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Learning to teach with simulation: historical insights

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Abstract

Simulation-based learning (SBL) has been trialed and embedded in many disciplines and professions over many years to practice complex skills before embarking on real-life applications. Much research has confirmed the benefits of SBL and found simulations are among the most effective means to facilitate the learning of complex skills across domains. Yet, despite this evidence-based support for SBL, teacher education continues to be slow to adopt and embed SBL within their programs. This paper compares literature on two of the longest and widest adopted simulated programs in teacher education, *Second Life* and *simSchool*—to gain insight into the research types, findings and reasons for limited implementation. The findings support previously confirmed pedagogical benefits of SBL increasing student self-efficacy and reveal commonalities and differences between the two simulated platforms and a lack of adoption of SBL that centres around costs, accessibility and technical issues. The findings are positioned in practice-theory literature and highlight SBL's ability to provide preservice teachers with a 'third space' where theory can be practiced, rehearsed and reviewed virtually before real classroom transference occurs. We offer recommendations that will stimulate future research and support wider adoption of SBL in Initial Teacher Education (ITE).

Keywords Simulation · Initial teacher education · Practice-theory · Simulation-based learning · Third-space

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Introduction

Throughout history, we have found ways to replicate real-life scenarios through authentic experiences and trialed and embraced these within a range of professions to practice and improve our skills, knowledge and understandings. From medical procedures to flight simulations, students are provided opportunities to practice learned skills or actively solve problems in scenario-based simulations of real-life situations (Owen, 2012). These real-life scenarios continue to become more sophisticated with the onset of emerging technologies and advances in the field (Levin et al., 2023). For example, in the medical field, bronze and wax anatomic models with acupuncture points were used in 987–1067 by Wang Wei-Yi, the Chinese imperial physician responsible for standardizing the teaching of acupuncture. Articulated skeleton models and birthing simulators were introduced in the 18-nineteenth century using glass, wax, and plaster to prepare students for difficult birthing situations. More recently, technology has replicated most medical procedures from the simple learning of how to draw blood through to robot-controlled surgeries. The medical field continues to embrace SBL as an essential component of their pre- and in-service training within the profession.

Almost 60 years ago, the importance of real-life scenarios or scenario-based learning progressed to simulation-based learning (Vogel et al., 2006). SBL was recorded as being a beneficial tool for the preparation of future teachers (Steel, 1965). During this time, Kersh (1965) developed a classroom simulator where student teachers watched a simulated class on a large projector screen, using film sequences and slides to depict scenes for the students to respond to. The study involved a randomized control trial which showed the simulation group gained more self-efficacy and were three weeks ahead of their peers in terms of 'classroom readiness' (Kersh, 1965). Emerging technologies saw the introduction of computers and simulation gaming being developed to make complex SBL models feasible for classroom learning (Wing, 1966). SBL during this time was found to provide a closely controlled environment enabling the designer the opportunity to present the student teacher with situations often not readily available in the real world. Even though the benefits of SBL were evident, Cantrell and Edwards (1974) were concerned that few teacher training simulations were being developed or used in teacher education programs, even though realistic re-enactments of classroom situations were possible using audio and video taping, sound films and an electronic computer (p. 2). Simulation was observed to provide student teachers with a realistic, responsive environment employing a sense of immediacy and involvement (Beck & Monroe, 1969). Simulations were also proven to be un-threatening, allowing teacher education student teachers to practice decision-making without the risk of censure and embarrassment (Cruickshank, 1966). The compressed nature of the experience, and replicable nature of simulation also allowed for targeted repetition of interactions to improve performance (Cantrell & Edwards, 1974).

Even though the benefits of SBL in ITE have been well-documented (Chernikova et al., 2020; Dieker et al., 2014; Ledger et al., 2022) global adoption and

implementation of SBL in ITE programs remains sporadic and ad hoc (Ledger et al., 2022). Over the last two decades a range of simulations have emerged within teacher education including a range of single user simulations and multi-user environments including: simSchool (Gibson, 2011); teachlive (Dieker et al., 2016); Mursion (mursion.com); Second Life (Dalgarno et al., 2016); Classroom Sim (Aha!Process, 2012); At Risk High School Educators and Step in/Speak Up (Kognito Interactive, 2012); Cook School District simulation, and Connect-ed (Commonwealth of Australia, 2014). The complexity and challenges of embedding SBL into ITE programs either single user or multi-use, still prevail and uptake remains limited, particularly when compared to other professions (Ledger et al., 2019; Salmon, 2009).

Sixty years after the initial SBL studies, we are still evaluating the advantages and limitations of SBL in teacher education. (Ledger & Fischetti, 2020; Ledger et al., 2022). However, as Boocock (1967) pointed out, "the more innovative a new technique is, the greater the difficulties of dissemination" (p. 94). As the evidence mounts over time about the benefits of SBL, the lack of dissemination and implementation becomes more of a concern. This study builds on the foundational findings from the 1960s to investigate two of the longest-standing and most adopted simulation platforms within ITE—simSchool and Second Life—to reveal historical insight into research evidence and solutions to wider dissemination. Second Life developed by Linden Lab in 2003 was embraced by over one hundred universities and colleges and listed on simteach.coms wiki Institutions and Organisations in Second Life (simteach.com, 2008). simSchool originated in 2003, as part of the US Department of Education's "Tomorrow's Teachers to Use Technology" program (Gibson, 2006). In 2015 simSchool had 12,000 registered users in over 156 countries (Hopper, 2018). Second Life is a freely available platform but multiple users within universities pay for access to increased levels of technical support and simSchool is paid at an institutional level based on number of users. Both platforms are two of the longest-standing simulated platforms adopted in teacher education. However, Teachlive™ and Mursion™ have entered the global field over the last decade with a growing and targeted body of research emerging in the field.

This study focusses on Second Life and simSchool because they are the longest-standing platforms adopted in ITE. A recent systematic review of Second Life (Ledger et al., 2022) will be used to compare the findings of a systematic review on simSchool undertaken in this study. Commonalities and differences in terms of research type, operational constraints, pedagogical benefits and quality of evidence from the comparison will expose insight and research recommendations and operational insight for implementation. The significance of this study supports Chernikova et al. (2020) conclusion that 'simulations are among the most effective means to facilitate the learning of complex skills across domains' (p. 499).

This study informs the design of future research related to new and emerging simulated technologies that support the development of teaching skills, practices, and research within ITE programs and also provides recommendations for broader dissemination in the preparation of future teachers to help overcome previous challenges.

