How can simulation games foster theory-practice integration in student teachers? Perspectives on their effects and instructional setting

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Für meinen Vater – der sicher darüber verwundert wäre,
dass man eine ganze Doktorarbeit über Telespiele schreiben kann.
Ich wünschte, du könntest sie lesen.

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> *„The presence of those seeking the truth is infinitely to be preferred to the presence of those who think they've found it."*
> – Sir Terry Pratchett, *Monstrous regiment* (2004), p.207

Theoretical Background

The theory-practice gap as a motivation for this work

During their university studies, student teachers in Germany learn how to teach effectively from two sources: school-based activities enabling (guided) teaching experiences and university courses conveying theoretical knowledge about how to teach (e.g., pedagogical content knowledge, subject-didactic knowledge). Connecting both settings should support student teachers to link their theoretical knowledge from university to actual classroom teaching. For example, student teachers could systematically discuss teaching situations with a mentor to understand how their prior knowledge applies to practice. By linking theory and practice repeatedly, student teachers should ultimately be able to use their theoretical knowledge to reflect on teaching experiences in the past (reflection on action) and to inform their teaching behavior in the present (reflection in action; see Schön, 1983). In support of this approach, previous research has shown various benefits of theories for teaching. Teachers' pedagogical content knowledge, for instance, seems to positively influence their professional development (Kulgemeyer et al., 2020; Kulgemeyer & Riese, 2018), as well as student outcomes and aspects of teaching quality (Baumert & Kunter, 2013; Blömeke et al., 2014; König et al., 2014). Despite these benefits, student teachers often perceive theory and practice as disconnected. This so-called theory-practice gap in teacher education (for an overview, see Korthagen, 2010b) is evident in student teachers' perception of theory and practice and their transfer of theoretical knowledge to teaching practice.

While theories about teaching and teaching experiences are complementary perspectives on teaching, student teachers tend to perceive them as incoherent (e.g., Standal et al., 2014; Velija et al., 2008). If student teachers perceive their theoretical knowledge as disconnected from practice, they may not feel that it prepares them to teach, while their practice-based knowledge does so (Allen, 2009; Markle, 2020). Accordingly, the subjective relevance of theoretical knowledge has been shown to decrease over time, with student teachers increasingly favoring practice-based knowledge instead (Bråten & Ferguson, 2015; Ezer et al., 2010). The increasing overemphasis on practice seems to persist throughout teacher education, well into novice teachers' first years of teaching (Allen, 2009; Conway, 2012). If student teachers perceive theoretical knowledge to be disconnected and irrelevant for teaching, they might not be willing or able to *transfer theoretical knowledge to the classroom*. It has been shown repeatedly that novice teachers experience it as difficult to apply their theoretical knowledge (Allen, 2009; Cochran-Smith et al., 2015; Cramer, 2013). When student teachers cannot derive teaching strategies from their own theoretical knowledge, they tend to adopt the strategies and routines of more experienced colleagues instead (McGarr & McCormack, 2014; Moore, 2003). This is especially apparent under the pressure of first-time teaching. Relying only on others' teaching strategies may broaden the theory-practice gap in two ways. First, even if the strategies novices learn from colleagues are grounded in theory, more experienced teachers may not be able to articulate and explain this knowledge (see e.g., Shim & Roth, 2007). Without being taught why and how their experienced colleagues use certain strategies, novice teachers may not be able to connect them to the theories that inform them. Second, novice teachers may perpetuate ineffective or even harmful teaching behaviors when they copy others' strategies and methods without reflection. In the long run, both processes may contribute to the neglect of state-of-the-art theoretical knowledge as one perspective that informs teaching (for a discussion, Renkl, 2022).

To find ways to close the theory-practice gap effectively, we must first understand the causes of this knowledge fragmentation in teacher education. The theory-practice gap in teacher education is discussed across many countries that divide teacher education into university- and school-based phases (e.g., Ferraz et al., 2021; Meij et al., 2022; Ó Gallchóir & McGarr, 2022; Standal et al., 2014). Although this structure should enable student teachers to first acquire, and then practice and discuss theoretical knowledge in guided teaching practice, how both phases are carried out potentially impedes connecting theory and practice. Korthagen (2010a) identified the *learning process* in teacher education and the *complexity of teaching* as two factors inherent to teacher education that may drive the fragmentation of student teachers' knowledge.

