, social skills, team-oriented skills, structured skills, and oral and written communication skills (Chigbu & Nekhwevha, 2022; Monaco & Martin, 2007; Ongbali et al., 2019; Schwieger & Ladwig, 2018). The trigger is that "the teaching method some years ago is not the method to achieve learning with this generation" (Monaco & Martin, 2007, p. 42). At present, the T&L format can be traditional classroom (face-to-face), electronic-based (E-learning or internet-based learning), or blended learning (a mixture of all formats) (Slomanson, 2014). Higher education (HE) students are increasingly interested in programs that provide them with the freedom to study when and where they please, demonstrate their knowledge and understanding in a variety of ways, and acquire the dispositions, skills, and knowledge they will need to become lifelong learners in the face of the challenges presented by an increasingly globalized and interconnected world (Shohel et al., 2021). Therefore, techno-pedagogical content knowledge has become an integral approach in modern T&L (Shohel et al., 2021).

Before the discovery of innovative pedagogies, the well-known and dominant method of T&L was face-to-face pedagogy, called the traditional teaching method. We will first discuss the conventional teaching approach before discussing the new techniques of T&L.

4.1. Traditional teaching and learning method

Studies have highlighted that the traditional teaching method is the dominant global pedagogy (Marinoni et al., 2020). This standard or conventional T&L method happens in the physical classroom setting that requires direct f2f lectures, small group seminars, one-to-one supervisory or tutor meetings, and interaction between the teacher and the students (Belias et al., 2013; Frank, 2021). Under the traditional f2f pedagogical model, the teacher lectures a group of students, in most cases, using a chalkboard or the equivalent or projector in more modern classrooms (Manohar et al., 2015). Some advantages of the traditional T&L method include allowing the instructor to monitor and understand a student during teaching (Lin, 2022). Again, the teacher can immediately respond to the questions and unanticipated students' reactions and compliment the students whose performances are remarkable (Srinivas & Singh, 2021).

However, the traditional T&L model is centered on teachers as the primary source of knowledge, while the students play a passive role rather than an active role (Srinivas & Singh, 2021). Thus, though this traditional mode of pedagogy has long been used in teaching methods (Frank, 2021), this approach is not practical enough to address the student's needs and interests, as students do not have the opportunity to play an active role and collaborate during the T&L phase. Undoubtedly, the traditional means of T&L are not meeting the learning needs of students as we face rapid technological changes (Chigbu & Nekhwevha, 2020b (Chigbu & Nekhwevha, 2022),) and the 4IR. The issue is that economic growth is now a considerably more complicated process than in the past, posing new problems for HEIs. As a result, for nearly two decades, worldwide educators have sought to use blogging, discussion forums, and similar T&L approaches to complement mainstream pedagogy (Frank, 2021). Therefore, this study asked: what are the innovative pedagogies in the HEIs as we embrace HE4.0 and 4IR?

4.2. New pedagogies of T&L in HEIs: A global analyses

This sub-section identifies some of the innovative teaching and learning methods below.

4.2.1. E-learning (Web-based learning)

E-Learning is a well-recognized global innovative T&L (Saini et al., 2014). E-learning can be delivered using some tools, including video and audio systems, multi-media, chat room applications, and conferencing applications (Saini et al., 2014), such as Zoom and Microsoft Team applications. Other E-learning tools include Learning Management Systems (LMS) and software platforms such as Blackboard Collaborate, Canvas, Moodle (Frank, 2021), eFundi, etc., designed to connect students and lecturers online. Thus, if a suitable infrastructure is given, LMSs may assist in supporting, reusing, and sharing digital learning objects developed on the system (Medio et al., 2020). The increasing availability and access to digital learning resources promote personalized learning and encourage "bring your device," whereby student study via personal electronic devices as a prevailing E-learning initiative (Kong & Song, 2015; Pegrum et al., 2013). It denotes the pedagogical models that involve the use of internet-enabled electronic gadgets to exchange information in the T&L process without the physical presence of the teachers and students, given that they are separated by distance, time, or both.

The E-learning model is being normalized, especially in the HE system, as the institutions, teachers, and students continue to adjust and adapt to the new realities (Armstrong-mensah et al., 2020; Mpungose, 2020) about the labor market and 4IR skills. This means that the opportunities offered by remote learning allow the students the flexibility to structure their education toward their career choices and life goals. However, the disadvantages of E-learning may include social isolation, the cost of developing and making available the E-leaning tools, and the tendency to develop technical problems that may discourage T&L.

Furthermore, internet facilities may not be easily accessible to all learners due to poor facility availability, cost, or technological breakdown (Saini et al., 2014).

4.2.2. Project-based learning (PBL)

PBL is widely adopted as a worldwide T&L strategy. Kokotsaki et al. (2016) have defined PBL as an active student-centered education method distinguished by student autonomy, constructive explorations, goal setting, cooperation, communication, and reflection on real-world activities. PBL is said to be based on three principles: context-specific learning, goal-oriented learning based on the active participation of the learners in the learning process, knowledge sharing, and understanding (Kokotsaki et al., 2016). Krajcik and Shin (2014) noted that PBL is founded on the idea that students learn best when they have several chances to solve real-world issues on their own via the processes of formulating questions, assigning tasks, performing research, analyzing results, and writing reports (Kgwete & Malatji, 2021). Every aspect of the group task is collectively carried out by the students (Bell, 2010), and these students can be assessed based on their performances in the group project execution (Cabrita et al., 2020) as it improves students' collaboration skills, test performance, and long-term content retention (Stiefvater, 2018).

