IMPACT ECONOMICS AND POLICY

Training new teachers with digital simulations

Evidence summary report

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ACKNOWLEDGEMENT OF COUNTRY

We acknowledge Aboriginal and Torres Strait Islander peoples as the Traditional Owners of Country throughout Australia and their continuing connection to both their lands and seas. We also pay our respects to Elders – past and present – and generations of Aboriginal and Torres Strait Islander peoples now and into the future.

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EXECUTIVE SUMMARY

Australian teachers do not have enough opportunities to practice their skills before they step into the classroom. Without a solid foundation, beginning teachers have high levels of stress and burnout. Digital simulations can provide valuable opportunities to practice and rehearse new skills, yet unlike other sectors such as nursing, medicine and aviation, simulations have not been a key part of initial teacher training.

This report shows the findings of a rapid review of the global literature on immersive simulation for teacher preparation. It finds that immersive digital simulations – and corresponding supports – can create significant positive shifts in trainee teacher skills, knowledge, and self-efficacy. The evidence is strong; of the 35 articles in our review, 30 studies show positive improvements in trainee teacher outcomes. The 30 studies showing positive effects include studies with rigorous designs, including a comprehensive systematic review with many well designed randomised controlled studies (the 'gold standard' of research). Benefits are seen across a range of teaching skills, from classroom management and teaching instruction through to better communication skills with parents and colleagues.

The benefits of simulations are well grounded in theory. 'Approximating' aspects of teaching in contexts that are less complex than school-based environments can help to reduce cognitive load and help trainees to work on specific skills one at a time. Digital approximations provide unique opportunities for repeated practice and do-overs, with increasingly difficult challenges that help with mastery. Importantly, digital simulations show larger shifts when compared to traditional in-person role play with peers in class, or reading materials or listening to audio.

Six active ingredients in the implementation of digital simulations are important. This includes incorporating opportunities for: [1] instructional coaching, [2] feedback, [3] observation, [4] visual examples or models of best practice, [5] high dosage, that is, practicing many times over and [6] strong underpinning theory and content.

Some Australian teacher training providers are already using digital simulations today, with a growing interest in the area. A range of digital simulation products are emerging internationally in the US and UK, from classrooms of virtual students through to interactive text-based platforms that can be used many times over at low cost.

As a next step, we call on system leaders to explore how to support the use of digital simulations in teacher training, ensuring it is high-quality, affordable and widespread. Like all initiatives, good implementation is key. Getting this right could significantly improve teacher training and help all new teachers be better prepared for service in Australian schools.

Key definitions in this report

Simulation: an umbrella term for opportunities which allow trainee teachers to rehearse components of teaching instruction in lower-stakes, supportive settings. It can be digital or in-person. Sometimes referred to as an 'approximation of practice'.

Digital simulation: computer-based attempts to create a situation, where trainee teachers can interact with the environment to practice skills.

High or semi immersive simulation: a digital simulation which aims to provide users with a highly immersive experience where they feel transported in a virtual environment, and typically involves realistic visuals and the ability to interact physically with a virtual world, for example a virtual classroom.

Low immersive simulation: a digital simulation which provides users with experiences with low level sensory stimuli and limited visual functionality, and where the user feels still a part of their own physical world. An example is a web-based platform which provides trainee teachers with text-based classroom scenarios to practice their responses to students in the moment.

Physical in-person simulation: places trainee teachers in improvised situations where they can put their knowledge and skills into practice. An example is a role play with peers in class.

1. THE PROBLEM WITH TEACHER TRAINING

A long-recognised gap in teacher training is that there needs to be better opportunities to practice new teaching skills. Beginning teachers often report that their university training lacks practical applicability, and that they are not ready when they start teaching.

In 2023, a major national teacher training review finds that 'more attention and investment is still required to ensure high-quality practical experiences for all [teacher education] students.'[1] There is often a big disconnect between what a teacher learns in teacher preparation theory and what they do in a classroom.

A key issue is that while trainee teachers typically have opportunities to practice new skills through short-term placements in schools, these placements are not necessarily high-quality experiences. Mentor teachers may be too time poor to give sufficient guidance or feedback, or not always able to model effective practices themselves. School capacity has also become very constrained, with increasing teacher shortages putting more pressure on teacher time and resources.[2]

University providers also don't often have the resources or capacity to invest in improving the supports for trainee teachers on school placements. A recent survey by the Expert Panel of the national teacher training review emphasised the wide variation in the quality of practical experiences for new teachers across Australia.[3]

Another issue is that university coursework is too theoretical. A recent 2022 survey of Australian graduate teachers found concerns with the way in which courses are taught and delivered.[4] Graduate teachers reported the current content is too theoretical and not relevant to the current teaching environment. Trainees want more training in behaviour management, identifying and dealing with learning difficulties, child development and wellbeing, report writing and assessments, and dealing with parents. Another recent research report reviewing Australian initial teacher education programs found they do not adequately cover key concepts and practices required to prepare pre-service teachers adequately.[5]

A failure to prepare beginning teachers with the practical knowledge and skills they need for the classroom has big ramifications. It can lead to teacher stress and burnout in the early years of teaching and contribute teacher attrition.

[1] Teacher Education Expert Panel (2023)
[2] Commonwealth Department of Education (2022)
[3] Teacher Education Expert Panel (2023), Australian Council of Deans of Education (ACDE) 2017
[4] Social Research Centre, ANU (2023)
[5] Australian Education Research Organisation (2023)

2. DIGITAL SIMULATIONS HOLD PROMISE

Digital simulations are increasingly being recognised as a useful tool to help trainee teachers practice skills on real world problems and situations. This belief stems from a solid theoretical underpinning in the literature of the benefits of simulations which is more than two decades old.[6] Academics have long argued that teacher candidates can benefit from opportunities to 'approximate' aspects of teaching in contexts that are less complex than school-based teaching placements. This reduced complexity helps to reduce cognitive load and helps trainees work on specific skills one at a time.

Approximations are also thought to be beneficial as they can provide opportunities for repeated practice and 'do-overs' of certain situations, with increasingly difficult challenges that help with mastery. They can help trainees receive more scaffolding and coaching than they might from school-based mentors during placement, and increase exposure to specific experiences, for example, working with students with specific behaviours. A key benefit is that they low stakes, without consequences for real students.

In addition, digital simulations can be rolled out in with consistency at a large scale, in stark contrast the varied experiences that teachers sometimes have on school placement. Digital technology can also allow trainee teachers to practice teaching skills remotely at times that are convenient for them.[7]

Lastly, there are wider benefits that digital simulations can provide for educational research, given simulations effectively create a research lab that can be used to measure and analyse what works in developing teaching skills. Such research could vastly improve the quality of teacher preparation and development long-term.

EMERGENCE OF DIGITAL SIMULATIONS IN TEACHER EDUCATION

A recent report emphasizes the use of virtual reality for teacher education is a 'growing trend' in Australia.[8] Approximately eight of 41 Australian universities have adopted virtual reality products for teacher training, reaching about 25% of the total student market.

A range of digital simulation tools are increasingly available, from highly immersive virtual programs to low immersion text-based platforms. For example, a popular and highly immersive simulation technology in Australia is **SimTeach,** involving a virtual classroom of a small group of students who are controlled by human actors to provide realistic teaching experiences. Another popular semi-immersive product is **SimSchool,** a game-based simulation where virtual students are allocated personalities through AI to react to strategies and tasks and even tonal inclinations.