For the *learning process* in teacher education to foster theory-practice transfer, instructors have to provide connections between theory and practice. However, those connections between theory and practice tend to be scarce in both settings of teacher education (Cramer, 2013; Metcalf et al., 1996; Moore, 2003; Velija et al., 2008). When theoretical knowledge is not discussed in relation to the context of its use, this knowledge will likely stay inert (for an overview, see Renkl et al., 1996). If their theoretical knowledge remains inert, student teachers may be able to recall it on a test but not flexibly use it to derive theory-based teaching strategies. Teaching inert knowledge may begin when university courses initially teach theoretical knowledge without addressing when or how to apply it in practice. Instructors in school-based activities then tend not to discuss experienced practice in relation to theoretical knowledge, which reinforces theoretical knowledge to stay inert (Cramer, 2013; Hegender, 2010; Moore, 2003).

The high *complexity of teaching* further makes it difficult for student teachers to establish links between theories and practice without the guidance of university instructors or mentor teachers. Teaching effectively requires teachers to filter incoming information in an ever-changing classroom for significant events to then interpret and take appropriate action (see *noticing*; van den Bogert et al., 2014). To handle this task, experienced teachers rely on a repertoire of *classroom scripts*, based on their professional knowledge and prior experiences with similar situations (Wolff et al., 2021). To distinguish them from classroom episodes as conceptualized by Bromme (2001), Wolff and colleagues (2021) define classroom management scripts as knowledge structures about common classroom events, including (interactions between) relevant objects, actors and locations in classroom events. As student teachers still lack these scripts, they often fail to notice enabling conditions in critical teaching situations (for an overview, see Wolff et al., 2021). However, gaining sufficient expertise in teaching requires novices to not only repeatedly engage with practice but to do so in a way that causes deep engagement (see Ericsson, 2018). Reflecting on (past) teaching experiences from a theory-based perspective can foster such deep engagement (reflective practice; Schön, 1983). Theoretical perspectives on teaching might additionally support the construction of effective classroom scripts by serving as frameworks that provide information about what classroom events might be relevant, how to interpret them and what consequent actions might be appropriate. In order to reorganize this knowledge into teaching scripts student teachers should engage in practice that is complex enough to challenge but not overwhelm them (Boshuizen et al., 2020; Ericsson, 2018; Wolff et al., 2021). The highly complex setting of real classroom teaching might be especially inappropriate for novices to connect theory and practice (Chernikova, Heitzmann, Stadler, et al., 2020). To provide access to practice without overwhelming student teachers, Grossman et al. (2009) suggest that student teachers should engage in frequent, small, manageable doses of practice rather than few extended, complex practice phases. Depending on the instructional goal, they suggest three ways that instructors can make practice accessible to novices: *representations of practice*, *decompositions of practice* and *approximations of practice*.

Engaging with *representations of practice*, such as videos or classroom protocols, allows student teachers to observe pre-recorded sequences of practice. (Repeatedly) Studying these representations in their own pace allows them to notice even subtle teaching behavior, make connections to theoretical knowledge, and discuss observations with their peers. When instructors *decompose practice*, they break down these complex sequences of teaching into their most basic processes and skills. Helping learners to deconstruct practice can make the underlying *grammar of teaching* visible to novices. By highlighting individual components of teaching, student teachers can focus on understanding them thoroughly. For further training, components can be combined back into more complex sequences, once student teachers have understood them sufficiently. Prior research has shown that classroom videos (see Blomberg et al., 2013) or case studies (Augsdörfer & Casper, 2018; Baier et al., 2021) can be effective tools to foster connections between theory and practice or new teaching skills. While representing and decomposing practice may teach theoretical knowledge with its use in mind, it does not train student teachers to apply their knowledge in the classroom.