It must be noted that I4.0 requires a practical approach to problem-solving, in which respect HE4.0 encourages a more pragmatic approach to education. This necessitates valuable knowledge acquisition (Cabrita et al., 2020). The challenge attributable to PBL based on an empirical finding includes that some students are domineering and would not allow relatively equal active participation of the project team members. In contrast, some confident students would want to impose their interests. Where this is the case, some students would like to cease participating in the project. More so, a lack of access to personal electronic gadgets would affect some students' participation levels (Aldabbus, 2018).

4.2.3. SCALE-UP pedagogy

SCALE-UP is an acronym for Student-Centered Active Learning Environment with Upside-down Pedagogies (Burke, 2015; Foote et al., 2014), and this T&L system is catching on globally (Erol et al., 2016). According to Beichner (2008) and Soneral and Wyse (2017), in a SCALE-UP classroom, students are seated at nine-person circular tables in groups of three. Each table has three laptops (one for each group) and whiteboards or chalkboards. Students can connect their laptops to pods to display their work on a computer monitor and utilize microphones. The technology of the teaching station enables the teacher to broadcast students' work on all screens (Beichner, 2008; Soneral & Wyse, 2017). Here, the teacher moves around the classroom, asking students questions, encouraging students to share their work, and supporting student learning in groups in SCALE-UP settings.

Compared to a standard lecture hall, the unusual classroom arrangement of SCALE-UP is advantageous because it encourages student cooperation, promotes student-to-student and student-to-teacher interactions, and boosts overall student engagement (Erol et al., 2016; Hacisalihoglu et al., 2018). The boost in student learning and motivation to study in this unique environment demonstrates the significance of this classroom layout.

Research indicates that this T&L is suitable for large enrollment in introductory undergraduate courses (Erol et al., 2016; Foote et al., 2014), adopted in physics, chemistry, math, biology, astronomy, engineering, political science, and even literary classes (Foote et al., 2014; Hacisalihoglu et al., 2018) - indicating that SCALE-UP is not domain specific (Foote et al., 2014). Interestingly, Soneral and Wyse (2017) noted that the benefits of a SCALE-UP experience could be achieved at a lower cost with collaboration and whiteboards without technology features.

4.2.4. Flipped classroom (FC) pedagogy

FC is a form of blended T&L method that engages students in active learning (Burke, 2015; Daniel, 2016), and it is widely adopted globally. In the FC model, the students are required to watch or read the necessary learning materials at home. At the same time, students focus on group discussions and assignments in the classroom, and the teacher guides the students through the practical exercise in classroom sessions (Burke, 2015; Slomanson, 2014). FC T&L strategy differs from the traditional classroom model, where the teacher would spend most of the class period dispensing information while the students must perform the practical exercise as homework (Burke, 2015; Nazarenko, 2015). As a form of blended learning model, the FC model puts the student in control and allows them to study at their own pace (Tallent-Runnels et al., 2006). It has also been observed that students' short- and long-term performance improves when they view the lecture video before the in-class session (Förster et al., 2022).

Some challenge attributable to the FC model is that it is more favorable to students who are disciplined enough to motivate themselves and take charge of their studies without persuasion (Du et al., 2014). Although the involvement of group activities in the FC approach may improve the student's confidence level, boldness, speaking, and presentation skills, it may also be a source of stress for specific students, especially those socially marginalized. Despite that students may note their questions when reading lecture notes at home and ask questions during class sessions, the inability of the students to ask questions and get an immediate response can be a source of confusion, and frustration, to students, especially in their home readings (Johnson, 2013; Taylor, 2015).

Notwithstanding, research revealed that reading study materials before classroom sessions in the FC model enables students to raise questions on grey areas during the classroom session (Burke & Fedorek, 2017), thereby fostering critical thinking and yielding statistically significant improvements in students' engagement, test scores, and overall long-term learning (Moravec et al., 2010). In addition, FC enables the instructor to attend to the unique challenges of the individual students (Förster et al., 2022; Hacisalihoglu et al., 2018; Lee & Wallace, 2018); through active and adaptable learning. Significantly, this strategy improves students' engagement, motivation, and satisfaction and reduces study anxiety (Adhami & Taghizadeh, 2022).

4.2.5. Blended learning (BL)

BL is a format rapidly spreading in HEIs worldwide (Nazarenko, 2015) that combines the traditional face-to-face and the E-learning T&L (Khine et al., 2021; Slomanson, 2014; Tallent-Runnels et al., 2006). With the online learning opportunities that promote anywhere-anytime learning using a range of E-learning tools, there is a growing trend in active BL pedagogical approach that further supports experimental and practical learning. As emphasized by Gaol and Hutagalung (2020), BL has been adopted in many industrialized countries due to the prevalence of the internet.