There are also promising low immersion products internationally which provide text-rich scenarios that are affordable and can often be used many times over. For example, **Proxima** in the UK is a newly established low immersion simulation which involves simple text-based problems with

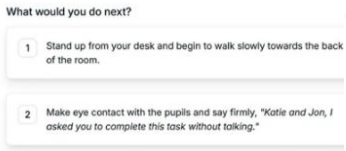
[6] See the original theory and work of Grossman (2005 and 2009).

[7] Discussed by Cohen and Wong (2021).

[8] AITSL Report (2023)

unlimited use for an annual fee. It's simple non-virtual design deliberately aims to minimise trainee teachers' cognitive load when learning new knowledge and skills. **Teacher Moments** at Massachusetts Institute of Technology (MIT) in the US is also a low immersion platform which uses simple text and video-based scenarios. It is open source and free for users.

Figure 1: Examples of digital simulations for teacher training

	SimTeach	Proxima	Teacher Moments
Type	Semi-immersive	Low-immersive	Low-immersive
Established	USA, established 2012 *Currently used in Australia*	UK, established 2022 *Currently used in UK*	USA, established 2018 *Currently used in US mostly*
How it works	Virtual student avatars controlled by human actors (human-in-the-loop). Interactive conversations. Can simulate students, parents, colleagues.	Text based scenarios with multiple choice, free text, and voice recording response options. Trainee teacher is given a scenario and then responds.	Text, image, and video-based scenarios with multiple choice, free text and voice recording response options. Trainee teacher is given a scenario and then responds.
			

3. EVIDENCE SHOWS DIGITAL SIMULATIONS WORK

This section shows the findings of a rapid review of the literature on the use of immersive simulations in teacher training. The review examined 35 studies and finds that immersive simulations can deliver significant positive shifts in trainee teacher outcomes.

LITERATURE REVIEW PURPOSE AND APPROACH

The literature review answers two critical questions:

1. Does immersive simulation improve novice teacher training outcomes?
2. What are the active ingredients of the intervention i.e. the core components which need to be adopted closely to achieve intended outcomes?

A rapid review was undertaken with a systematic process for identifying studies. There were 35 studies which met the inclusion criteria. Rigorous evidence standards were adopted, giving preference to articles with well-designed randomized controlled trials (RCTs) and strong quasi-experimental study designs. Given the limited amount of literature available, studies with pre-post study designs were allowed. Qualitative studies were excluded.

The identified articles mostly explore highly immersive or semi-immersive simulation products which tend to involve a virtual classroom with interactive virtual students. We only include articles which examine novice teacher preparation, not training teachers already working in schools. The articles were published between 2004 and 2024 and originated mostly from the United States, with a small number of studies from the United Kingdon, Germany, Taiwan, Israel, and Australia. The results of the full literature review are included in Appendix 1 to this report.

DOES SIMULATION IMPROVE TRAINING OUTCOMES?

Overall, our review suggests that immersive simulation and corresponding supports can help deliver positive shifts in novice teacher skills, knowledge, and beliefs, as well as self-efficacy. The evidence is strong; of the 35 articles meeting the inclusion criteria, 30 studies show positive improvements in trainee teacher outcomes. The 30 studies showing positive effects include many rigorous study designs, including a comprehensive systematic review as well as 9 well-designed randomised controlled studies.[9] See table 1 for the sample studies examined.

RANGE OF SKILLS DEVELOPED

Studies show that immersive simulation can support various aspects of trainee teachers' development. Commonly studied skills include classroom management, student behaviour, general instructional skills such as planning and delivering lessons, and supporting students with additional

[9] The systematic review is by Cohen et al., (2024). The nine RCT studies with sample sizes larger than 50 participants are: Sailor et al., (2023); Yu-Chu Yeh., (2004); Cohen et al., (2020); Cohen et al., (2021); Sims et al., (2023); Spencer et al., (2019); Passig and Mosche., (2008); Lamb and Etopio., (2020); Seufert et al., (2023).

needs and disabilities. A smaller group of studies explore impacts on subject-specific instructional practices in maths, science and reading, general communication skills and supporting student well-being, showing positive results.

CORRESPONDING SUPPORTS MATTER

A key finding is that immersive simulation together with corresponding supports – such as coaching, feedback, observation, and modelling – can achieve *much larger* positive effects. Ten studies compare different program designs of immersive simulation, showing that when the simulation is paired with certain features and supports the effects are much greater.[10]

For example, Cohens and colleagues' (2020) study 100 randomly assigned trainee teachers to different coaching conditions conducted around simulation sessions. It found that all trainee teachers who participated in the simulators showed improved outcomes, however those who were coached experienced *much larger* improvements in skills than those who only self-reflected. Another randomised study of 'modelling' of videos shows that the impacts are *double* on trainee teacher development (Sims and colleagues 2023).

BETTER THAN TRAINING ALTERNATIVES

The literature review shows that immersive simulation achieves more positive improvements than alternate training solutions, such as in-person role play with peers, written resources and audio. In particular, six studies show that candidates improved in their skills, knowledge and beliefs more through digital simulations than in-person role plays.[11] One study by Aguilar and Flores' (2020) of 40 participants found the difference between the mixed reality simulator group and the control group who engaged in role-play was *almost double*.

CAVEATS ON THE LITERATURE

Many studies in our sample rely on small sample sizes and a number do not report statistically significant results, which limits the causal claims which can be made. The literature also does not discuss impacts on university educators, real students, or school communities. Another gap is there are few academic studies on the impact of low immersion simulations, an area for further research.

[10] The ten studies are: Cohen et al., (2020); Cohen et al., (2021); Robbins et al., (2019); Ely et al., (2018); Judge et al., (2013); Gundel at al., (2019); Y-Che Yeah., (2004); Sailer et al., (2023); DeSantis et al., (2023) and Sims et al., (2023).
[11] The six studies are: Aguilar & Flores, (2022); Lee et al., (2021); McKown et al., (2021); Schussler et al.,2017; Spencer et al., 2019; Walters et al., (2021).