To practice knowledge-application in the classroom, instructors can confront student teachers with *approximations of practice*, which can cover single skills or processes, as well as situations where multiple processes and skills are relevant. These practice-derived scenarios with reduced complexity (e.g., face-to-face roleplay, simulations) offer several advantages over learning in real teaching scenarios. First, when learning from everyday teaching, student teachers are limited to scenarios they encounter naturally. On one hand, this makes it difficult for them to focus on the application of certain theories, as they may not encounter a situation where using that theory would be appropriate. For example, if student teachers want to practice strategies for mobbing prevention, they might not have sufficient contact with the same class to do so or encounter the class in a situation where mobbing is already present. On the other hand, relying on common teaching experiences does not allow student teachers to train how to deal with rare but critical situations (e.g., medical emergencies). Instructors can avoid both problems by providing scenarios that approximate real-world situations that match the task to be learned with an appropriate level of complexity (e.g., number of students, amount of information) to the learners' prerequisites (e.g., prior knowledge). Second, when engaging with an approximation of practice, student teachers learn in an environment of educational safety (see Breckwoldt et al., 2014). In forms of approximated practice, like simulation-based activities, learners can experiment with knowledge application and immediately observe the consequences of their actions. Even if they fail to apply their knowledge correctly, failure is not sanctioned and does not harm themselves or others. This environment allows student teachers to experiment and treat mistakes as an opportunity to learn and reflect on.

To sufficiently learn from approximated practice, Grossman et al. (2009) argue that student teachers should engage with it regularly. From a practical perspective, doing so can be difficult if approximated practice relies on face-to-face interaction (e.g., role-play, experimental games). As these formats require resources and time to prepare and execute, individual student teachers will likely not be able to regularly train knowledge-application in the role of a teacher. Furthermore, as face-to-face formats depend heavily on input provided by participants, the quality of how they are carried out may vary between groups. Digital approximations of practice, like digital simulations or serious games, may solve these problems. Although they require much time and resources to create, instructors can afterwards reuse them for future courses. Creating a collection of various teaching scenarios over time could enable more student teachers to frequently practice applying theoretical knowledge across various situations. Additionally, different properties of digital approximations of practice expand on already existing advantages of approximated practice (e.g., customizability, standardization). For this reason, among others, simulations and serious games have been repeatedly recommended as particularly effective ways to approximate practice to teach knowledge application (De Coninck et al., 2019; Hajian, 2019). Their effects on transfer indicate that approximating practice with digital simulations and serious games may be a promising way to close the theory-practice gap in teacher education.

In spite of their proclaimed potential, there is still little empirical quantitative research systematically exploring the effects of simulations or serious games in teacher education (for an overview, see Chernikova, Heitzmann, Fink, et al., 2020). Beyond their general effects, it remains unclear how and when teacher education can use them most effectively. To accurately assess the potential of simulations and serious games to foster theory-integration in student teachers, it is essential to understand the boundary conditions of their use. To the best of my knowledge, there is currently no research on these boundary conditions that identifies at what point in their studies and how simulations and serious games should be used in teacher education for their best impact. The current dissertation provides insights into this question by observing the use of the same teaching simulation game in two use-cases: 1) fostering the transfer of pre-existing knowledge in advanced student teachers, and 2) teaching novice student teachers about theories and their transfer. The findings of both studies will provide insights into the processes, potentials and pitfalls of student teachers learning to apply theoretical knowledge with a teaching simulation game. Furthermore, this dissertation will discuss the challenges observed in student teachers' learning experiences and their potential implications for boundary conditions and the (instructional) design of simulation games.

Digital Simulations und Simulation Games

Simulations (digital or non-digital) are commonly defined as interactive models representing a real system (or scenario) by reproducing a set of variables building that system as well as their interplay (e.g., Beaubien & Baker, 2004; Sauvé et al., 2007). Learners can interact with the variables in the system and learn about their interplay by studying the consequences of their manipulations. Simulations may simplify aspects of a real system for didactical purposes (e.g., focus on certain aspects), but they ultimately aim to capture the system they represent with a certain degree of fidelity (Sauvé et al., 2007). As a tool for learning, simulations have a long history in professions like medicine, where novices learning in the field would be dangerous, unethical or costly. There is a vast amount of research in these fields demonstrating the effectiveness of (digital) simulations for conveying knowledge and building up critical skills for the targeted profession (e.g., Chernikova, Heitzmann, Stadler, et al., 2020; Gegenfurtner et al., 2014; McGregor & Bartle, 2019). Considerably less research has focused on their use in teacher education (for an overview, see Chernikova, Heitzmann, Fink, et al., 2020).