The relevance of BL is the opportunity it creates to effectively combine E-learning and other remote learning opportunities with the traditional classroom-based T&L method in a complementary manner (Srinivas & Singh, 2021). According to Border et al. (2021) and Stack (2015), BL produces more effective outcomes than traditional f2f classrooms or e-learning alone. It promotes student academic responsibility, prepares students for a technology-centered labor market, reduces the expenses of online learning, improves collaborative, exciting, and entertaining abilities, and encourages full (physical and socio-emotional) engagement of students in the learning process. Many HEIs now offer students flexible alternatives to engage in BL, balancing the advantages and disadvantages of f2f and online T&L (Bower et al., 2015; Caner, 2012).

In summary, the conventional face-to-face instruction technique is the preeminent form of T&L in the world. Although traditional pedagogy is still relied upon, creative techno-pedagogical content knowledge has

emerged as a crucial component of contemporary T&L. E-Learning, PBL, SCALE-UP, FC, and integrated teaching and learning are just a few examples that have found widespread acceptance in the HEIs throughout the world. Video and audio systems, multi-media, chat room applications, conferencing applications, Zoom, Microsoft Team, Blackboard Collaborate, Canvas, Moodle, and eFundi, are just a few examples of the E-learning management software platforms that facilitate the use of these innovative approaches to teaching and learning both inside and outside the classroom.

There is a growing trend in HE4.0 toward combining conventional and innovative pedagogical approaches, supporting experimental, practical, and problem-solving learning. This combination thrives for an active student-centered education method characterized by student autonomy, constructive explorations, goal setting, cooperation, communication, reflection, and adjustment to the real world of the 4IR activities.

Thus, via the innovative tools made available by I4.0, teachers can now help each student reach their full potential while equipping them with the knowledge and abilities they will need to help shape the future workplace through cutting-edge technologies. Consequently, we can argue that the 4IR, propelled by Artificial Intelligence and the Internet of Things, is improving T&L, and opening new opportunities for HEIs to contribute sustainably to society. As I4.0 will further transgress and modify the antiquated global educational system, it will be a pioneering step toward guaranteeing an innovative and progressive pedagogy for students everywhere. On the other hand, the pandemic has accelerated the use of new technologies in teaching and learning around the globe, serving as a vaccination for the start of digital learning in the global education sector. It is crucial to recognize that as the 4IR continues to reshape the labor market and the human-technology connection develops, innovative HEIs will continue to adapt their pedagogical methods to meet the demands of the current and evolving future of work. The following sub-section examined the second research objective of this study: investigating the innovative approaches of teaching adopted by SA HEIs educators.

4.3. Innovative approaches to teaching and learning in South Africa

Several studies (see: Aheto & Cronje, 2018; Majanja, 2020; Ralushai & Nkonki, 2017) have highlighted the conditions and efforts of SA institutions of higher learning to modernize their T&L practices. The question is, which innovative teaching approaches are adopted by South African HEIs educators?

In the South African educational system, the traditional f2f approach remains the predominant pedagogical approach to teaching university courses (Beltran-Cruz & Cruz, 2013). The current global context, including rapid technological changes and the 4IR (Avis, 2018; Daemmrich, 2017), means that economic development is a more complex process than in the past and therefore poses new challenges for HEIs (University of the Witwatersrand [Wits], 2020). The COVID-19 pandemic has, however, radically revolutionized how education is delivered in the country (Khan et al., 2021; Mhlanga & Moloi, 2020), which means that the period of the pandemic created an emergency leap in pedagogy (Mhlanga, 2020; Mhlanga & Moloi, 2020). McKenna (2021) revealed that before the COVID-19 pandemic, most courses provided in SA HEIs used a Learning Management System. Students might use forums to obtain course manuals and readings, post homework, and chat with their lecturers and classmates. However, many academics seemed to resist using technology, even though it may allow for better engagement and interactive learning (McKenna, 2021).

The University of Pretoria (UP) (2017) has been experimenting with and refining a hybrid approach to T&L for over two decades. Simply put, the UP has established a delivery approach combining conventional, classroom-based learning aids with online and technology-enhanced activities. Similarly, Wits also adopted blended teaching and learning. To do this, Wits T&L plan aimed to align the mode of instruction and technology to achieve quality education. Again, the university designs its course in different ways to ensure successful students' academic output. Such learning institution also pays attention to creating innovative formal and informal BL spaces. Wits have been redefining its position as an institution within a larger society with a developmental goal (University of the Witwatersrand, 2020).

Further, University of Western Cape (UWC) instructors are fans of blended learning, combining e-tools and technology with traditional classroom activities (Dankers et al., 2022). Blended or hybrid learning has become common practice across all UWC faculties. Course materials, examinations, quizzes, surveys, and announcements are among the e-tools used (University of the Western Cape, 2018).