This study is positioned within the wider literature of practice-theory (Woolgar, 1998) and teacher preparation. The belief that supports this perspective is that educators require a blend of both theoretical and practical knowledge, to comprehend the methods and reasoning behind their teaching and need to possess the ability to self-evaluate and improve upon their technique. Orchard and Winch (2015) argue for a conception of teachers as professionals who require a deep understanding of the conceptual, empirical and normative dimensions of educational practice. Unfortunately, calls for practical-only teacher education (Lawlor, 1990) or school-based teacher education in response to current teacher shortages, are reducing teaching and teachers to narrowly focused technical skills and teacher technicians imparting content knowledge to children (Orchard & Winch, 2015). The utilisation of practice without theory in education is a short-sighted and detrimental approach to the field, as the imparting of knowledge is not a simplistic endeavour, but rather a multifaceted process that encompasses the facilitation and shaping of the learning experience.

Practice-theory suggests we acquire the skills necessary to become a teacher through a combination of hands-on experience in the field, theoretical study, and simulations (Steel, 1965). One of the original methods of learning how to teach future teachers involves micro-teaching (Allen & Eve, 1968; Ledger & Fischetti, 2020). Since the 1960s, micro-teaching dominated initial teacher education as a strategy used to practice teaching skills. Originally, school-aged students were used within a practice classroom that simulated a small group context. Student teachers 'taught' a lesson to the small group in a reduced period of time (micro-teaching). After the interaction, the student teachers reflected on their interactions and identified areas to improve and areas of strength. This pattern of reflective practice is repeated for continual improvement to occur. The use of simulation offers a 'third space' for this reflection and interaction. The third or virtual space allows opportunity to experience, evaluate and practice the skills and knowledge involved in teaching to gain confidence for the challenges of the classroom. Bhabha (1994) considers third spaces as creative spaces where possibilities, ideas and relations can be constructed. Third space helps link theory and practice (Land et al., 2014) and offers reflexivity to change, improve, practice and for sense-making to occur. Virtual spaces and avatar (an icon or figure representing a person in a virtual environment such as gaming and simulation) form the foundation of a simulated learning platform. Samuelsson et al. (2022) suggests training with avatars enables the user to experience four factors described by Bandura et al. (1999) as: enactive mastery experience, vicarious experiences, verbal persuasion, and physiological and affective states. Samuelsson et al (2022) suggest that short periods of intense training with avatars, combined with feedback, significantly enhances student teachers' self-efficacy. The interactions and subsequent reflections on the interactions were completed simultaneously. However emerging technologies have seen adaptation of the traditional micro-teaching approach. With the onset of video, live micro-teaching interactions were captured and stored allowing reflective practice on the interactions to be completed asynchronously or with larger audiences. More recently, simulation technologies replicate the classroom environment using virtual class settings and avatars.

One of the first and longest applied SBL tools for classrooms is simSchool™ developed in the early 2000s at the Vermont Institute for Science, Mathematics and Technology and continues to be used globally. A decade later Second Life emerged as a social platform and was adopted for educative purposes (Dalgarmo et al., 2013). Twenty years after simSchool, mixed reality options have evolved which enables student teachers to interact synchronously with a virtual classroom of avatar students. This latest technology involves a human in the loop professional actor (interactor) operating as a puppeteer, morphing sound and manipulating movements so that the avatars look and feel like real-life students. The origins of this mixed reality learning environment lay with a team of academics from the University of Southern Florida (Dieker et al., 2014). Academics from teacher education programs have led each of these teaching initiatives, borrowing technologies used in other professions and developing them to reflect the skill development needs of future teachers. These recent hybridizations of technologies foreground pedagogy over technology, in their pursuit to embed technology into ITE (Aubrey-Smith, 2021).

The importance of pedagogy driving the adoption of technologies in initial teacher education (ITE) underpins this study. By exploring research that has been undertaken on the two longest standing and most widely adopted simulated platforms over the past two decades will help inform the move to mixed reality options and future research on emerging technologies to further advance the pedagogical advantages of SBL to prepare teachers. The significance of choosing both Second Life and simSchool is that they are the oldest and most researched simulation-based program employed in initial teacher education. The technological complexity of the simSchool program positions it as the only platform which allows for interaction to occur as well as automated feedback (Ledger & Fischetti, 2020). It provides a combination of interactive simulated teaching environments and automated feedback for educators in a game like context.

By focusing on research over the last 20 years, captured in systematic reviews of current literature on Second Life (Ledger et al., 2022) and Simschool (this study) this study aims to expose the depth and breadth of research undertaken to help inform a research agenda for future simulation-based technologies including the more recent mixed reality learning environments such as TeachLive™ and Mursion™.

The paper is structured in three parts aligning with the research questions that form the basis of the comparative review:

a. What are the trends exposed in Second Life literature implemented for ITE as revealed in the systematic review by Ledger et al. (2022)
b. How do these trends compare with the trends from simSchool literature captured in this systematic review?
c. What can we learn from literature on the two most widely used simulated technologies over the last two decades to support and inform future research and adoption of simulated learning environments in ITE programs?

The first section of the comparative review highlights key findings from a recent systematic review of Second Life (Ledger et al., 2022). The second

presents a scoping review of simSchool literature and compares these findings with the findings from Second Life. The third summarizes the findings from each review highlighting trends and makes recommendations about future research on emerging technologies and the wider dissemination of simulation in ITE.

Methods

This multi-method comparative review consists of three phases. Firstly, a summary of systematic reviews of Second Life literature was conducted to capture and reveal the scope of research undertaken on the platform. Secondly, a systematic review of simSchool literature from 2002 to 2022 was conducted to align with the review of Second Life literature. The findings from the simSchool review were compared to those of Second Life. The aim of this comparative review was to identify analytical themes related to theoretical, methodological, and pedagogical foci of literature as well as locations. The two SBL platforms are the most widely adopted in teacher education and comparing them allowed for synthesis and summary of their use in preservice teacher preparation to guide future implementation. The results will help inform future research on SBL and provide recommendations for broadening SBL use in ITE programs.