Another way to approximate practice allowing stronger adaptations to the approximated target are serious games. Despite many approaches across different disciplines, there is no current consensus on which general criteria define a game (for an overview, see Salen Tekinbas & Zimmerman, 2003). As one of the least reductive approaches, Suits defines playing a game as “the voluntary attempt to overcome unnecessary obstacles” (Suits, 2005, S.41). A game can design a specific kind of voluntary struggle by defining a goal-state to strive for and a set of rules confining the space of permittable action to reach that goal (Suits, 2005). By combining these goal-states and rules, game designers are able to design a space of agency allowing players to engage in a particular kind of activity (for a discussion of agency in games, see Nguyen, 2020). Participating in these activities effectively may afford players to solve problems by assuming new perspectives or thinking outside the box. Designers of serious (or applied) games use these tools to craft games intended to impact players' cognition, (motor) skills or behavior (Ravyse et al., 2017) beyond the game's context. Similar to simulations, simulation games, as a subgenre of serious games, allow learners to learn through engaging with a (authentic) representation of a real system. Even though they still simulate a real system, simulation games additionally utilize techniques of game-design (rules, goals, etc.) to shape an activity within that system for learners to engage in. By changing how the system is represented, they may abstract from authenticity in favor of changing some of its aspects to facilitate learning (e.g., visualizing invisible processes, incentive structures). Their freedom of design allows serious games to create learning activities focused on two main goals: to foster student learning and to be an engaging and desirable activity for learners (see e.g., dual flow, Sinclair, 2011). Thus, the way in which simulation games create a learning activity can be beneficial not only for the *cognitive outcomes* of learners, but also for their *motivational outcomes* (see Wouters & van Oostendorp, 2017).

On the cognitive side, digital simulation games as approximated practice have learners participate and cognitively engage in authentic settings of practice. Multiple facets of learning with simulation games can potentially facilitate transfer of knowledge in student teachers. First, digital simulated teaching offers various teaching scenarios in which student teachers can practice the transfer of theoretical knowledge. To successfully solve a simulated problem, learners must understand its structure and then derive strategies from their theoretical knowledge (see Gick & Holyoak, 1983). This productive engagement with a serious game or simulation can be enhanced when their design employs instructional techniques based in theory (Clark et al., 2016; Wouters et al., 2017). In order to develop cognitively flexible knowledge structures that facilitate the transfer of their knowledge to real-world teaching situations, student teachers should engage in a variety of simulated teaching scenarios (see Gruber et al., 2000; Renkl, 1996). Prior studies have demonstrated simulations and serious games to positively influence skill acquisition and knowledge transfer in different domains, including teacher education (Chernikova, Heitzmann, Fink, et al., 2020; Chernikova, Heitzmann, Stadler, et al., 2020; Lamb et al., 2018; Riopel et al., 2019; Theelen et al., 2019; Wouters et al., 2013). Current findings suggest that these effects can be robust even a year after intervention (Raupach et al., 2021).