COVID-19 forced some universities in SA to leap forward in teaching and learning (Khan et al., 2021; McKenna, 2021). For instance, during the COVID-19 pandemic, the University of Cape Town (UCT) and Northwest University (NWU) redefined their approach to T&L at the undergraduate level. According to Morei (2021), at the NWU, instructors had to be trained in the use of technology, and laptops and data had to be offered to students. UCT, like all other institutions in SA, was unable to create online courses from scratch. Before the pandemic, there was just no time for this. As stated by UCT (2021: p.2-3):

> *"While there was not an explicit prohibition of the use of various teaching and learning approaches, the result was that most academics did not try synchronous teaching even when this might have been possible. The lack of interaction between academics and students and the restrictions of the online environment as used at UCT has resulted in the disengagement of students. This, in turn, has had an impact on the quality of their learning. Students were not introduced systematically to the skills of learning online and to the expectations in terms of self-management that learning online entails"* (www.news.uct.ac.za, 2021).

In 2022, however, UCT flipped their classrooms, offering most lectures online and requiring students to arrive on campus having completed lectures, readings, and assigned tasks to engage in practical experiences, tutorial discussions, or other appropriate learning experiences in small groups. While UCT remains a contact-based residential university (www.news.uct.ac.za, 2021), its vision for 2030 promotes a digitally enabled education (DEE) system that supports student success in inclusive and equitable ways. Thus, UCT strives to offer education that adapts to the changing technological world and connects to a socially aware diverse student body. Their vision is to adopt a blended teaching and learning approach that will.

- Embrace diverse modes of provision
- Build a vibrant learning community
- Create an integrated teaching and learning ecosystem
- Explore practical ideas on what it means to create a blended learning experience.

At Rhodes University (RU) in SA, the primary mode of T&L at the undergraduate level is contact in-person sessions. However, courses are increasingly designed by blending f2f facilitation of learning with the online provision of opportunities for student engagement with university teachers, their peers, resources, tasks, and assignments through the institutional learning management system and various other digital platforms. One principle involves the need for alignment whereby all elements of courses (for example, purpose, learning outcomes, associated assessment criteria, learning materials, pedagogical approaches, and assessment tasks) are congruent and support students' attainment of learning outcomes (www.ru.ac.za, n.d.).

In conclusion, the traditional face-to-face strategy of providing university courses remains the dominant pedagogical style in South Africa's educational system. Before the COVID-19 outbreak, there was neither the time nor the necessity to combine conventional classroom-based learning aids with online and technology-enhanced activities. Before the COVID-19 crisis, while there were no explicit restrictions on using

various innovative teaching and learning strategies, most academics were not compelled to integrate their T&L tactics. As a result, students were not systematically introduced to online learning techniques and self-management expectations. Therefore, despite the close connection of the 4IR labor market, which strives for a reformed, transgressive, and sustainable HE4.0 environment, many teachers in South Africa were unwilling to innovate and blend their pedagogy.

4.4. SCALE-UP, flipping and blending South African HEIs classrooms: suitable pedagogical strategies

According to the review by Nortvig et al. (2018), it is difficult to compile a ranking and identify the best T&L method because of many other factors, such as educator presence in online settings, interactions between students, and teachers, content, intentional connections between online and offline activities as well as between campus-related and practice-related activities, which affect the effectiveness of any teaching method. Nevertheless, it is essential to establish or identify instructional approaches and delivery styles that will result in successful learning outcomes for students of this generation (Monaco & Martin, 2007). Studying on a university campus provides more than only the chance to learn and broaden one's knowledge, professional abilities, and social network (Frank, 2021) - knowledge creation and learning are social and communal activities. All of this is possible if SA's HEIs adopt more multi-strategy pedagogies.

While there are several blended learning models, the FC is one of the most prevalent, especially in HE (Dimella, 2020). With its element of BL, the FC form of education delivery can mitigate some of the detrimental consequences of hidebound schooling traditions and colonialism in SA (Daniel, 2016). It achieves so by fostering an environment in which students are encouraged to be self-sufficient and self-determined by their aspirations (Daniel, 2016). According to research, several SA university students who participated in the FC considered it fun (Cilliers & Pylman, 2022). Although the students worked more in the course and required more technical support, most would choose a similar teaching style in the future (Botha-Ravyse & Reitsma, 2015; Cilliers & Pylman, 2022; Viviers, 2019). Fig. 3 below depicts steps in flipped classrooms.

To ascertain that a flipped classroom will be effective, the following three key phases must be considered.

4.4.1. Phase 1: before scheduled seminar

The first stage of flipped T&L is usually the one that gets the most attention. Students are expected to supplement their in-class lectures with independent online work at this stage. By putting the introductory material online and making it available asynchronously, students not only have more control over when and where they engage with the content, but they can also divide up their study time into smaller chunks, which reduces their mental workload. Students can go back over previously covered ground if they need to. Videos are an essential element of this phase, but they are not the only ones. Step one material must be passive if they are to be effective. An easy way to engage students and keep them responsible for their learning is using formative exams incorporated inside the course content or following a video. This first phase enables the teacher to gather, either directly or indirectly (formative assessment), crucial information regarding the student's comprehension of the present content and their past knowledge - this information is essential to step two.