Table 1: Overview of the 35 studies in the rapid review

Authors	Country	Study design	Sample size	Comparison group	Outcomes for trainee teachers
Studies showing positive outcomes					
Cohen et al., 2023	US	Systematic review	26 articles	Various	**Overall positive improvements** in skills, knowledge, self-efficacy from approximations (most of which are digital) with corresponding scaffolds
Sailer et al., 2023	Germany	Randomised controlled study	178	Compares imm simulation designs which include adaptive feedback	**Positive improvements** in performance and skills for the group with imm simulation plus adaptive feedback; more than no feedback group. Statistically significant.
Yu-Chu Yeh, 2004	Taiwan	Randomised controlled study	149	Compares imm simulation designs which include feedback	**Positive improvements** in teaching performance for the group with imm simulation plus supports; more than no support group. Statistically significant.
Cohen et al., 2020	US	Randomised controlled study	105	Compares imm simulation designs which include coaching	**Positive, large improvements** in skills for the group with imm simulation plus coaching; much more than self-reflection group. Statistically significant.
Cohen et al., 2021	US	Randomised controlled study (5 studies)	100	Compares imm simulation designs which include coaching, across conditions	**Positive, large improvements** in skills for the group with imm simulation plus coaching; much more than self-reflection group. Effects replicate across tasks, timing and online. Statistically significant.
Sims et al., 2023	US	Randomised controlled study	90	Compares imm simulation designs which include video models	**Positive improvement** in skills for the group with imm simulation plus video models; more than no video model group. Twice as large. Statistically significant.
Spencer et al., 2019	US	Randomised controlled study	90	Compares imm simulation versus peer role play (alone)	**Positive improvements** in beliefs in imm simulation group; more than peer role play (alone). Statistically significant.
Passig and Moshe, 2008	Israel	Randomised controlled study	90	Compares imm simulation versus film, statements (alone)	**Positive improvements** in knowledge and awareness in imm simulation group; more than when watching films or written statements (alone)
Lamb & Etopio, 2020	US	Randomised controlled study	54	Compares imm simulation versus real life teaching (alone)	**Perceived VR to be 'as real'** as real-life teaching. Knowledge and skills development equally effective in imm simulation to real life. Statistically significant.
Seufert et al., 2023	Germany	Randomised controlled study	55	Compares imm simulation versus video learning (alone)	**Positive improvements** in skills and self-efficacy in imm simulation group; more than the video setting (alone). Statistically significant.
Green et al., 2020	US	Randomised controlled study	46	Compares imm simulation versus training such as text, audio, resources (alone)	**Positive improvements** in preparedness and confidence in the imm simulation group; more than other training via text, audio, links, resources (alone). Statistically significant.
McKown et al., 2021	US	Randomised controlled study	30	Compares imm simulation versus peer role play (alone)	**Positive improvements** in skills and knowledge in imm simulation group; more than peer role play (alone). Statistically significant.
Walters et al., 2021	US	Randomised controlled study	30	Compares imm simulation versus peer role play (alone)	**Positive improvements** in skills in the imm simulation **group**; more than peer role play (alone). Statistically significant.
DeSantis et al., 2023	US	Randomised controlled study	30	Compares imm simulation designs which include coaching, feedback	**Positive improvements** in performance for imm simulation plus coaching and feedback; more than other group with no supports. No significant difference in self-efficacy between the groups.

Authors	Country	Study design	Sample	Comparison group	Outcomes for trainee teachers
Studies showing positive outcomes (CONTINUED)					
Schussler et al.,2017	US	Randomised controlled study	27	Compares imm simulation versus self-reflection (alone)	**Positive improvements** in communication skills in imm simulation group; more than self-reflection (on some indicators but not all)
Ely et a., 2018	US	Randomised controlled study	22	Compares imm simulation designs which include peer observation	**Positive improvement** in knowledge for both groups who either participated and peer observed. Observation resulted in learning *comparable* to practicing.
Judge et al., 2013	US	Randomised controlled study	6	Compares imm simulation designs which include feedback	**Positive improvements** in skills for imm simulation plus feedback; more than no feedback group.
Gundel et al., 2019	US	Quasi-experimental, comparison group, pre-post	53	Compares imm simulation designs by length of time in simulator (dosage)	**Positive improvement** in self-efficacy with increased time spent in the imm simulation, after an initial dip. Statistically significant.
Aguilar & Flores, 2022	US	Quasi-experimental, comparison group, pre-post test	40	Compares imm simulation versus peer role play (alone)	**Positive improvements** in skills in imm simulation group; more than peer role play. Differences are almost double.
Robbins et al., 2019	US	Quasi-experimental, comparison group, pre-post test	29	Compares imm simulation designs which include peer observation	**Positive improvements** in performance; peer observation positively affected performance
Peterson-Ahmad, 2018	US	Quasi-experimental, comparative, pre-post test, mixed-methods	8	Compares imm simulation designs which include coaching	**Positive improvements** in performance and skills for half of the trainees. Statistically significant. Coaching not linked to improvements.
Ledger and Fischetti, 2019	Australia	Pre-post test	376	No comparison group	**Positive improvements** in confidence and preparedness for teaching.
Grant & Ferguson, 2021	US	Pre-post test, mixed-methods	59	No comparison group	**Positive improvements** in perceived readiness and confidence for teaching. Statistically significant.
Bosch & Ellis, 2021	US	Pre-post test	44	No comparison group	**Positive improvements** in self-efficacy. Statistically significant.
Kaka et al., 2021	US	Pre-post test, mixed-methods	35	No comparison group	**Positive improvements** in teaching confidence. Statistically significant.
Pankowski & Walker, 2016	US	Pre-post test	26	No comparison group. Test different education	**Positive improvements** in knowledge and perceived performance.
Rosati-Peterson et al., 2021	US	Pre-post test, mixed-methods	15	No comparison group	**Positive improvements** in skills with imm simulation plus video, reflection, feedback and coaching. Statistically significant.
Driver et al., 2018	US	Pre-post test, mixed-methods	7	No comparison group	**Positive improvements** in perceived readiness to collaborate. Statistically significant.
Dawson & Lignugaris-Kraft, 2017	US	Pre-post test	4	No comparison group	**Positive improvements** in skills, seen in virtual classroom and in the real classroom (to varying extents)
Yung-Chi Lin, 2022	Taiwan	Pre-post test	27	No comparison group	**Positive improvements** in skills and performance on one indicator but not another indicator. Statistically significant.
Studies showing neutral or negative outcomes					
Lee et al., 2021	US	Randomised study, mixed methods	60	Compares imm sim versus peer role plays (alone)	**Equal improvement** in skills in both the imm simulation group and role play group.
Artun et al., 2020	Turkey	Randomised controlled study	54	Compares imm simulation versus hard-copy (alone)	**Equal improvement** in skills in both the imm simulation and hard-copy groups.
Regalla et al., 2016	US	Quasi-experimental, pre-post test	113	Compares imm sim versus coursework (alone)	**No statistical difference** in teacher self-efficacy between groups using imm simulation and not using imm simulation.
Enicks., 2012	US	Pre-post test, mixed methods	19	No comparison group.	**No statistical difference** in teacher skills between groups. However positive impact on self-reflection behaviours.
Hudson et al., 2019	US	Pre-post test, mixed methods.	24	No comparison group	**No change** in perceived ability to manage classrooms, and a decline in perceived teaching ability.

WHAT ARE THE ACTIVE INGREDIENTS OF THE INTERVENTION?

Getting a good grasp of what we mean by the nature of the intervention, and exactly what it entails when implemented effectively, is essential to achieving the expected benefits. The literature review suggests six components of immersive simulation are likely to support improved outcomes for trainee teachers, or 'active ingredients', discussed in turn below.[12]

1 INSTRUCTIONAL COACHING

Instructional coaching supports before and after immersive simulations are beneficial, often because novice teachers lack the background knowledge and experience to recognise their own strengths and weaknesses.[13] A number of rigorous studies show directive, targeted coaching can significantly improve trainee teacher learning, although one study shows no effects.[14]

Two of the studies showing positive results involve a series of randomised studies of ~100 participants (Cohen and colleagues (2020 and 2021)). Both studies examine the impact of short, 5 minute, highly structured and directive coaching in-between simulation sessions. The authors find that coached trainee teachers had significant and large improvements on skills and candidates perceptions of behaviour relative to those who only self-reflected on their teaching performance.[15]

2.OBSERVING PEERS IN THE SIMULATOR

'Vicarious' observational learning can occur in the simulation, and some studies suggest observation can be as effective as practicing oneself.[16] For example, Ely and colleagues (2018) conducted a randomised, experimental study of 22 participants using a *TeachLive* simulation, and found that trainee teachers experiences in observing their peers resulted in learning comparable to that from trainee teachers actively practicing their skills in the simulation.

3.FEEDBACK

Providing feedback to trainee teachers on their performance in the digital simulation can have positive effects, for example providing users with data on their own teaching performance or the 'virtual' student learning, as well as peer feedback.[17]

Automatic adaptive feedback may hold promise as a future scalable solution. A recent experimental study in Germany by Sailer and colleagues (2023) found positive impacts from 'automatic adaptive

[12] The six components have been identified from studies which specifically evaluate the relationship between implementation and trainee teacher outcomes. Further research is needed to test these findings.