Second, simulation games allow instructors and designers to control not only their content to meet the intended instructional goal but also the way learners engage with that content. This allows instructors to support learning by both adapting the materials learners interact with and by supporting learners and their behavior directly (for an overview, see Renkl & Scheiter, 2017). Serious games should, thus, be designed so that every aspect of their design fosters cognitive processes relevant to learning, like the selection, organization and integration of information related to the game's learning goal (for a discussion, see Wouters & van Oostendorp, 2017). Designing an activity that fosters learning in every aspect of its design can be challenging, as the effects of some design elements may vary between individual learners. One example illustrating this problem is the role of realism in a simulated setting. On one hand, it is recommended for simulated learning environments to feature high fidelity. This design rationale assumes that being close to the setting of later skill-use later eases the transfer of knowledge from training to real practice (e.g., DeConinck et al., 2019; Gegenfurtner et al., 2014). On the other hand, focusing on fidelity does not equally benefit all learners. Just as in real practice, novices may be overwhelmed when simulated teaching environments place high demands on learners by featuring realism in ways irrelevant to the instructional goal (for a discussion, see Renkl et al., 2017). Consequently, there has been a lack of conclusive evidence demonstrating benefits of high-fidelity simulation in facilitating transfer (Norman et al., 2012). Game designers and instructors should therefore consider whether certain elements of their game (e.g., realism, instructional support, etc.) will promote learning in their target audience before including them.

Third, simulation games provide a digital standardized system for learners to interact with. As this system maintains consistency between playthroughs in the depicted teaching situations as well as possible reactions to player behavior, learners can engage with the same situation repeatedly. When reengaging with a scenario, learners can apply what they have learned through succeeding or failing in prior playthroughs. Matsuda (2008) identifies a high potential for student teachers in this approach, as it allows them to apply intuitive or flawed teaching strategies to then compare their effects to those of best practice approaches in future playthroughs. Other cyclical learning approaches posit it as crucial for learners to receive feedback about their performance after each session to facilitate the acquisition of knowledge and skills (see Darling et al., 2005; Jossberger et al., 2022; Taylor et al., 2012). This feedback should establish links between theoretical knowledge and the events of the simulated practice and encourage learners to reflect on their actions and their consequences. The feedback's content may also act as a form of instruction by guiding learners’ attention towards relevant information and giving hints about how to interpret them (for a discussion, see Johnson et al., 2017). Learners can then use this knowledge in future playthroughs. Prior research supports that learning over multiple sessions (Clark et al., 2016; Wouters et al., 2013) and receiving feedback after playing (DeConinck et al., 2019; Gegenfurtner et al., 2014) facilitate learning with simulations and serious games. Since the effects of simulation games seem to depend on repeated use and cognitive engagement with feedback, student teachers would need the motivation to do so in order to effectively learn how to apply theoretical knowledge.

On the motivational side, the design of simulation games and how they interact with student teachers can influence learners' motivation to engage with them or to apply what they learned from playing. According to situated expectancy-value theory (Eccles & Wigfield, 2020), student teachers' motivation is influenced by two factors: the subjective value of the task at hand and their expectancy to succeed in it. On a general level, these factors can influence learners' motivation to (repeatedly) learn about theoretical knowledge in a simulation game. If, for example, the subjective value of playing a simulation game and the expectancy for success of playing are high, student teachers should be sufficiently motivated to engage with it. Simulation games can potentially manipulate this motivation by providing additional sources of task value compared to more traditional learning materials, like texts. For example, student teachers may be motivated to read a text on classroom management because knowing about classroom management is important to being a teacher (attainment value), because they want to avoid being sanctioned for not reading it (cost reduction), and possibly because its content may prove useful in the future (utility value). In comparison, simulation games may provide an additional source of intrinsic task value (e.g., entertainment) or emphasize utility value through interaction (e.g., by demonstrating usefulness of certain knowledge in use). Learners might consequently be more motivated to learn with a game compared to a text. This potential motivational benefit could be particularly relevant for teaching advanced student teachers. As discussed earlier, student teachers tend to perceive theoretical knowledge as les useful as they progress through their studies (Bråten & Ferguson, 2015; Ezer et al., 2010). Learning about theories that, to them, are of low utility may not have a high subjective task value, possibly resulting in them being less motivated to learn about them. Learning with a simulation game that adds alternative intrinsic value to the task (e.g., entertainment) may lead advanced student teachers to learn about a topic they would otherwise avoid. Instructors and game designers need to be careful to design simulation games not only so that student teachers are motivated to use them, but also so that they encourage learners to engage in effective learning activities. To support this, the central mechanics of the simulation game should be linked closely to the instructional goal (see intrinsic integration, Habgood & Ainsworth, 2011).