4.4.2. Phase 2: during scheduled seminar

The second stage involves a return to the classroom for the students. If a f2f meeting is not feasible, it may be replaced with a synchronous online discussion using a platform like Google Classroom, Zoom, Blackboard Collaborate, Adobe Connect, Microsoft Teams, Moodle, or eFundi. The second stage is when active learning and feedback-informed education success takes place. Both tactics may be modified to work in real-time via the internet. Instead of just listening to someone go over the material again, you may use active learning techniques to make the review session more engaging. Many teachers like to utilize a brief mini-lesson to fill in the blanks before moving on to a more involved collaborative activity with students applying what they learned in class and continuing the conversation about the topic after class. For blended learning to be successful, phase two must include active learning practices. Active learning has increased student success even when not combined with a flipped classroom (see: Essop & Beselaar, 2022; Freeman et al., 2014; A. Khan et al., 2017; McConnell et al., 2017; Tomas et al., 2019). The second portion of the exercise is often completed before the session's conclusion, although it may run over and require students to continue working together outside class. Evaluation is necessary at any point after the activity is over. Most lecturers evaluate

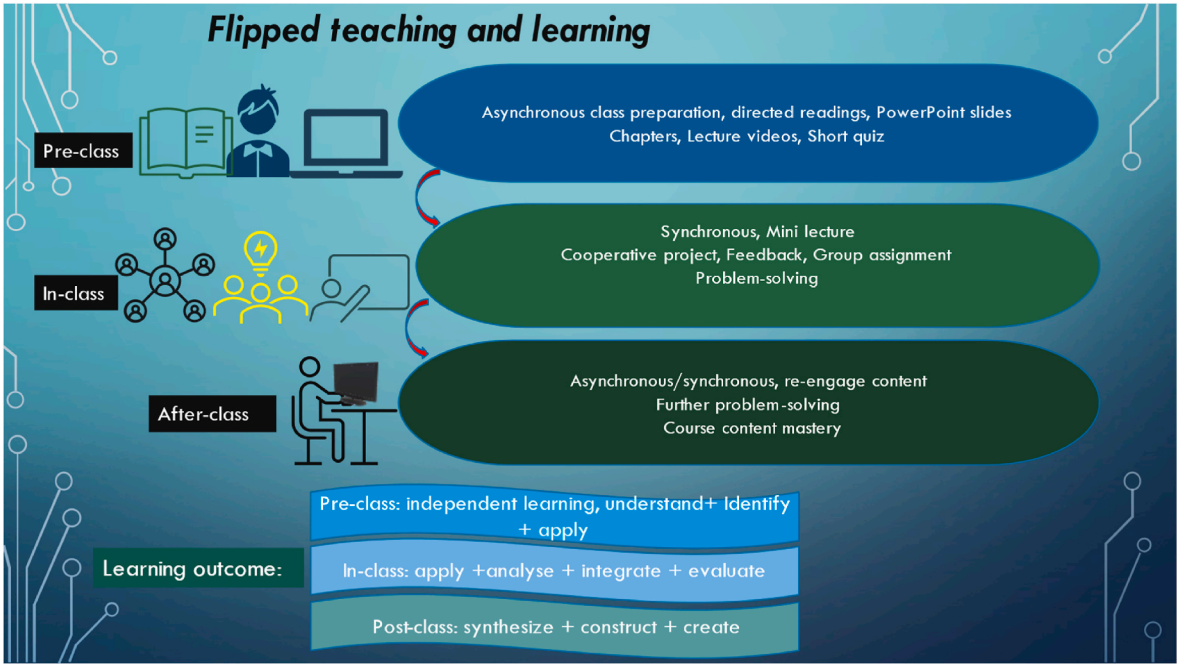

Fig. 3. Flipped T&L. Source: authors.

their students in groups. However, others would insist on both group and individual efforts. Submitting work in a group is preferable because it cuts down on the workload associated with grading and forces students to work together to solve problems, share resources, and reach a consensus on solutions. Consequently, a lighter grading burden means more time for constructive, in-depth discussions with students. The third stage will be built on the foundation of this input.

4.4.3. *Phase 3: After the scheduled seminar*

At this stage, students should reflect on their feedback and decide how best to use it. Here, students improve their relevant knowledge and metacognition by analyzing and reflecting on comments made by the teacher. Students implementing feedback has several purposes. Initially, it may enhance learning - this is essential if phase two omitted it. The student may improve their critical thinking by interspersing course material with material from other courses and the real world. Again, reflection serves as spaced practice. Spacing enhances memory recall and refreshes knowledge. The data from the third phase will allow the teacher to evaluate the comprehension growth of students from the previous two steps. This allows the lecturer to adjust their pedagogical practices and identify future activity themes in the curriculum.

Despite the effectiveness of the FC model, BL is the most effective T&L technique (Khalaf & Zin, 2018; N. Khan et al., 2021; Liu & Long, 2014). The relevance of BL is the opportunity it creates to effectively combine E-learning, FC, f2f, SCALE-UP, and other T&L options in a complementary manner, as shown in Fig. 4 below. According to Border et al. (2021) and Stack (2015), BL produces more effective academic outcomes than traditional f2f classrooms or e-learning alone.