Summary of Second Life literature

The first section summarises recent systematic review of 24 articles lon Second life (SL) implemented in teacher education programs (see Ledger et al., 2022). The corpus of literature reveals research type, characteristics, learning affordances implementation and applications of SL (Dalgarno et al., 2013; Duncan et al., 2012; Ledger et al., 2022). Duncan et al. (2012) developed a taxonomy of virtual worlds (VW) in response to the widespread and increasing usage of

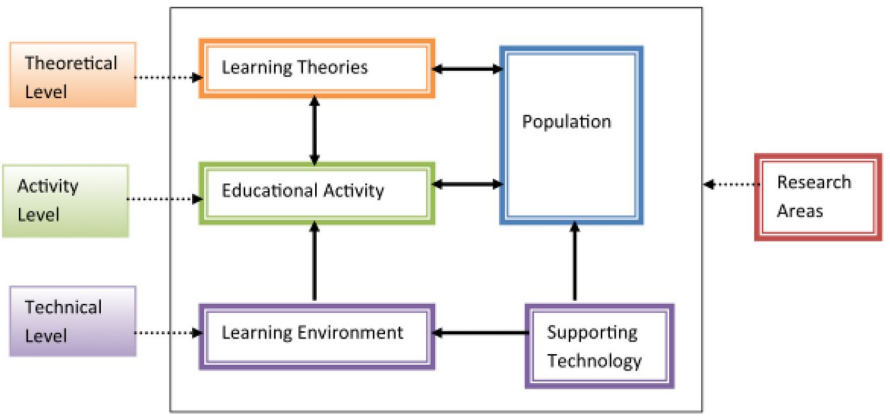


Fig. 1 Hierarchy relationships between categories within Duncan et al.'s (2012) taxonomy

VW and SL. The taxonomy differentiated population (who), educational activity (what), learning theory (why), learning environment (where), supporting technologies (how), and research areas/type. Hierarchy relationships were identified within the taxonomy—theoretical level, activity level and technical level. Much research during this time focused on activity level and technical level. For instance, Ryan (2008) outlined 16 pedagogical approaches to the use of SL aligning to Duncan et al. (2012) activity level (Fig. 1).

A systematic review by Dalgarno et al. (2013) of Virtual Worlds (VW) including Second Life (SL) captured implementation concerns that were directly technical, identity, cultural, collaborative, time, economic, standards, and scaffolding issues. Kelton (2008) classified the challenges into four categories—perceptual, technical, operational and pedagogical. The issues and challenges exposed in SL research are similar to studies of early adoption of other technologies for teaching and learning in higher education (see. Leggett & Persichitte, 1998) who reviewed 50 years of technology uptake in higher education and suggest time, expertise, access, resources and support as key implementation obstacles.

Dalgarmo et al.'s (2013), systematic review of literature ($n=371$), online questionnaire ($n=117$) and interviews ($n=13$) identification of higher education staff interested and using immersive virtual worlds in Australia and New Zealand revealed Second Life as having 75% of the worldwide immersive virtual world usage by platform. It also discussed the emerging competition Second Life had in the field by public and private platforms such as *OpenSim.* The authors predicted a gradual rationalization in the number of emerging platforms including large network platforms such as Google+ and Unity 3D. They also predicted growth in mobile virtual world, blending of real, virtual and online spaces and user interface enhancements.

A systematic review by (Ledger et al., 2022) explored trends in the benefits and limitations of Second Life (SL) in initial teacher education (ITE) during 2003–2020. They noted that simulated platforms are helpful but underutilized in ITE and suggested that SL has the potential to facilitate an environment in which the three elements of Grossmans' (2009) Pedagogies of Practice (representations, decomposition and approximations of practice) can be taught and made explicit. The literature reviews of SL during this time included the effectiveness and impact of SL in ITE; and how SL has been used to augment field experiences for pre-service teachers. The empirical/descriptive studies focused on SL in teaching and learning (Blankenship & Kim, 2012; Gregory & Masters, 2012), role play and professional experience (Cho et al., 2015), simulation teaching practice (Ke et al., 2016), collaborative learning (Kim & Blankenship, 2013; Mørch et al., 2018), the role of SL in teacher professional development (Cho et al., 2015), application of SL for rural and remote teachers (Gregory et al., 2014), the use of SL for foreign language education (Tuncer & Simsek, 2015) and student experiences and perceptions of SL(Masters et al., 2015; Mørch et al., 2018).

According to Ledger et al. (2022), benefits of SL focused on pedagogic transformations (Kim & Blankenship, 2013), replicating real world role-plays (Cho et al., 2015), opportunity to engage in collaborative and reflective practice (Muir et al., 2013; Nussli et al., 2014; Oh & Nussli, 2014), sense of place and self (Teoh, 2012), positive online presence and virtual teaching performance (Badilla Quintana et al.,

2017), and confidence for those that feel self-conscious in real-life settings (Mørch et al., 2018).

Limitations of SL literature were described as difficulties accepting or relocating real-life experiences within a virtual environment (Blankenship & Kim, 2012) and scepticism in translating real worlds within virtual contexts (Guzzetti & Stokrocki, 2013). In addition to issues transferring and accepting real world contexts in virtual worlds, the majority of concerns centred on technical difficulties with interface, hardware and software issues (Muir et al., 2013; Oh & Nussli, 2014). Students using SL had the potential to be exposed to inappropriate content within the VW platform (Kuznetcova & Glassman, 2020). Literature recognized the anxiety that could occur during the steep learning curve required to navigate around SL and general lack of confidence surrounding virtual technology (Bower et al., 2017).

Across the sector there was a lack of institutional policies and guidelines related to virtual worlds and IT coupled with lack of funding available within institutions to support the use and development of VW. This resulted in commercial enterprises capturing the market. This process adds another layer of perceived tension between adopting commercial products initiated within universities or only university products.

The findings from the Second Life literature confirm of the benefits of including SBL In ITE. It also highlighted the issues impacting the uptake of SBL in ITE, namely, costs, technical difficulties with software and hardware, sustainability of the staff and programs and the lack of institutional policies and guidelines related to virtual worlds. Many of the pedagogical challenges related to the acceptance of accepting simulation as an alternative pedagogical equivalent to practicum (Guzzetti & Stokrocki, 2013), these align with Kelton's (2008) four categories of ITE challenges-related toimplementation—perceptual, technical, operational and pedagogical.

Scoping review of simSchool

The scoping review of simSchool literature attended to similar elements featured in the Second Life review. Both are grounded in the belief that pedagogy should guide the integration of technology in initial teacher education. Through this analysis, the study identifies the theories, methods and pedagogies used to capture knowledge transference within simSchool implementation in ITE programs over the last two (2) decades. The reviews identified regions, countries, years, and foci of each study. The analysis identified themes and gaps across these domains as outlined in the findings and provides a glimpse into the changing directions of simSchool research which might ignite discussion for future directions and technological transformations in ITE.