Learning with a simulation game might also positively influence student teachers' motivation to use their theoretical knowledge outside of the game. For one, being successful in applying theoretical knowledge in a simulation game might change student teachers' perceptions about the usefulness of that knowledge. When student teachers use their theoretical knowledge in simulated teaching to make decisions or reflect on classroom events, they can experience how to use their theoretical knowledge and reflection as tools for teaching.

Supporting this assumption, prior research suggests that experiencing the utility of a strategy by using it successfully can raise the perceived utility value of that strategy (Hui et al., 2021). Lastly, using theoretical knowledge to solve simplified simulated teaching situations could influence student teachers' expectancy for success for doing so in a real classroom. This feeling of preparedness might be reflected in their teaching self-efficacy. As one form of self-efficacy (Bandura, 1996, 1997), teaching self-efficacy is conceptualized as teachers' perceptions on their ability to support student learning through their actions (Hoy & Spero, 2005). As self-efficacy is seen as a prerequisite for applying skills to novel situations (Bandura, 1997; Gegenfurtner et al., 2014), high teaching self-efficacy has been found to be associated with the application of knowledge and skills to novel and challenging situations. As simulation games can offer mastery experiences (see Bandura, 1997) by interacting with authentic settings of skill-use that challenge but do not overwhelm student teachers, they may foster teaching self-efficacy. Accordingly, prior research demonstrated that simulated teaching scenarios can enhance teaching self-efficacy in student teachers (Christensen et al., 2011; Samuelsson et al., 2022). Higher teaching self-efficacy, then, is positively associated with using teaching skills in challenging classroom scenarios (Gegenfurtner et al., 2014).

In contrast to their theoretical potential, meta-analyses have shown no distinct motivational benefits of learning with serious games and simulations compared to traditional learning materials (Clark et al., 2016; Wouters et al., 2013), as the effects of the studies included tend to be heterogeneous (e.g., Chernikova, Heitzmann, Stadler, et al., 2020). The observed heterogeneity of effects reflects the heterogeneity of the simulations and serious games examined in individual studies. This is especially severe in research on serious games, as their freedom of design allows them to create vastly different ways for learners to approach a topic to learn. Because of this, serious games in individual studies not only differ in quality, but also in genre (e.g., arcade-style games with high replay value vs. roleplay games) and instructional goal (e.g., drill and practice for automatization of knowledge recall vs. understanding others' perspectives). The resulting different learning activities may not only target different outcomes but also require different strategies to use them effectively. Before this backdrop, it is unclear if it is reasonable to draw conclusions from comparing the outcomes of very different learning activities whose only common feature is “being a game”. At the same time, it is often hardly possible for meta-analyses to account for differences in quality or instructional goal because individual studies rarely provide sufficient information on the material's design. Providing interactable excerpts is also often not possible, partly due to copyright-concerns with materials. The inability to assess the quality of the included serious games and simulations might limit the quality of conclusions that can be drawn from meta-analyses. It remains unclear if overarching null-effects reflect a real lack of such effect or the methodical concerns described prior. Further research is needed to explore how serious games and simulations with different approaches affect specific motivational variables.

How should we implement serious games in the teacher education and in learning units?

Until now, I pointed out why simulation games may have the potential to teach student teachers theoretical knowledge so that they will want to learn and apply that knowledge. However, it remains unclear how the implementation of simulation games affects their ability to promote knowledge transfer in teacher education. Knowing more about how to implement them effectively would be very important because, as with any other kind of material, the effects of a simulation game as a learning tool can only be as good as its implementation. Some facets of implementation that influence their effects have been explored in the past. For example, a meta-analysis by Wouters and Spek (2013) found that serious games show greater effects when used together with other forms of instruction. In a discussion of serious games for teaching basic reading skills, McTigue and Uppstad (2019) argue the effects of learning with a serious game to highly depend on its implementation. They argue that effectively implementing a serious game in a lesson may enhance its motivational (e.g., by stating goals for game sessions) and cognitive potential (e.g., by encouraging learners to play mindful and self-reflect). Despite these potential benefits, McTigue and Uppstad (2019) identify a gap in research assessing how instructors should implement serious games to fully use their potential. This gap seems to be especially prominent in settings like teacher education where serious games are used to convey complex skills (e.g., classroom management) to adult learners. Here, it remains unclear *when* and *in which instructional setting* teacher education can best use simulation games to teach for transfer and how their implementation supports or hampers learning.