All instructional formats have advantages and disadvantages (Okaz, 2015), and BL is no exception. A study reported that some teachers viewed BL as challenging to manage (Ashraf et al., 2021). However, this shortcoming necessitates careful design, training, implementation, and evaluation (Khan et al., 2021). Blending pedagogical strategies – improves learning skills and enables more students to be involved in learning (Fisher et al., 2021; Khan et al., 2021; Okaz, 2015; Rao, 2019). Khan et al. (2021) reported that students believed that BL enhanced their understanding of lecture content, boosted interaction, and increased learning efficiency significantly. This is a good reason to embrace BL because the demands of students and the education environment in SA need a more active, involved, and student-centered HE system that encourages personal obligation, liability, and independence (Daniel, 2016).

To sum up, BL, with its diversified and multi-modal approach, offers students flexible alternatives to engage in novel and varying T&L - thus, balancing the advantages and disadvantages of the adoption of sole PBL, E-learning, SCALE-UP, FC, and f2f – which qualifies BL to be the most effective pedagogical strategy.

4.5. *Challenges of blended learning in SA*

There is no gainsaying that adopting HE4.0 is the way to fill the skill gap in I4.0. Nevertheless, institutionalizing blended T&L as HE4.0 pedagogy poses various challenges, especially in developing countries, including South Africa. In an attempt to blend teaching and learning, SA's HEIs will encounter issues attributed to connectivity, computer illiteracy, system and technical problems, equipment (Frank, 2021; Khan et al., 2021), electricity cut-outs, and gadgets (Kayembe & Nel, 2019; Okaz, 2015) and lack of financial resources (Morei, 2021), which are constraints to blended T&L and could create stark inequalities in student learning experiences across localities. For instance, some educational settings do not have generators as backups (Mhlanga, 2020); other challenges affecting the digital transformation of the education system in SA include inequality, exclusion, skills deficit, resource constraints, and the absence of a clear, integrative national strategy.

Some other challenges are attributable to the socioeconomic landscape. In the 2016 draft of the National Education Collaborations Trust (NECT, 2016) on the Status of ICT in South African education, the draft indicated the status of integrating technology in education in SA as follows:

> *Despite strategy and policy, execution is delayed, and capacity is limited. The objectives are unclear, and there is no system-wide coordinated plan. Access to technology is restricted and uneven across provinces and income quintiles. The lack of defined provincially integrated plans makes development fragmented and driven by solution suppliers. Solutions are not aware of resource limits. Various aspects of the school system have the substantial opportunity for improvement. System-wide change*

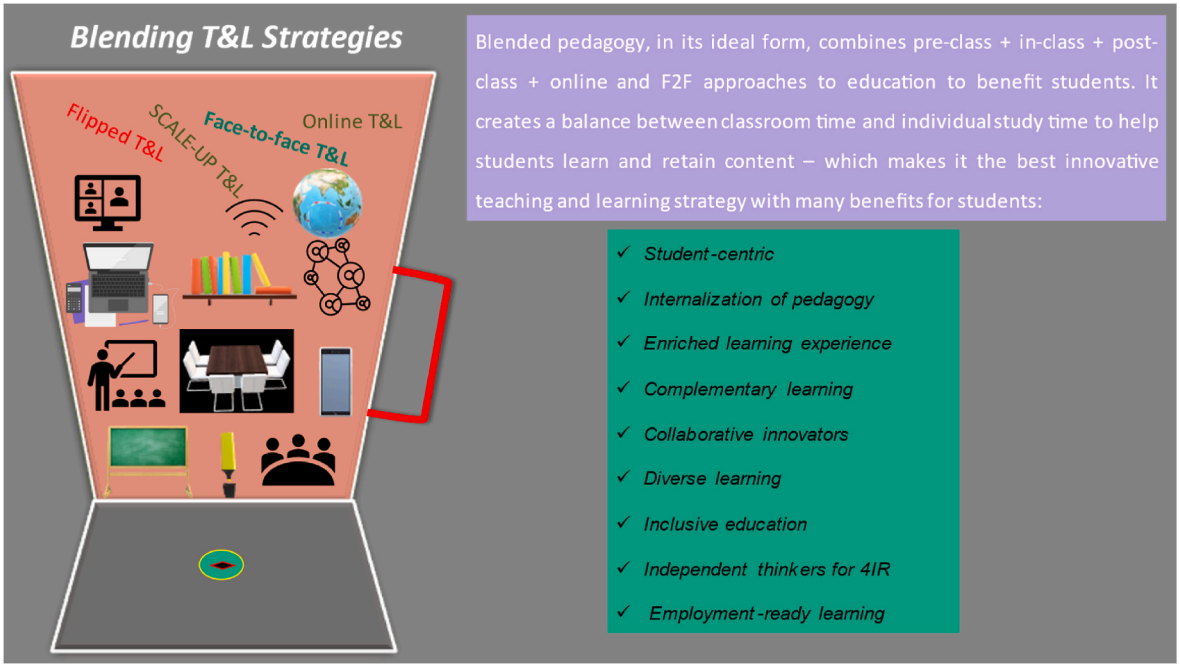

Fig. 4. Blended teaching and learning. Source: authors.

management must be prioritized, and ICT-enabled evaluation must be considered (Meyer & Gent, 2016).