Data collection

A scoping review was conducted on simSchool literature guided by the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping

Reviews (PRISMA) (Tricco et al., 2018). Databases for sources of information were drawn from Scopus, Web of Science, ERIC, ProQuest and Google Scholar. Preliminary search terms were developed to reflect the focus on "simSchool" research between "2002–2022". Using search terms such as "SimSchool", "SimSchool Simulation", "SimSchool Virtual Simulation", and "SimSchol Research", the initial search yielded 194 studies which were reduced to 54 after implementing the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) protocols (see Fig. 2). The criteria for inclusion involved included peer reviewed journal articles s and all research on simSchoollinked to initial teacher education and teaching contexts. Only English texts on simSchool were

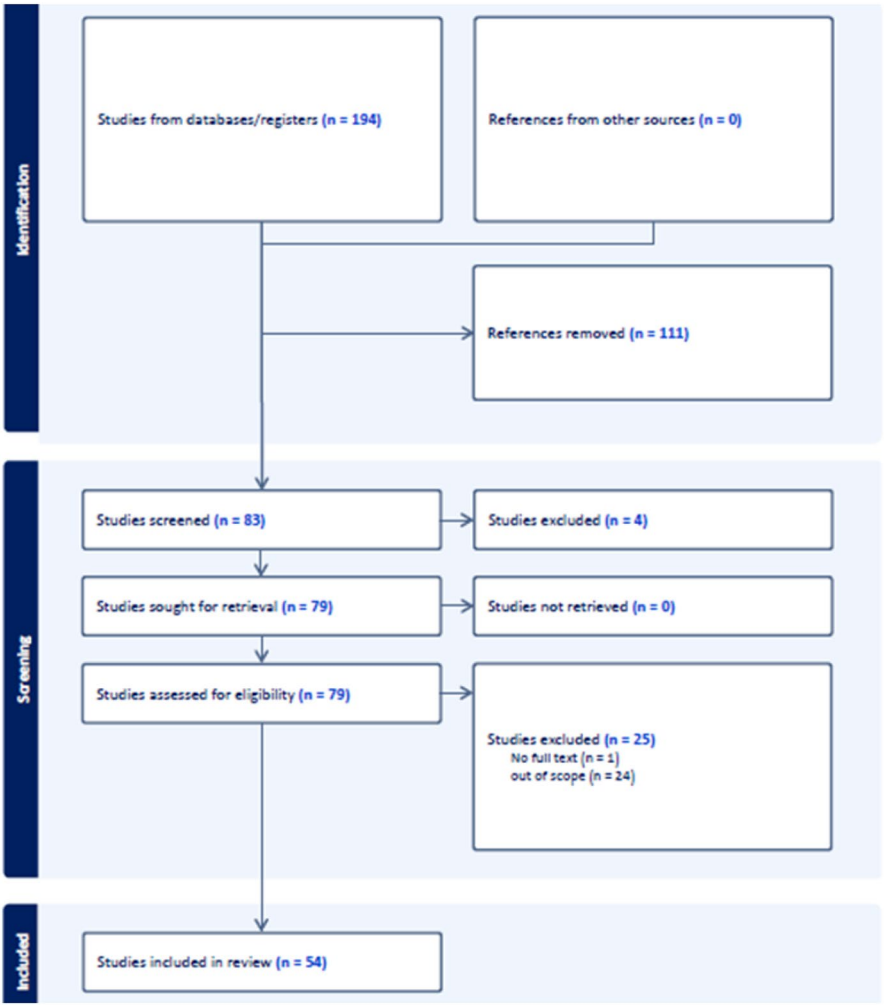


Fig. 2 Preferred reporting items for systematic reviews and meta-analysis (PRISMA) of simSchool Search

Table 1 Interrater reliability

Reviewer A Yes, reviewer B Yes	Reviewer A Yes, reviewer B No	Reviewer A No, reviewer B Yes	Reviewer A No, reviewer B No	Proportionate agreement	Yes probability	No probability	Random agreement probability	Cohen's Kappa
61	0	19	3	0.771	0.708	0.010	0.718	0.188

included. Exclusion criteria included commentaries, magazines, grey literature and non-English texts.

The review process revealed 194 studies that were collated in Endnote and transferred to Covidence software (*Covidence*) (2021). Using Covidence processes, each of the abstracts were previewed and interrater reliability were calculated. Full papers were previewed thereafter by the same two researchers and screened for inclusions and exclusions. Interrater reliability of the full papers was 0.771 (see Table 1).

Duplicates were removed from the abstract screening ($n = 111$) and irrelevant texts, such as promotional material, were excluded ($n = 4$), see Fig. 2. A total of 79 studies were retained at this point.

Further reduction and extraction were employed by the authors because of identification of anomalies within the system including the removal of out of field and technical reports. During this process, 22 studies were excluded. As a result, 54 studies were retained for further analysis.

Data analysis

Data were extracted by the authors (redacted for review purpose) and categorized according to year, author, country of research, aims, research methods/design, theoretical underpinnings, and outcomes. Tables, graphs and figures were used to collate findings and key themes emerged within this process of analysis. Study characteristics, context, quality and findings are reported, and similarities and differences compared across simSchool findings and Second Life. Textual and thematic synthesis of the literature was undertaken in tandem allowing gaps in the literature to be revealed and the potential for hypothesis generation to occur (Lucas et al., 2007).

Findings from scoping review of simSchool literature

Overall, the scoping research analysed research in terms of research type, methodology, authors, years, country, participants, aims and theoretical underpinnings analyzed within this study varied substantially but key themes and gaps were revealed that will inform research on future simulated platforms adopted in initial teacher education. Themes related to each of the analysed areas—research type and methodology, authors, publications, country of research, participants, aims and theoretical underpinnings are identified below.

Research type and method

Of the 54 studies analyzed, six were literature reviews, thirteen technical applications and design studies, and the remaining 35 were empirical studies. The papers were grouped by method as defined in the papers. The majority of papers were classified mixed method (50%), quantitative (30%) and qualitative (20%). The following Fig. 3 provides an overview of the research methods outlined. Evidence of longitudinal research on simSchool was found (Knezek et al., 2012). This uneven distribution of research methodologies on simSchool should inform future research design.