[13] This idea is discussed in Cohen et al., (2021), page 8

[14] The three studies showing positive results are: Cohen et al., (2020 and 2021); and De Santis et al., (2023). The study showing no impact is by Peterson-Ahmad (2018).

[15] Cohen and colleagues use a four step 'directive coaching' model, where coaches provide trainee teachers with targeted feedback on a specific set of instructional skills, give detailed information about the high-quality enactment of the targeted skill, specific strategies the candidate can utilise in future, along with opportunities to rehearse the targeted skill.

[16] Cohen et al., (2024) systematic review, Robbins et al., (2019), Ely et al., (2018)

[17] Judge et al., (2013), Yu-Chu (2004), Sailer et al., (2023)

feedback' in a computer-based platform i.e. where feedback which was tailored to the specific response submitted by trainees. The study found that trainee teachers improved in their quality of justifications in written assignments *more* when they received adaptive feedback than static (generic) feedback.

4.MODELLING OF BEST PRACTICE

Visual examples or 'models' of a specific teaching practice by more experienced colleagues or coaches can provide a mental image of the focal teaching practice.[18] A recent UK based study by Sims and colleagues (2023) tests the effects of video models together with digital simulations, and finds that it improves trainee teachers' skills, knowledge, and self-efficacy in using 'retrieval' practice in a Mursion simulator. The study randomly allocated 89 trainee teachers to different groups and found that trainee teachers exposed to the video models did *twice as well* in their second simulator attempt, relative to the trainee teachers who did not watch a video model.

5.ALIGNMENT TO COURSEWORK

A strong conceptual underpinning of the skills, knowledge, and beliefs targeted in the simulation is important.[19] Cohen and colleagues (2021) emphasise the importance of coherent and coordinated learning experiences, where 'candidates engage with the theory underlying teaching practices, have opportunities to observe and analyse use of such practices, and *then* have chances to enact those practices with coaching supports'.[20] Cohen and colleagues suggest that approximations of teaching should not be stand-alone experiences, where skills are decoupled from their conceptual bases.

Few studies have specifically tested this issue, but one empirical study by Cohen and colleagues (2021) finds that trainee teachers enrolled in a concurrent methods coursework focused on the practices targeted in simulations improved much more than trainee teachers in an undergraduate course.

6. AMOUNT OF TIME OR 'DOSAGE'

An essential feature of successfully training teachers is the extent to which there is frequency of practice. Novices are much more likely to achieve mastery when the opportunities for targeted practice are routine and frequent. One article suggests opportunities to practice should be weekly in teacher training.[21]

A systematic review suggests that 'dosage of practice time' in a digital simulation may contribute to trainee teacher learning, however few studies directly examine the optimal 'dosage' i.e. number of sessions or time spent to experience positive outcomes. Several rigorous studies show *more time* in the mixed reality simulator for teachers generates more positive effects.[22] A study by Rosati-Peterson and colleagues' (2019) involved participants completing three mixed reality simulator

[18] Sims et al., (2023) discusses the existing literature.

[19] Discussed in Cohen et al., (2021)

[20] Cohen et al., (2021), page 30, cites Grossman et al., (2009)

[21] Reich (2022). Also discussed in Ericsson and Harwell (2019).

[22] Rosati-Peterson et al., (2019), Gundel et al., (2019), Aguilar and Flores (2022)

sessions and found that novice teachers significantly improved their skills between the second and third rounds.[23]

4. CONCLUSION

This report outlines strong evidence that digital simulations can deliver positive impacts for trainee teachers, and that many Australian teacher training providers are already integrating the use of digital simulations today.

As a next step, we call on system leaders to further examine what is required to ensure the successful spread and implementation in Australian teacher education courses. Like all interventions, good implementation is key. With a range of digital simulation products emerging in international markets, a key consideration is how to ensure implementation is high-quality and affordable in Australian universities. Attention should be paid to the six active ingredients for effective implementation highlighted in this report – the incorporation of instructional coaching, feedback, modelling of best practice, observation, high-frequency usage, and strong underpinning content.

[23] In addition, Gundel and colleagues (2019) similarly examine how trainee teachers' outcomes changed when dosages of mix reality simulator practice varied and found that, on average, candidates significantly improved their teaching self-efficacy after the end of the practice (with a dip for students mid-way through).

Appendix 1:

Full Literature Review

APPENDIX 1: FULL LITERATURE REVIEW

1. RESEARCH QUESTIONS AND DEFINITIONS

RESEARCH QUESTION 1: DOES IMMERSIVE SIMULATION IMPROVE INITIAL TEACHER TRAINING OUTCOMES?

We examine the impact of immersive simulation when used for novice teachers in their initial training courses at university. We seek to explore outcomes for various participants, including university educators (i.e. lecturers), trainee teachers, registered teachers, students as well as school communities.

We examine sub-questions such as: What are the strengths of the results? Is the intervention better than alternate training solutions? For whom does it work (or not work), and under what conditions is it successful?

'Outcomes' here is defined as covering a variety of impacts on participants. For example, for trainee teachers we are interested in changes in their skill development, knowledge, beliefs and self-efficacy across a range of content areas. Student learning outcomes include academic learning, behaviour and well-being impacts. The experiences of university educators and trainee teachers in using the technology will also be explored (where available) to help understand any enablers or barriers to successful implementation (this relates to research question 2).

We define '**immersive simulation'** here as technology-based simulations which approximate classroom learning environments to help trainee teachers practice complex skills before real world application. Physical-based simulations are out-of-scope.

'Initial teacher training' here refers to the training that occurs at a university-level for novice teachers before they start working in schools. This is commonly referred to as 'initial teacher education' and 'pre-service teacher education' in the literature. This review does not explore the use of immersive simulation for registered teachers who are already working in schools.

We note that literature on immersive simulation in other fields, such as nursing or medicine, is not explored in this report.

RESEARCH QUESTION 2: WHAT ARE THE 'ACTIVE INGREDIENTS' OF THE INTERVENTION?

This research question examines the components or features of the intervention which need to be adopted closely to achieve intended outcomes.[24] A well specified set of 'active ingredients' captures the essential principles and practices that underpin an initiative or approach, including the key behaviours and content that make an initiative work. Active ingredients are important to identify as it can be difficult if there isn't a shared understanding of what the intervention involves.

[24] 'Active ingredients' in education is discussed in this document by *Evidence for Learning*.

2. RESEARCH METHODS

We undertook a rapid review to synthesize the evidence, taking a pragmatic approach to drawing out relevant insights within limited timeframes, while still maintaining a systematic process for identifying rigorous studies.

We adopt an evidence hierarchy in line with standards set by the *US Institute of Education Sciences*.[25] In short, we give preference to articles which involve well-designed randomized controlled trials (RCTs) and strong quasi-experimental study designs. However given the limited amount of literature meeting strict quality criteria, we allow for studies with pre-post study designs. We exclude qualitative studies.

INCLUSION CRITERIA

INTERVENTION

- We define the intervention as immersive simulation-based training for trainee teachers. This means digitally mediated simulations which offer learning experiences during initial teacher education training programs courses that help candidates 'approximate' aspects of teaching. It uses technology to simulate classroom learning environments to help trainee teachers practice complex skills before real world application. It does not include articles that *only* discuss in-person peer role play, including micro-teaching, or physical simulations.