On top of that, the shift to blended pedagogy has resulted in more work for teachers, who must now master online teaching techniques and design content optimized for this approach. As a result of these challenges, the traditional classroom model continues to dominate over blended learning pedagogy in SA (Beltran-Cruz & Cruz, 2013; Machumu et al., 2018). Consequently, transforming a f2f curriculum into a blended T&L approach that maximizes its potential calls for concentrated work, devoted technology, and pedagogical assistance (Protsiv et al., 2016).

Challenges militate against the efficient and effective blended pedagogical model in SA related to the resource constraints, consolidated national planning, development, provision, and digital components of the T&L ecosystem. To maximize the effectiveness of student learning, it is essential to choose pedagogical methodologies with consideration of their suitability in every educational ecosystem where all stakeholders will collaborate to co-create a sustainable blended T&L that will overcome students' academic barriers.

4.6. The need for change

At the time of the writing, a recent study in South Africa by Essop and Beselaar (2022) finds that while active learning methods are becoming more popular in the developed world, they are still in their infancy in the African setting and South Africa. The importance of active learning (Bishnoi, 2020; Essop & Beselaar, 2022; Freeman et al., 2014), problem-solving teaching, and learning strategy (Beyleveld et al., 2019; Kgwete & Malatji, 2021) can never be over-emphasized as it enables students to demonstrate their creativity and problem-solving skills needed for future jobs in the I4.0 (Moloi & Mhlanga, 2021).

Mhlanga and Moloi (2020) have stated that the South African education system has been lagging in promoting the innovation and creativity required in I4.0. The 4IR, like the previous industrial revolutions, has necessitated a new wave of transformation, including in the higher institutions of learning. However, the HEIs in SA "have not embraced 4IR as a lens through which to pursue transformation" (Masinde & Roux, 2020). The current structure calls for creative curricular re-imagining to meet students' current and future demands (Menon & Castrillón, 2019; Schwieger & Ladwig, 2018).

There is a chasm between what the government expects and what teachers do in South Africa, according to a study by Mooketsi and Chigona (2014). In SA HEIs, "lecturers could have different reasons why they would choose a specific teaching strategy including the government policy, education institution policy or management directive" (Beyleveld et al., 2019, p. 16).

The indication is that some policies and directives in the HEIs could hinder innovative pedagogy and students' academic success. This could be one of the reasons why Mzangwa (2019) concluded that attempts to amend the policy on SA's higher education have not translated into material benefits for most citizens in terms of social progress. We must note that if an academic environment (including institutional policies and directives) fails to provide a high-quality learning environment for its students, it has failed in its goal (Chigbu & Nekhwevha, 2021a).

Nonetheless, lecturers may choose to use specific instructional and pedagogical methods in their initiative (Beyleveld et al., 2019) because these pedagogical practices can make a difference in promoting both epistemological access and the success of students (Nyamupangedengu, 2017).

As Hénard and Roseveare (2012) explained, the efforts required to support excellent teaching are multi-faceted. Three tiers of interconnected support provide high-quality education.

i. At the institution-wide level: This may include policy formulation, organizational assistance, and internal quality control checks.
ii. Program level: This includes activities to evaluate and improve departmental and school programs' design, content, and delivery.
iii. Individual level: Including activities that assist teachers in realizing their purpose by pushing them to innovate, encourage student learning improvements, and embrace a learner-centered perspective.

Frank (2021) concluded that turning back the clock to how things were done before the pandemic would do nothing to help academics create the future of HE, teaching, and learning other than to keep in place the same inequitable and exclusive systems that were in place before. The issue is that students today are characterized by their ability to work together and share information as they seek solutions to problems using various strategies (Monaco & Martin, 2007). It will, however, need students, teachers, and officials from the institutions themselves to engage in collaborative thinking and constructive discourse (Díaz-Gibson et al., 2020; Jamaludin et al., 2020; Virolainen et al., 2021) to shape more innovative institutions which can serve a sustainable South African society (Mhlanga, 2020; Penprase, 2018). Therefore, the integration of SA HEIs curricula and instructional activities must aim to qualify the students to have future jobs (Allais, 2021; Chigbu & Nekhwevha, 2022) because, in the future, the issue may not be a lack of employment but a dearth of skills (Christiaensen et al., 2021; Maisiri & Van Dyk, 2021; Sutherland, 2020; Wakefield et al., 2022) that will depend entirely on I4.0 ideas (Chigbu & Nekhwevha, 2020b, (Chigbu & Nekhwevha, 2020a), (Chigbu & Nekhwevha, 2021b); Elayyan, 2021; Malomane et al., 2022; Moloi & Salawu, 2020; Ongbali et al., 2019).

It is time for HEIs to adapt to these changes to meet the rising needs of both students and employers (Okaz, 2015). According to Wessels and Wyk (2022), the 4IR can improve teaching and learning at SA institutions, but only if the country has a plan for institutional renewal that meets the anticipated needs of the 4IR. Although technology is the backbone of the 4IR, its demands may be addressed partly via flexible leadership, well-trained lecturers, and an understanding of the demographics of both the existing and future student body (Wessels & Wyk, 2022).