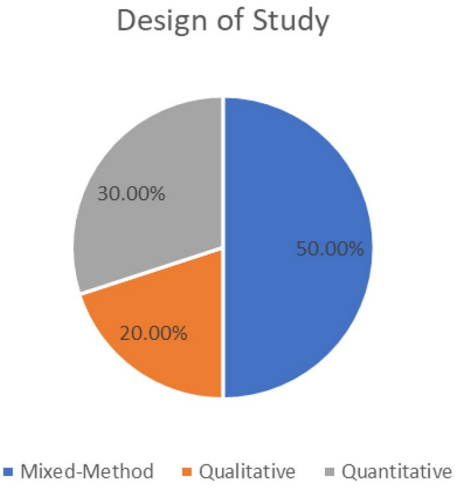


Fig. 3 Overview of research methods undertaken in simSchool Research 2002–2022

Fig. 4 Authors of simSchool Research 2002–2022

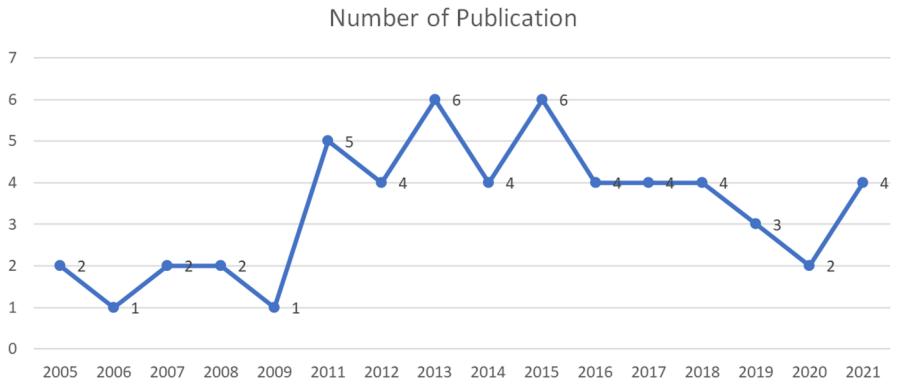
Authors

David Gibson, Rhonda Christensen, Gerald Knezek and Tyler-Wood have produced much of the literature on simSchool (Fig. 4). Professor Gibson was one of the original developers of simSchool. Figure 4 provides a Word Cloud of key authors of simSchool research during this period of literature review.

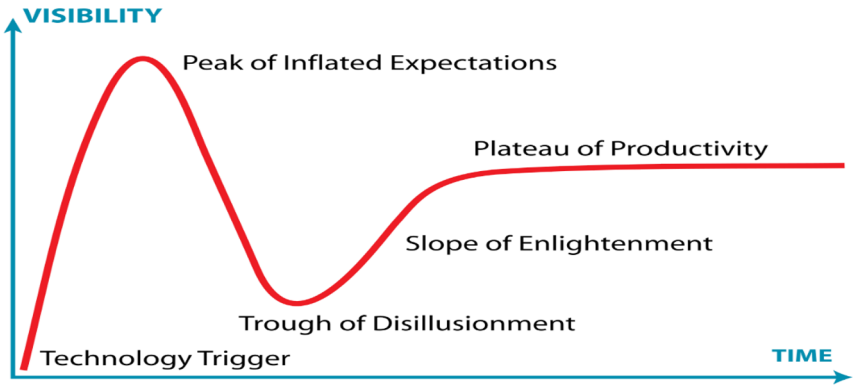
The text size represents most prominent authors in the field. For instance, Gibson has 14 publications, accounting for 8.70% of the total, followed by Christensen with 12 publications (7.45%). Knezek has 11 publications (6.83%), while Collum, Wood and Tyler have 7 publications each (4.35%). Other researchers in order of publication outputs include Bishop, Delicath, both with 5, Hopper with 4, Dennis, Johnston and Kruse with 3, and Badiee, Bush, Deale, Den, Fluck, Hall, Mavrotheris and Kaufman all with 2 publications. The recent increase in simSchool publications is heralding new researchers studying simSchool such as Ko and Ko (2021)

Publications per year

The number of publications on simSchool between 2002–2022 show a range of peaks, troughs and plateaus. Gartner's Hype Cycle (2022), provides a typical graphic representation of the maturity and adoption of technologies and applications, see Fig. 5b. The adoption of simSchool in ITE follows a similar pattern. The hype cycle separates hype from real drivers of the uptake of technology. The cycle captures five phases of a technology's life cycle: innovation trigger; peak of inflated expectations; trough of disillusionment; slope of enlightenment; and plateau of productivity. Since the inception of simSchool in 2002, research was limited, peaking between 2013–2015, plateauing in 2016, and dropping in 2018–2020, but is seeing a resurgence in outputs in, 2021 (see Fig. 5a). The latest publications align with the 2018 and 2019 modifications to the simSchool



a Number of publications of simSchool 2002-2022



b Gartner's Hype Cycle

Fig. 5 **a** Number of publications of simSchool 2002–2022. **b** Gartner's Hype Cycle

platform which developed a wider range of avatars with regard to of age, blended assistive and mobility devices into the simulations, gender and appearance, and wider range of scenarios that related to diversity, and challenges of poverty and trauma within the school settings.

Country of research

It is not surprising that the majority of publications have emerged from the United States of America (U.S.A.) since it is the home of simSchool and has the widest dissemination within initial teacher education programs than any other country (see Fig. 6). However, simSchool has continued to be modified over the years and has become a highly customizable dynamic form of SBL capable of being adjusted to suit differing educational, geographical, age, or classroom contexts as well as being scalable. simSchool has differentiated payment schemes for developing countries as outlined in the operational guides available on their website.

Synthesis of SimSchool research

The majority of the 54 papers reviewed were conducted on preservice teachers in initial teacher education programs and were grouped as empirical or technical papers. The empirical studies overall were designed to capture teachers' knowledge and skills; teachers' self-efficacy; teacher behavior and teacher perception. The studies on in-service teachers were primarily responses to perception and utilization. Although nine studies crossed between in-service and pre-service realms, no studies were specifically related to in-service only. A synthesis of the empirical literature and the common themes are outlined in Table 2.