STUDY DESIGN / METHODS

- We include empirical studies that evaluate the effectiveness of immersive simulation-based training, including both experimental studies, quasi-experimental studies as well as studies with pre-post test design. We do not include studies which use qualitative research.

PARTICIPANTS

- Trainee teachers
- University educators, coaches, supervisors
- School students and school communities

OUTCOMES

- Effectiveness outcomes
    - Trainee teachers: improved self-efficacy, skills, knowledge
    - School students: improved learning outcomes, well-being, behaviour

- Implementation impacts [included only where article also explores effectiveness outcomes]:
    - Active ingredients: impact of components on participant outcomes
    - Trainee teachers: satisfaction with the tool, perceived realness, acceptability
    - University educators: satisfaction with process, intervention fidelity

[25] The evidence hierarchy adopted by the US Institute of Education Sciences, *What Works Clearing House*, is here.

    - School students: satisfaction with teacher performance
    - School communities: parent satisfaction, parent perceptions of student experience
- Note we only examine implementation impacts in the articles which discuss implementation factors *in the context of* their impact on outcomes.

SEARCH STRATEGY

We took a two-step approach to searching relevant literature.

- First, we identified systematic reviews and then searched the reference list to identify articles which met our inclusion criteria.
- Second, we conducted a wider search for articles within online academic databases.

We searched the EBSCO database using Melbourne University Discovery tool. We used the following search terms below in various combinations.

- Teacher education: Teacher education / trainee teacher / novice teacher / pre-service teacher / practice-based teacher education
- Type of practice: Mixed reality simulation / immersive simulation / rehearsal / approximation / TeachSIM, TeachLivE, Simschool, Mursion, TechME / interactive virtual training / Virtual reality
- Active ingredients: Implementation factors / components / program design

We also added 'systematic review' to our search terms to identify these reviews as a first step.

COLLATING AND SYNTHESIZING THE LITERATURE

A reviewer worked independently to screen the search results against the inclusion criteria. We screened the first 10 pages of search results. We conducted a variety of searches using different combinations of the search terms above.

The full text of each of the studies that potentially met the review criteria were then screened to determine their suitability for inclusion in the evidence summary. We extracted data from each of the studies into an excel table. Extracted data included publication data; country; title; authors; research objectives; number of participants; study design; description of the intervention; active ingredients; description of the outcomes; outcome measures and results. To explore the second research question, we noted any discussion of active ingredients in the screened studies.

We read through the documents and synthesized the literature according to key themes. The results of the review are described narratively in the following sections.

QUALITY OF THE SAMPLE OF ARTICLES

Our search identified 35 papers which met our inclusion criteria. This includes 1 systematic review, 18 randomised controlled studies, 5 quasi-experimental studies with a comparison group, and 11 studies with pre-post test design only. We note that 21 of our articles are sourced from the systematic review by Cohen and colleagues (2024).

For Research Question 1, studies in our sample analysed 'outcomes' in terms of trainee teacher self-efficacy, skill development, and / or knowledge of teaching practices. We did not identify articles which examined outcomes for university educators, school aged students or the school community.

For Research Question 2, we identified 10 articles which considered 'active ingredients' or factors related to the intervention.

The articles were published between 2004 and 2023 and originated mostly from the United States, with a small number of studies from the United Kingdon, Germany, Taiwan, Israel and Australia.

QUALITY OF THE WIDER LITERATURE

The broader literature on immersive simulation for trainee teachers is not empirically based. We identified six broad reviews on this topic which all found a lack of empirical research in this area.[26] A relevant systematic review by Cohen and colleagues (2024) – included in our sample of 35 articles – highlights that the wider literature on 'approximations' of practice and digital simulations is vast but not empirically based. Their search identified over 1,200 articles but found *only* 26 studies met their inclusion criteria.

The other five literature reviews similarly find that the research is mostly qualitative and with small sample sizes.[27] For example, the systematic review by Ersozlu et al (2021) closely examined the type of research done on *TeachLivE*, a commonly used immersive simulation platform, and found the wider literature was predominately qualitative, single-subject experimental research design and theoretical reviews. Similarly, Theelen et al (2019) could only identify 15 studies which meet basic quality standards, describing the literature as being in a 'nascent state'. And an Australian review by Ledger et al (2022) found that most literature is descriptive rather than quantitative inquiry.

[26] Note five of the six reviews did not meet inclusion criteria and are not discussed in Chapters 4 and 5. The five reviews were not included because they either 1) did not either directly answer our research questions or 2) did not meet our evidence standards, for example they included qualitative research studies.

[27] The reviews are: Ersozlu and colleagues (2021), Theelen and colleagues (2019), Ade-Ojo and colleagues (2022), Ledger and colleagues (2022) and Billingsley and colleagues (2019)

3. THEORY OF CHANGE

There are many potential benefits of simulations and their corresponding supports, as discussed by Cohen and colleagues (2023) drawing on the original work of Grossman (2005 and 2009). Candidates benefit from opportunities to "approximate" aspects of teaching in virtual contexts that are less complex than school-based teaching placements. It can reduce cognitive load by helping trainees work on specific skills one at a time. And it can help trainees receive more scaffolding and coaching than they might from school-based mentors.

There are also opportunities for repeated practice and 'do-overs' of certain situations, with increasingly difficult challenges that help with mastery. Targeted coaching and feedback can be easily provided on ways to improve, without incurring the travel costs of school visits. In addition, approximations can increase exposure to specific experiences (for example, working with students with autism or specific behaviours) that may not always be available in school-based placements. Finally, simulations are low stakes, without consequences for real students.

Digital approximations are considered to have advantages over *physical* approximations, such as in-person role plays with peers in university classes. Trainee teachers themselves tend to report more positive learning experiences in immersive simulations, which can provide more motivation to learn.[28] Mixed reality simulators may be more realistic, engaging and easily combined with peer support and coaching.

The digital simulation allows trainees to practice that feedback by immediately implementing a skill with virtual students, which is not as readily possible in in-person role-play. Digital simulations can also create more *consistent* high quality practice experiences at a large-scale. Finally, the technology allows trainee teachers to practice teaching skills remotely, at times that are convenient for them.[29]

Importantly, immersive simulated approximations are not designed to replace in-school placement experience, but to act as a supplement that can help teacher trainees refine their skills.

4. WHAT IS THE IMPACT ON OUTCOMES?

Summary: This section answers the first research question, what is the impact of immersive simulation on outcomes in initial teacher training? Overall, our review suggests that immersive simulation and corresponding supports can help with shifts in teacher skills, knowledge and beliefs, as well as self-efficacy. Section 4.1 discusses the strength of the evidence, and Section 4.2 discusses findings from a recent systematic review, which similarly suggests positive results.

We also provide various insights on our findings. Section 4.3 shows that immersive simulation can deliver better outcomes than alternative training solutions. Section 4.4. shows that immersive simulation with corresponding supports gets *much larger* positive results. Section 4.5 discusses for whom, and under what circumstances, the findings hold. Finally, section 4.6 discusses the small number of studies showing neutral or negative impacts and why this may have occurred.

[28] McKown et al., 2021 and Walters et al. 2021 ask participants questions related to their respective experiences.

[29] Discussed by Cohen and Wong, 2021.

4.1 STRENGTH OF THE POSITIVE RESULTS

We identified 35 articles which meet the inclusion criteria. Of these articles, 30 studies show positive improvements in trainee teacher outcomes after an immersive or digital simulation relative to a baseline measure or a comparison group. These studies report shifts in trainee teacher skills, knowledge and beliefs, as well as self-efficacy.