5. Conclusion and recommendations for future study

The 4IR is revolutionizing the pedagogical landscape globally, and South African HEIs are no exception. To date, little research has focused on innovative pedagogies in HEIs. Based on a systematic and narrative analysis of 138 academic journal publications, this work has revealed fresh insights into creative teaching and learning practices worldwide. After reviewing the literature on micro and macro innovative global pedagogies and their effectiveness in HEIs, we made a series of conclusions.

Based on our examination of existing research, the education sector in the period of HE4.0 and the 4IR has been trying to satisfy students' learning expectations to globalize, internalize, and advance teaching and learning. T&L in formal education has traditionally depended on the classroom method, which necessitates the instructor's and students' actual presence in a designated classroom. As the educational environment evolves to accommodate 4IR and HE4.0, software and devices are developed to support face-to-face, online, and remote teaching. The argument is that HEIs have been aware of the mutually beneficial interaction between HE4.0, I4.0, and Work 4.0. (a shift toward digital, flexible employment and the internalization of labor has become a cornerstone of today's economic landscape). Learning in today's smart manufacturing, services, and labor processes is best accomplished in new ways, and traditional T&L methods no longer work.

Further, in some developing countries, including SA, adaptation to HE4.0 pedagogy was slow with gradual improvement, although COVID-19 influenced the remodeling of T&L patterns in these countries. Further, COVID-19 changed the reluctance and lack of interest of many HEIs across many nations in introducing novel T&L. Considering the

future of work; it is unlikely that most HEIs would forsake their newly obtained T&L skills and its deployment in favor of reverting to rigid pedagogies that do not expose students to the methods of learning necessary in the 4IR. However, Section 4.5's analysis of the challenges associated with innovative pedagogies raises serious concerns that may make its continued use impossible. All else being equal, the T&L expertise gained through virtual pedagogy should be creatively merged with f2f T&L to achieve the best out of innovative pedagogy.

We also conclude that blending PBL, E-learning, SCALE-UP, FC, and F2F teaching and learning strategies are the most student-centered, result-oriented, transformational, and sustainable pedagogy that ensures dynamic support, hands-on activities, practical assessments, active collaboration, and inquiry-based learning for students. Transgressive learning is what we need in our classrooms; it will develop collective agency, critical thought, and altered pedagogical habits that will explicitly challenge the status quo and drive social change. That said, all aspects of T&L must be centered on students' education, including culture, technologies, strategies, stakeholders, infrastructure, and policies of the HEIs. Our analysis of the literature has revealed that for us to achieve blended teaching and learning and sustainable student-centered academic progress, all the T&L ecosystem components must work collaboratively towards transgressive, innovative, transformative, sustainable, and inclusive education with the 4IR and HE4.0 in mind. Our review further shows that I4.0 is revolutionary, introducing an innovative and technology-based approach to business and service delivery and requiring capable humans skilled to function in modern industries characterized by technological improvement, innovation, and creativity.

We call the HEIs in SA and globally to co-create training, resources, and frameworks that strengthen teachers' ability for pedagogical innovation, such as digital literacy and student-centered teaching skills, to optimize learning as students return to in-person classes. Notably, working knowledge of all pedagogical strategies and breaking them into manageable, achievable activities will assist HEIs teachers in developing a more effective T&L approach. Perhaps, an initial classroom conversation is an excellent starting point to get insight into how students feel about the teaching and learning processes. Ultimately, instructors may determine the educational style that best matches the requirements of each student via creativity and experimentation.

We expect to see more innovative pedagogy initiatives, hybrid, and blended learning, to address the challenges HEIs and students face today. For HEIs to progress, the government of SA, education policymakers, teachers, and other stakeholders identified in the learning ecosystem have a significant role to play, perhaps incorporating a clear roadmap towards adopting HE4.0 pedagogical model necessary to produce the workforce in demand for I4.0. Hence, training lecturers to provide capable hands to pilot the effective implementation of HE4.0 in South African institutions should be prioritized. More so, HEIs should also ensure an adequate number of teachers and T&L support staff. This will also make it possible to implement a successful and effective blended pedagogy by reducing the workload of each lecturer. Finally, students, especially those from poor socioeconomic backgrounds and prone to T&L exclusion, should be assisted with the requisite gadgets to benefit from the blended T&L system. We acknowledge the limitation of our language bias as our review search has returned documents in English only. Also, the systematic literature review adopted in this study might not have been enough to capture the in-depth reasons why teachers would embrace traditional methods of teaching than blend their pedagogy - even after the COVID-19 pandemic.

5.1. Future research directions

Thus, future research can look at the gaps in HEIs policies that limit effective blended innovative teaching and learning strategies – considering the wholesome institutional learning ecosystem.

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The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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CRediT authorship contribution statement

BiancaIfeoma Chigbu: Conceived and designed the experiments; Performed the experiments, Formal analysis, Analyzed and interpreted the data, Contributed reagents, materials, analysis tools or data, Wrote the paper. **Viwe Ngwevu:** Conceived and designed the experiments; Performed the experiments, Formal analysis, Analyzed and interpreted the data, Contributed reagents, materials, analysis tools or data, Wrote the paper. **Avela Jojo:** Conceived and designed the experiments; Performed the experiments, Formal analysis, Analyzed and interpreted the data, Contributed reagents, materials, analysis tools or data, Wrote the paper.

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