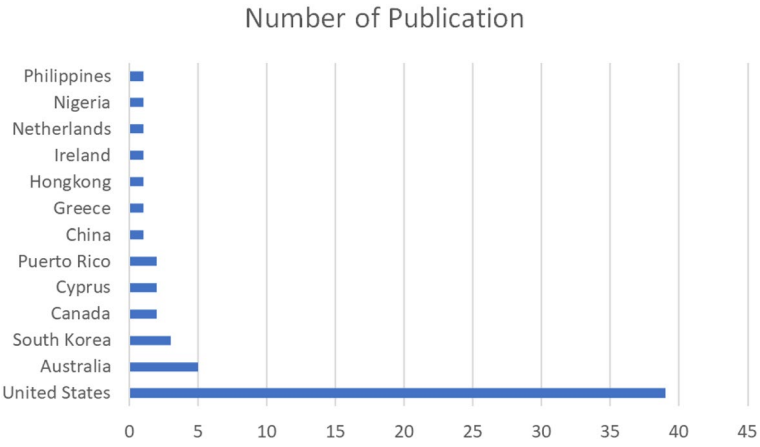


Fig. 6 Number of simSchool publications and country

Table 2 Synthesis of simSchool research (pre-service and in-service)

Pre-service teacher	Teachers' knowledge and skill
	simSchool enhances pre-service teachers' understanding of the use of differentiated instruction for diverse learners (Johnston & Collum, 2018)
	simSchool activities result in gains in teaching skill (Gibson et al., 2011)
	simSchool increase pre-service teachers' abilities in diverse areas of teaching, including instruction, activities, facilitation, and material use (Lee & youn Ahn, 2021)
	simSchool helped pre-service teachers realize their weaknesses in teaching and enabled them to transfer their newly learned knowledge to practice (Lee & youn Ahn, 2021)
	simSchool contributes to raise awareness and build and enhance pedagogical knowledge and skills in various areas without worrying about consequences (Knezek et al., 2015)
	Technology skills are improved by the simulated environment however some types of pedagogical skills show greater improvement due to the simulation (Knezek & Christensen, 2009)
	The use of simSchool holds promise for helping students develop a better understanding of student characteristics in a classroom setting (Sorohan & Thomas, 2016)
	simSchool engages the pre-service teachers in a simulated school and promotes contextualized decision-making (Foley & McAllister, 2005)
	Teachers' Self-Efficacy
	Pre-service teachers gain a sense of instructional self-efficacy more rapidly using the simulator, compared to traditional teacher preparation classes and related activities (Gibson et al., 2011; McPherson et al., 2011)
	simSchool activities result in gains in instructional self-efficacy (Christensen et al., 2011)
	Teacher Behavior
	Participants experienced more positive and less negative emotions during play with simSchool, including excitement, motivation and satisfaction (Kalliopi Evangelia Stavroulia et al., 2016)
	simSchool generated real-time emotions to pre-service teachers (Kalliopi Evangelia Stavroulia et al., 2016)
	Teacher Perception of simSchool
	Pre-service teachers were much more enthusiastic about simSchool (Bush & Hall, 2013)
	Pre-service teachers had very good perception of the simSchool platform. simSchool can help in ameliorating the challenges of teaching practice and practical teaching (Oteyola et al., 2020)
	Pre-service teachers found simSchool is an instructional program of educational value (Badiee & Kaufman, 2014; Rayner & Fluck, 2014)
	simSchool provides experience that simulated a real classroom in a virtual setting (Lucy Bush et al., 2012a, 2012b; Hopper et al., 2013)

Table 2 (continued)

Pre-service teacher	Teachers' knowledge and skill
In-Service Teacher	*Teacher perception of simSchool*
	The responses from in-service teachers were less supportive of simSchool than the pre-service teachers (Lucy Bush et al., 2012a, 2012b)
	Compared to the pre-service teachers, the concerns that in-service teachers had with the program were more mechanical than technical (Lucy Bush et al., 2012a, 2012b)
	The utility of simSchool for in-service teachers is less pronounced, but even these teachers felt that simSchool would be beneficial for pre-service teachers (Bush & Hall, 2013)
	In-service teachers appreciated that the use of simSchool provides the opportunity to learn to teach or practice and experiment on particular teaching approaches before entering a classroom (Mavrou & Meletiou-Mavrotheris, 2014)
	In-service mathematics teachers appreciated simulations as virtual environments that provide the opportunity to practice and experiment on particular teaching approaches in a safe environment (Mavrou & Meletiou-Mavrotheris, 2014)
	In-service teachers were more interested in the theoretical and reflective aspects of simSchool (Bush & Hall, 2013)
	simSchool allow teachers to test out pedagogical ideas to see what combination of strategies helps all students learn (Zibit & Gibson, 2005)

Identified aims of each study

The retained studies were grouped into two types—empirical studies, technical and design application studies. The proposed aims outlined in each of the studies were grouped into themes that emerged from the content of the papers. Overall, the studies aimed to capture data on; teachers' knowledge and skills, teachers' self-efficacy, teacher perception, effectiveness of simSchool implementation and teacher behavior (see Table 3).

Summary of theoretical underpinnings

Of the 35 empirical studies reviewed, over 62% of them were without any theoretical foundation. Of those that did link directly to theory the largest ($n=8$) related to the OCEAN or Big five model of personality (McCrae & Costa, 1997) the second largest ($n=2$) drew from a Cognitive apprenticeship model (Collins & Kapur, 2014) and Theory of Action (Argyris, 1997). Other theories that were mentioned included: ($n=1$) self-efficacy (Bandura, 1977); Four Level evaluation model (Kaufman & Keller, 1994);Technology Acceptance model (Davis, 1989); and model centred instructional theory (Gibbons, 2008). The theoretical basis is centred on personality and practice theory.