The 30 studies showing positive effects include many rigorous study designs, supporting the strength of the results. There is a rigorous systematic review (unpublished) showing similarly positive results, which includes only empirical studies with a comparison group or pre-post assessments. [30] There are also 16 studies with randomised controlled study designs which consistently show positive outcomes (9 of these studies have more than 50 participants). The 13 remaining studies showing positive impacts are comprised of 4 quasi-experimental studies (including comparison groups), and 9 studies with pre-post test design. Table 1 (next page) gives an overview of the individual studies by study design, sample size and findings.

We emphasise two points on the positive findings from the literature. First, immersive simulation can achieve more positive improvements than alternate training solutions, such as in-person role play with peers, written resources and audio. This is supported by 9 studies, including 8 randomised controlled studies.

Second, immersive simulation when paired with corresponding supports – such as coaching, feedback, observation, and modelling – can achieve *much larger* positive effects. One randomised study finds that without instructional coaching in between simulation sessions the effects are very modest (Cohen et al 2020). A randomised study of 'modelling' of videos shows that the impacts are *double* on trainee teacher development (Sims and colleagues 2023). This is found in 10 studies, 8 with randomised controlled designs.

However we do express caution around the strength of the positive findings, given that many studies in our sample rely on small sample sizes (many are less than 100 participants) and a number do not report statistically significant results. This limits the *casual* claims which can be made.

4.2 SYSTEMATIC REVIEW SUGGESTS POSITIVE IMPACTS

Cohen and colleagues' (2024) review examines a range of questions on 'approximations' of teaching, including the impact of both physical and digital simulations on trainee teacher outcomes. The review examines 26 articles within the United States, screening for those which include a comparison group or pre-post assessments.

Overall, it finds that approximations of practice and corresponding scaffolds, can support candidates in learning to teach. In 23 of the 26 studies reviewed, the trainee teachers demonstrated improvement after the intervention relative to a baseline measure or comparison group, and many of these were in the form of digital simulations. [31]

[30] The systematic review is by Cohen et al., (2024)

[31] Cohen and colleagues' 2024 review includes both physical and digital simulations, which is broader than the scope of this report. Where possible, we identify findings that relate to studies involving only digital simulations.

The review finds that benefits can be seen across a range of instructional tasks: communication with others, content specific practices, general pedagogy, supporting students' mental health, modality of approximations. It also emphasises that instructional supports – paired with the simulation experience – may significantly contribute to trainee teacher learning, in particular instructional coaching, opportunities to observe peers, and dosage of practice time.

However Cohen and colleagues' (2024) review cautions that nearly all included studies rely on small samples and employ designs that do not afford causal claims. The paper finds that 'we can [only] offer a range of hypotheses we argue can and should be tested systematically through a coordinated set of research efforts.'[32] It calls for more research to understand a number of issues, including the circumstances under which digital simulations could have benefits for trainee teachers, and the best types of instructional supports before, during and after simulations.

Note we include 21 articles from Cohen et al's (2024) systematic review in our own sample of 35 articles, which inform discussion in the following sections.

4.3 STUDIES SHOW IMMERSIVE SIMULATION IS BETTER THAN TRAINING ALTERNATIVES

Ten studies suggest immersive simulation can produce more positive effects than other alternative solutions trying to achieve similar goals, such as in-person role plays with peers, written text and audio.

Six studies show that candidates improved in their skills, knowledge and beliefs more through digital simulations than in-person role plays.[33] These studies found trainee teachers can find immersive simulations more useful and realistic than real role plays, providing a more authentic approximation of teaching.

Two of these studies are randomised controlled trials of the same 30 participants (i.e., McKown et al., 2021; Walters et al., 2021), and a third study by Spencer and colleagues (2019) had a larger sample size of 90 students as well as some randomisation. One study by Aguilar and Flores' (2020) of 40 participants found the difference between the mixed reality simulator group and the control group was *almost double*.

Three studies show that trainee teachers improve more in the virtual simulation than other training that included text, audio and other resources.[34] Passig and Moshe (2008) is one of the larger studies, with 90 Israeli trainee teachers, and it finds that trainee teachers improved their awareness of student test anxiety after the virtual simulation more than in the two control groups where students either watched a TV film or read statements by pupils. A study in Germany of 55 candidates by Seufert and colleagues (2023) found that trainee teachers significantly improved more in classroom management competencies in VR settings compared to video-based settings, according to external instructor ratings.

[32] Cohen et al., 2024, page 36.

[33] The six studies are: Aguilar & Flores, 2022; Lee et al., 2021; McKown et al., 2021; Schussler et al.,2017; Spencer et al., 2019; Walters et al., 2021. Note Cohen et al., 2024 cites these six studies, as well as a seventh by Henry et al., 2019 which is not included here as it includes non-digital forms of approximation.

[34] The four studies are: Seufert et al., 2023; Passif and Moshe, 2008; Green et al., 2020; Lamb & Etopia, 2020.

Interestingly, one interesting study by Lamb and colleagues (2020) of 54 participants shows that VR is perceived as 'real' an environment as real life teaching, using psychological measures (e.g. heart rate), and composite neuroimaging. It also finds that trainee teachers' knowledge and skill developed *equally* in both conditions according to supervisor ratings. This is a very interesting finding that should be explored in further research studies.

4.4 SPECIFIC PROGRAM DESIGNS SHOW LARGER IMPROVEMENTS

Ten studies compare different program designs of immersive simulation, showing that when the simulation is paired with certain features and supports, for example instructional coaching or feedback, there are much larger positive effects.[35] In these studies all participants used immersive simulation but also had different supports or experiences. Most of these studies used rigorous experimental designs with some randomisation.

The two most rigorous studies are by Cohen at al (2020 and 2021) which conduct multiple randomised control trials. Cohens and colleagues' (2020) study 100 randomly assigned trainee teachers to different coaching conditions conducted around simulation sessions. It found that all trainee teachers who participated in the simulators showed improved outcomes, however those who were coached experienced much larger improvements in skills than those who only self-reflected. Importantly, Cohen et al's (2020) study shows that those trainee teachers who only self-reflected on teaching around the simulation showed *very* modest improvements, suggesting extra instructional supports are important to deliver sizeable results.[36]

4.5 POSITIVE OUTCOMES: FOR WHOM AND UNDER WHAT CIRCUMSTANCES?

FOR WHO

Studies in our review only assesses the impact of immersive simulation on trainee teachers. Unfortunately we did not identify articles examining broader outcomes for university educators, school aged students or the school community.

Studies do not provide much insight into how the benefits of immersive simulation might vary for different types of trainee teachers, for example by age, year of study, or background.[37] Cohen et al's (2024) systematic review examines this question and similarly finds there is little that can be inferred from the current literature available.

[35] The ten studies are: Cohen et al., 2020; Cohen et al., 2021; Robbins et al., 2019; Ely et al., 2018; Judge et al., 2013; Gundel at al., 2019; Y-Che Yeah., 2004; Sailer et al., 2023; DeSantis et al., 2023 and Sims et al., 2023.

[36] Cohen et al's (2021) study provided a conceptual replication of the 2020 study, running 5 randomised controlled studies, finding that these effects replicate across different tasks, timing and modes of delivery (online).

[37] We note one pre-post study by Pankowski and Walker (2016) which found no differences in trainee teacher performance regardless of whether they were from a traditional program or alternative certification programs in the US.

UNDER WHAT CIRCUMSTANCES

The literature is scant on this issue, although commonly studied areas give us a picture of the 'topics' and types of technology used in circumstances where the intervention shows positive effects.

Positive effects are seen across a range of topic areas of trainee development, with commonly studied areas including classroom management, student behaviour and engagement, general instructional skills, for example planning lessons, leading discussions, as well as supporting students with learning difficulties, additional needs and disabilities. A smaller number of studies in our sample found positive results in content-specific instructional practices, including in maths, science, reading, as well as communication skills with various stakeholders (students, colleagues and parents), as well as initiatives supporting student mental health.

A large number of studies use a semi-immersive program with virtual students, sometimes referred to as a 'Mixed Reality Simulator'. A handful of studies use virtual role play with AI chatbot.

4.6 STUDIES SHOWING NEUTRAL OR NEGATIVE IMPACTS

Five studies in our sample did not show positive or differential effects compared to a baseline or comparison group. Within this group, one study showed negative outcomes. These findings were seen across both skill and self-efficacy measures, and across topic areas including special education, instructional skills and communication skills.

One innovative dissertation study by Enicks (2012) tested the impact in real classrooms - not done in any other studies in the sample. It found that trainee teacher participation in *TeachLivE* did not have a statistically significant impact on effective teaching behaviours in classrooms.[38]

Explanations for the neutral or negative findings were varied. One explanation of why trainee teacher self-efficacy declines over time is that the experience in implementing strategies in a simulated environment gives trainee teachers a more realistic picture of their skills and implementation abilities.[39] Hudson and colleagues (2019) hypothesize that perhaps the participants were realizing 'what they still needed to know to be competent teachers'.[40] Regalla and colleagues (2016) notes that this realistic picture may be an important step in candidates' development of a strong sense of efficacy longer term.

Studies also cited statistical or methodological reasons for the neutral findings, for example, small sample sizes (Artun et al., 2020), or issues with assessment items (Enicks 2012).

5. WHAT ARE THE ACTIVE INGREDIENTS?

[38] Note Enicks (2012) did find a relationship does exist between TeachLivE and trainee teachers' demonstration of a *subset* of explicitly observable effective teaching behaviors related to ongoing self-reflection strategies.

[39] Regalla et al., 2016 and Hudson et al., 2019.

[40] Hudson et al., 2019, page 91.

This section explores Research Question 2 on the active ingredients of the intervention. Getting a good grasp of what we mean by the nature of the intervention, and exactly what it entails when implemented effectively, is essential to achieving the expected benefits.

This chapter has two parts:

- Section 5.1 discusses Cohen and colleagues' (2024) systematic review findings on what matters for effective implementation of the intervention.
- Section 5.2 provides our own assessment of six 'active ingredients'.

5.1 FINDINGS FROM THE 2024 SYSTEMATIC REVIEW

The systematic review by Cohen and colleagues (2024) provides an overview on what activities are common in the approximations and examines what factors matter for delivering positive outcomes. Overall it suggests that three factors - 'dosage', opportunities to observe peers and instructional coaching - may contribute to improved trainee teacher learning however there are few empirical studies which show exactly what, how and when.

First, the review explains that supports '*into*' approximations are likely to be vital for developing candidates' schema around the targeted practice. Pre-work should consist of representations of examples of the targeted practices alongside decompositions of the key features of those practices, inline with the work of Grossman and colleagues' (2009). This preparation gives trainee teachers an important theoretical understanding of the practices. However Cohen's review did not find many studies which explicitly detailed the types of pedagogical supports before the approximation. Most studies gave some form of preparation, such as group discussions, or podcasts, but it was not clear whether they sufficiently provided the conceptual underpinnings that would be useful. Other common strategies included preparing lessons, collaborating with peers and writing lesson plans.

Second, Cohen and colleagues (2024) find that supports '*through*' approximations, either during or in-between sessions, are likely to matter, but that the evidence is not clear on which supports, their duration, their quality, are most likely to positively impact outcomes. Commonly, instructional supports during simulations often include live feedback, opportunities to pause the session and receive feedback, as well as the chance for 'do-overs'. Sometimes other people can observe the trainee teacher in the simulator, including the coach, peers and / or university educators. In between simulation sessions, there is often opportunities for self-reflection, feedback from coaches, peers and educators, or modelling of skills via video and setting goals for improvement.

Cohen and colleagues (2024) note that while evidence is thin on which supports matter more, evidence *does* point to coaching between rounds of simulation or after practice as being more beneficial than receiving in the moment feedback (citing Cohen et al., 2020, discussed in section 5.2).

5.2 SIX ACTIVE INGREDIENTS

We suggest six components of immersive simulation are likely to support improved outcomes for trainee teachers, or 'active ingredients':

- Instructional coaching
- Observing peers in the simulator
- Feedback
- Modelling of best practice
- Alignment to coursework
- Dosage of time in the simulator

These six components have been identified from studies which specifically evaluate the relationship between implementation and trainee teacher outcomes. However, given the limited amount of research available, we suggest these six components be considered only as a framework to test in further research. The six components are discussed in turn below.

INSTRUCTIONAL COACHING

Instructional coaching supports around immersive simulations are suggested to be highly beneficial, often because novice teachers lack the background knowledge and experience to recognise their own strengths and weaknesses.[41] Three studies show positive results when instructional coaching is paired with immersive simulation; and one study shows no impact.[42]

Two of the studies showing positive results involve a series of randomised studies of ~100 participants (Cohen and colleagues (2020 and 2021)). Both studies examine the impact of short, 5 minute, highly structured and directive coaching in-between simulation sessions. The authors find that coached trainee teachers had significant and large improvements on skills and candidates perceptions of behaviour relative to those who only self-reflected on their teaching performance.

Infact, both studies go as far to suggest that practice in simulated classrooms and self-reflection alone are unlikely to help candidates significantly develop and improve their instructional skills.[43] In the 2020 study, teachers who only self-reflected between simulations, were more likely to assess minor off-task behaviour as more severe, and less likely to adopt evidence-based behaviour management practices.

An important feature is that Cohen and colleagues use a four step 'directive coaching' model, where coaches provide trainee teachers with targeted feedback on a specific set of instructional skills, give

[41] This idea is discussed in Cohen et al., 2021, page 8, citing: Albornoz et al., 2020; Deussen, Coskie, Robinson & Autio, 2007; Hammond & Moore, 2018

[42] The three studies showing positive results are: Cohen et al., (2020 and 2021); and De Santis et al., (2023). The study showing no impact is by Peterson-Ahmad (2018).

[43] Cohen and colleagues (2020 and 2021)

detailed information about the high-quality enactment of the targeted skill, specific strategies the candidate can utilise in future, along with opportunities to rehearse the targeted skill.

Several other interesting insights from the studies by Cohen and colleagues (2020 and 2021) include:

- Coaching may be more beneficial than live feedback during the simulation for trainee teachers. Instructional coaching between rounds was found to be *as* beneficial as receiving both coaching and (live) bug-in-the-ear feedback during a simulation session.[44] Live feedback may not be as useful for trainee teachers who do not yet have sufficiently robust ideas about "good teaching", unlike more experienced teachers for whom studies have shown benefits of in-the-moment feedback.[45]
- Coaches do not need to have long standing relationships with trainee teachers. Performance-oriented coaching, where coaches support trainee teachers in only brief, directive, skill-focused sessions, were shown to be effective for improving practice experiences.[46]
- There is no empirical clarity in existing literature around whether *higher* dosage coaching is associated with greater observable improvements in instruction.[47]

However one study in our review does not show positive results from coaching around simulations. In Peterson-Ahmad's (2018) study of 8 participants, candidates who received instructional coaching after participating in an immersive simulation session showed *similar* improvements to candidates who did not. The author suggests a number of other supports and high-quality pre-preparation in coursework may explain why coaching had less of an effect than expected.[48] Given these conflicting findings around coaching supports, Cohen and colleagues (2024) calls for further research with larger sample sizes on the impact of coaching.