Table 3 Summary of themed simSchool articles (2002–2022)

Empirical study	Teachers' knowledge and skill
	To examine impact of simSchool on pre-service and in-service teachers' understanding of the educational needs of diverse learners (Collum et al., 2017c, 2019)
	To explore impact on pre-service teachers' understanding of the educational needs of diverse learners, their understanding of differentiated instruction and their understanding of classroom management (Collum et al., 2017a)
	To exploit the use of simSchool for providing pre-service teachers enhanced instructional experience (Meletiou-Mavrotheris & Mavrou, 2014)
	To evaluate the use of simSchool to enhance the experiences of pre-service and in-service teachers' understanding of the use of differentiated instruction and classroom management (Johnston & Collum, 2018)
	Teachers Self-Efficacy
	To explore the effect of simSchool on pre-service mathematics teachers' sense of self-efficacy (Ledet et al., 2015)
	To investigate pre-service and in-service teachers' perceptions of simSchool and its effects on their self-efficacy (Bush et al., 2012a, 2012b)
	Teacher Perception
	To examine pre-service teachers' perception on the use of simSchool and differentiated instruction (Collum et al., 2017b)
	To examine the perspective of pre-service teachers on simSchool (Rayner & Fluck, 2014)
	To investigate the perception of the pre-service teachers on the usefulness of simSchool in pre-service teachers' preparation (Oteyola et al., 2020)
	Effectiveness of simSchool Integration
	To investigate simSchool effectiveness for pre-service teacher education (Badiee & Kaufman, 2014)
	To evaluate the effectiveness of simSchool as an instructional simulation (Deale & Pastore, 2014)
	To explore the effectiveness of simSchool in improving students' scores in teacher preparation and attitudes toward inclusion (McPherson et al., 2011)
	Teacher Behavior
	To investigate emotional experiences of pre-service teachers after the implementation of simSchool during the semester (Stavroulia et al., 2016)
	To investigate the impact of pre-service teachers' use of simSchool on their confidence and experience levels (Hopper et al., 2013)
Technical Application and Design	To introduce an overview and example of a simSchool module (Hopper, 2018)
	To highlight the unique functions of the main components of simSchool by discussing the system requirements and gamification algorithm in a cognitive apprenticeship framework (Ko & Ko, 2021)
	To discuss a few key areas that should be improved for future editions of simSchool (Trombley et al., 2009)
	To raise and briefly define key data challenges of assessing learning in a complex domain of performance within a digital simulation, which at the atomistic level include time and event segmentation, cyclic dynamics, multicausality, intersectionality, and nonlinearity (Gibson & Jakl, 2013)
	To outline a complex systems framework of simSchool for simulating teaching and learning (Gibson, 2011)

Summary of simSchool literature (2002–2022)

The scoping review of simSchool literature over the last two decades revealed insight and variance across all aspects of the analysis. These have been summarized as follows: *research types and methods* were primarily exploratory and mixed methods (Fig. 3); the contributing *authors* were mainly American and involved in the development of simSchool (Fig. 4); the *publications* by year showed alignment to Gartner's Hype cycle with peaks, troughs and plateaus (Fig. 5a, b); researchers and *countries* being researched were U.S.A. centric but this aligns to its adoption within ITE programs in the region. Recent uptake in Australia is evident and its involvement in developing countries is part of the platform's contribution to being inclusive and affordable (Table 2); most of the *participants* in the studies were pre-service teachers with some joint research comparing pre- and in-service teachers and no studies were conducted exclusively for in-service teachers (Table 3). The *aims* of the simSchool research were empirical or technical and application studies which captured teachers' knowledge and skills, teachers' self-efficacy, teacher perception, effectiveness of simSchool implementation and teacher behavior (Table 3) and only 38% of the empirical studies were theoretically underpinned. The major theoretical focus included Big five model of personality, cognitive apprenticeship and theory of action. The findings revealed SBL offered authentic experiences within the ITE context and improved self-efficacy.

The general corpus of simSchool literature analyzed in this study reinforced the benefits and uniqueness of SBL in particular simSchool's ability to generate feedback through the Artificial Intelligence (AI) engine and simulate human behaviour, cognition and emotion.

Comparison of scoping reviews of Second Life and simSchool

The significance of comparing Second Life and simSchool scoping reviews is the historical contribution they add to the emerging field of research into SBL in ITE. Historically, Second Life and simSchool are two of the longest-standing and widely implemented simulated platforms in teacher education globally, these scoping reviews add valuable insight into the affordances of SBL and the challenges of mplementation of SBL during a specific period of time and to the corpus of literature on SBL in general. The affordances of simulated platforms such as Second Life and simSchool are noted as being consistent with the conception of 'affordances' by Norman (1999), who differentiates between 'real' and 'perceived' affordances and argues that, until an affordance is perceived, it is of no utility to the potential user. The view implicit within the model is that what is 'afforded' is not specific learning benefits or outcomes, but rather the tasks that educators, educational designers and learners perceive the technology as being useable for (Dalgarno et al., 2013). This paper addresses the perceived benefits and challenges of SBL in ITE.

Research on the two platforms builds on findings from earlier versions of SBL including micro-teaching which involved classroom simulation with real students followed by videoing of interactions for reflective practice and more recently

micro-teaching 2.0 integrating mixed reality platform and micro-teaching processes (Ledger & Fischetti, 2020). Findings from this comparative review will provide insight and recommendations for emerging simulated platforms such as simTeach (Mursion ™) with regards to research type, methods, theoretical underpinnings and aims. Commonalities and differences from the summary of SecondLife systematic review and SimSchool scoping review are outlined below.

Commonalities

The pedagogical benefits of a simulated platform for ITE programs and its ability to achieve educational goals such as collaboration, skill development and reflective practice were found in both reviews. In particular, they found that simulated platforms such as Second Life offer opportunities for ITE providers in facilitating a learning environment that can develop pedagogies of practice through representations, decomposition and approximations of practice (Grossman et al., 2009). Similarly, the scoping review of simSchool highlighted the educational benefits of SBL platforms for ITE programs and its ability to expand the range and quality of pre-practicum practices and experiences that can be scaffolded and tailored to specifically address particular components of teaching practice and knowledges (Ledger et al., 2022). The use of simulated platforms over time was found to enhance students' self-confidence and address areas of individual need and promote self-regulatory learning (Kim & Blankenship, 2013). The research and uptake of each of the technologies aligned to Gartner's Hype cycle as both clearly identified triggers, peaks, troughs, and plateaus of productivity within its uptake within ITE programs. Most of the reasons for limited uptake included technical issues, confidence in use and cost.

Both reviews of Second Life and simSchool revealed commonalities in research type and methodology (mainly experimental, mixed methods), authors (mainly American), years (fluctuated as per Gartners Hype Cycle), country (USA, UK, Australia), participants (predominately ITE pr-eservice teachers), aims (captured knowledge, skills, self-efficacy, perception, implementation) and theoretical underpinnings (practice theory, instructional theory, technology acceptance methods).