OBSERVING PEERS

A number of studies indicate that observing peers practising in an immersive simulation can improve trainee teacher knowledge and development.[49] Ely and colleagues (2018) conducted a randomised, experimental study of 22 participants using a *TeachLive* simulation, and found that trainee teachers experiences in observing their peers resulted in learning comparable to that from trainee teachers actively practicing their skills in the simulation.

Another study by Robbins and colleagues (2019) of 29 participants found similar results, and that 'vicarious' observational learning occurred that occurs in the simulation may be just as effective as practicing oneself. The trainee teachers who observed peers practice in a mixed reality simulator

[44] Cohen et al., 2020.

[45] This point is discussed in Cohen et al., 2024.

[46] Cohen et al., 2021.

[47] Cohen et al., 2020 cites: Blazar & Kraft, 2015; Desimone & Pak, 2017; Kraft et al., 2018. It also cites one randomized control trial in this area which found no relationship between coaching dosage and teacher outcomes (Pas et al., 2015).

[48] Peterson-Ahmad's (2018) discussion page 7.

[49] This point is also emphasised by Cohen and colleagues (2024) systematic review.

before enacting their own practice performed significantly better than those who (only) practiced twice.

FEEDBACK

Three studies show that feedback is an important element for candidate learning, including a recent study on 'automatic adaptive feedback'. These studies are in addition to the instructional coaching studies (above) which also include a form of feedback to trainee teachers.

First, a study by Judge and colleagues (2013) found that trainee teachers who received both training *and* feedback improved their use of the strategies more than the groups who did not receive feedback. The 'feedback' consisted of peer focus group feedback and email feedback. However the generalisability of these results are limited given the sample size is very small, at only 6 participants.

Second, a larger, randomised study by Yu-Chu (2004) in Taiwan of 149 participants found that trainee teachers who received extra supports when using a computer-based simulation program – including written research-based literature and a personalized bar chart depicting each individual participant's usage rate of each of the teacher behaviors during the first simulation - improved their teaching behaviours more compared to the other groups.[50]

Third, an experimental study in Germany by Sailer and colleagues (2023) found positive impacts from automatic adaptive feedback in a computer-based platform. In this randomised study of 178 participants, there were six simulated pupils with various learning difficulties, and following each case, trainee teachers wrote an explanation of their diagnostic reasoning. After that, the trainee teachers received either automated or static feedback on their written explanation [static feedback is where learners compare their responses to a written 'correct' answer from an expert, while adaptive feedback is where the learners diagnostic explanation was analysed in real time with specific paragraphs of pre-defined feedback then activated]. Overall, the study found that trainee teachers improved in their quality of justifications in written assignments *more* when they received adaptive feedback than static feedback (although these findings did not hold for improving trainee teachers' diagnostic accuracy skills). The study finds that automatic adaptive feedback in simulations 'offers scalable, elaborate, process-oriented feedback in real-time to high numbers of students.'[51]

MODELS OF PRACTICE

'Models' are observable examples of a specific teaching practice, and can be done either in videos, written explanations, or live models delivered in person by a more experienced colleague or coach. Theory suggest that models help teachers to develop a mental image of the focal teaching practice, and that they should be incorporated into initial teacher education.[52]

We find one study which specifically tests the impact of modelling and simulations for trainee teachers, with large positive results. A recent UK based study by Sims and colleagues (2023) tests the effects of video models, and finds that it improves trainee teachers' skills, knowledge, and self-

[50] Note it is unclear if the computer simulation was 'immersive', especially given the older nature of this study.

[51] Sailer et al., 2023, p 1.

[52] Sims et al., 2023 discusses the existing literature on this point.

efficacy in using retrieval practice in a Mursion simulator. The study randomly allocated 89 trainee teachers to different groups, and found that the use of video models improved trainee teachers skills relative to no model where trainee teachers only read an evidence summary. Interestingly, it found that trainee teachers exposed to the video models did *twice as well* in their second simulator attempt, relative to the trainee teachers who did not watch a video model.

ALIGNMENT TO COURSEWORK

Theory suggest that trainee teacher should have a strong conceptual underpinning of the skills and beliefs targeted in immersive simulations, and that this should be taught in concurrent coursework with immersive simulations. Few studies appear to have specifically tested this issue, but one empirical study supports this idea.

The study by Cohen and colleagues (2021) finds that trainee teachers enrolled in a concurrent methods coursework focused on the practices targeted in simulations improved much more than trainee teachers in an undergraduate course. Cohen and colleagues (2021) highlight that this finding is aligned with other coaching literature which finds that 'coaching in isolation, without corresponding coursework on targeted practices, is not as effective'.[53]

Cohen and colleagues (2021) emphasise the importance of coherent and coordinated learning experiences, where 'candidates engage with the theory underlying teaching practices, have opportunities to observe and analyze use of such practices, and *then* have chances to enact those practices with coaching supports'.[54] Cohen and colleagues suggest that approximations of teaching should not be stand-alone experiences, where skills are decoupled from their conceptual bases.

DOSAGE

The systematic review by Cohen and colleagues (2024) suggests that dosage of practice time 'may' contribute to trainee teacher learning. However few studies directly examine the optimal 'dosage' i.e. number of sessions or time spent in a simulator for trainee teachers to experience positive outcomes.

We find three articles suggest that *more* time in the simulator increases trainee teacher learning. The first study by Rosati-Peterson and colleagues' (2019) involves participants completing three mixed reality simulator sessions, and found that candidates significantly improved their skills between the second and third rounds.

The second study, by Gundel and colleagues (2019) similarly examines how candidates' outcomes changed when dosages of mix reality simulator practice varied, by either 30 minutes, 60 minutes, and 90 minutes. On average, candidates significantly improved their teaching self-efficacy after the end of the practice, but there was a dip for students who practiced for 60 minutes.

[53] Cohen et al., 2021, page 33, cites Kraft et al., 2018.

[54] Cohen et al., 2021, page 30, cites Grossman et al., 2009.

The third study, by Aguilar and Flores (2022) shows that candidates who were exposed to three, rather than one, Mixed Reality Simulation session displayed a higher percentage use of the desired teaching strategies. Each session lasted 7-10 minutes in the simulator.

It is worth noting that in our sample of 35 studies there is a wide range in 'typical' dosage. For example, the 'total time' spent in the simulator per trainee often ranges from between 15 – 60 minutes across a number of studies.[55] There is also variation in the number of sessions and duration of each session. For example, some studies had 3-4 short sessions of 5-10 minutes each,[56] while other studies had only one session of 50-60 minutes.[57]

To give a full picture, we note findings discussed in our articles on the 'dosage' for current teachers, rather than trainee teachers. Two quasi-experimental, randomised research projects which show that four sessions in a TeachLivE simulator, consisting of 10-minutes each and 40 minutes in total, significantly improved target teacher behaviors during instruction with real students.[58]

[55] The range of 15 – 60 minutes (in total) is across around 14 studies in our sample.

[56] Cohen et al., 2020, De-Santis et al., 2023, Driver et al., 2018, Yung-Chi Lin, 2022

[57] Spencer et al., 2019, Schussler et al., 2017, Green et al., 2020

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