In a recent scoping review of mixed reality simulation in ITE, (Ade-Ojo et al., 2022) conclude that simulation in education is a promising way to train future teachers and that it has practical and pedagogical advantages over traditional practicums. Even though evidence continues to mount that virtual worlds are important 'third spaces' for teaching and learning, and as technologies improve, the options of simulated learning environments to support ITE programs also improve (Gregory & Bannister-Tyrrell, 2017), the uptake of simulated platforms in teacher education programs around the globe remains somewhat limited in uptake and scope. Reviews on both programs also confirm compelling reasons to continue to explore current and future simulation platforms in ITE particularly because of its potential to foster and make visible the highly relevant pedagogies of practice (Grossman et al., 2009), micro-teaching 2.0 (Ledger & Fischetti, 2020) and reflection in, on and for action and within practice (Schon, 1991). They also confirm the need for more large-scale,

high-quality studies within the field including longitudinal studies, possible random controlled trials and more work with in-service teachers.

Although the studies analyzed within this study varied substantially, commonalities existed which highlighted the affordances of SBL and difficulties implementing it. Keltons (2008) implementation categories—perceptual, technical, operational and pedagogical issues offer useful analysis of the common difficulties of implementation.

Differences

Overall, the combined reviews aimed to capture data on teachers' knowledge and skills; teachers' self-efficacy; teacher perception; effectiveness of the implementation of technology and teacher reflective practice. The research on each platform varied in terms of geographical location, research design andmethodology and depth of findings. Research on SecondLife was predominately in order of frequency located in US, whilst simSchool saw a wider uptake globally ranging from US (14), Australia (6), Chile (1), South Korea (1), Turkey (1), and Taiwan (1). The cost of the products could contribute to the update within countries.

Whilst, both Second Life and simSchool studies were predominately exploratory or mixed methods in research design, Wang and Burton (2013) showed that research on Second Life has moved from the initial stages of research to empirical investigations whereas, simSchool remains in the initial stages. Many studies across both platforms, were small, single site datasets within ITE contexts, with only one longitudinal study found for both. This aligns with Ade-Ojo et al. (2022) and Theelen et al. (2019) concern that few large-scale, high-quality studies exist within literature on SBL.

Commonalities and differences were revealed within the literature on SecondLife and Simschool, particularly the difficulties in implementing and embedding SBL in ITE programs. These were primarily related to what Kelton (2008) refered to as typical implementation categories—perceptual, technical, operational and pedagogical issues. To contextualise this within an Australian context, the authors are aware of only 5 out of 39 teacher education programs in Australia using simulation in the delivery of their ITE programs. Is it easier to maintain the status quo for teacher education programs rather than adopt new technologies as discussed in 2012 by Blankenship and Kim, (2012). Concern, anxiety and costs involved in learning and implementing new technologies continue to restrict the uptake of simulated platforms in ITE. This concern is reflected in historical literature dating back to Boocock's (1967) statement of innovation being difficult to implement, Dalgarno et al. (2013) recommendations based on an extensive review of virtual worlds in higher education, Bahr and Mellor (2016) call for innovation to be adopted at a macro level of reform not simply at micro levels and Ledger et al. (2022) review of simSchool literature which encourages us to build on past practices to inform future innovation. It recommends using Duncan et al.'s (2012) hierarchical relationships (theoretical, activity and technical level) within his taxonomy of differentiated population (who), educational activity (what), learning theory (why), learning environment (where),

supporting technologies (how), and research areas/type, as a useful tool for capturing and informing future research, policy and practices involving SBL in ITE.

This study has revealed strong evidence of the benefits of SBL as a third space to practice the art of teaching and learning in ITE within a structured and reflective manner. It has also revealed the common issues impacting the implementation of SBL in ITE anmely, technical issues, confidence, use and cost. Higher Education policies need to be modified to ensure SBL is included in ITE not only for the opportunity to practice in a third space but also for future teachers to become technologically competent as both users and creators of technologies like the students in their classrooms.

Conclusion

Learning to Teach with simulated platforms has progressed since the 1960s when micro-teaching first appeared in Stanford teacher education programs (Allen & Eve, 1968). The historical and salient insights gained by comparing scoping reviews of Second Life and simSchool will inform current and future designers, users and early adopters of future simulated platforms. Each of these past platforms offer teacher educators a 'third space' in which students can practice, rehearse, repeat and review their interactions with virtual children and adults in virtual worlds. What we notice is that simulated platforms have over time proved to be beneficial for scaffolding future teachers and increasing their self-efficacy (Dalgarno et al., 2013; Ledger et al., 2022). This article raises the importance of continuing to embed SBL in ITE programs even if faced with perceptual, technical, operational and pedagogical issues.

The importance of finding ways to develop professional confidence of student teachers is a crucial factor in classroom and school practices (Kunter & Baumert, 2006; Shulman, 1986) and a great starting point for simulation being more embedded in ITE policy and practices. Johnson et al. (2012) predicted the increase in applications of game technology or gamification for teaching and learning purposes, Simschool is testament to the emergence of gamification in ITE. Krammer et al. (2006) who proposed three basic dimensions of instruction quality that can develop professional confidence: clear and well-structured classroom management (which includes components of direct instruction), student orientation (including a supportive climate and individualised instruction) and cognitive activation (including the use of deep content, higher order thinking tasks etc.). SBL offers ITE programs opportunity to focus on these three dimensions to within a simulated 'third space' before real-life placements occur.

The research questions underpinning this study: *What are the trends exposed in SecondLife literature for ITE? How do these Trends compare with trends for simSchool literature conducted by the authors? What can we learen form literature on the two most widely used simulated teachnologies over the last two decasdes to support and inform future research and adoption of SBL in ITE programs?* have exposed common trends in Second Life and simSchool implementation and the research that surrounds it. It has also confirmed the affordances of these SBL platforms in initial teacher education. Additionally, it revealed limited research differentiation and

theoretical basis to a significant number of the studies. These trends, affordances and research limitations become starting points for future research on SBL. Traditionally, professional and theoretical knowledge is taught in classrooms of academia whilst practical skills and experiences are developed in schools. The authors, supported by research on SBL over the last 60 years, argue that simulated platforms offer initial teacher education a 'third space' where theory can be practiced and reviewed virtually before enacting it in reality. This is particularly useful during a time when teacher education calls for more explicit teaching and classroom management skills (TEEP Report, 2023). It is within this educational ecosystem that we may find more uptake of SBL in ITE programs. More importantly, SBL could move from the realms of being considered innovative and be implemented as a mainstream approach in ITE programs.

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Declarations

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