There are some meta-findings concerning which age groups of learners tend to benefit most from using simulation games (e.g., Riopel et al., 2019). However, research on when and how playing a simulation game in teacher education best facilitates knowledge transfer in student teachers is still lacking. While it is still unclear if student teachers profit more from using simulation games for initial knowledge acquisition and transfer of new knowledge or for practicing to apply pre-existing knowledge in more advanced stages of their studies, arguments can be made for both sides. From the perspective of inert knowledge, one could argue that *novice student teachers* should be the ones who benefit most from learning with simulation games. If student teachers acquire initial theoretical knowledge and apply it directly in simulated teaching, their knowledge should be less likely to become inert. Aligning with this approach, Schmidt and Rikers (2007) recommend that student teachers should approach authentic problems early and repeatedly in their studies to foster the development of effective professional scripts. Because novices, unlike advanced student teachers, do not have prior teaching experience to draw upon, but only their experience of being taught, they have fewer alternative sources of knowledge other than theoretical knowledge that might inform their approach to simulated teaching scenarios. Given the empirical evidence that the devaluation of theoretical knowledge increases over time, novice student teachers may also be more motivated to use theoretical knowledge than more advanced student teachers. On the contrary, novices' scarce prior knowledge on teaching could leave them easily overwhelmed by complex simulated teaching scenarios (for a discussion, see Codreanu et al., 2020). Simulated teaching designed for novices, thus, might need to simplify authentic teaching scenarios while providing additional instructional support for learners to deal with them. As discussed earlier, decreased authenticity due to simplification might conversely hamper the transfer of knowledge to real situations.

By contrast, *advanced student teachers* not only possess knowledge on theories, but also potential first experiences in teaching practice. This prior knowledge may allow them to productively engage with more authentic and complex teaching scenarios. The meta-finding that learners with high prior knowledge benefit the most from receiving feedback to reflect on simulation-based learning somewhat supports this assumption (Chernikova, Heitzmann, Stadler, et al., 2020). As the effects of simulations and serious games on transfer seem to partly rely on these elements, advanced student teachers may be better prepared to learn in a simulated teaching environment. As previously discussed, advanced student teachers might also especially profit from the motivational benefits of learning with a well-designed simulation game. Due to advanced student teachers' perception of theoretical knowledge being not useful, learning about them with a simulation game that provides intrinsic task value to learning (e.g., fun) might convince them to engage in learning they would not do with other materials. Also, perceiving theoretical knowledge as useful when applying it in a simulation game might increase the perceived usefulness of theoretical knowledge in general, which might lead to increased motivation to use this knowledge in other contexts.

In conclusion, both groups of student teachers (novice and advanced) could benefit from learning about theories with a simulation game, both in being able to transfer their knowledge and in being willing to do so. Influencing one or both of these factors (ability and motivation to transfer) could contribute to closing the theory-practice gap in teacher education. However, it is still unclear how the individual prerequisites of both groups affect their success of learning with a teaching simulation game and how they use it. By observing the effects of simulation games across different phases of teacher education and with varying degrees of instructional support (after a text-based learning-phase vs. in isolation), we might gain insights on when and how it is most effective to use them. Moreover, these findings might indicate which aspects of learning with a simulation game prove to be challenging for student teachers at different stages of their studies. To address these questions, we conducted two studies on the effects of applying same teaching simulation game with advanced (Study 1, Kienitz et al., 2024) and novice student teachers (Study 2; Kienitz et al., 2025). In both studies, participants learned with either a teaching simulation game (*Me as a teacher* by Darya Frantskevich) or a series of screenshots depicting the full game, with participants in Study 2 playing the game after learning with a text on classroom management. The following chapter will provide a brief summary of both studies.

Summary of Studies

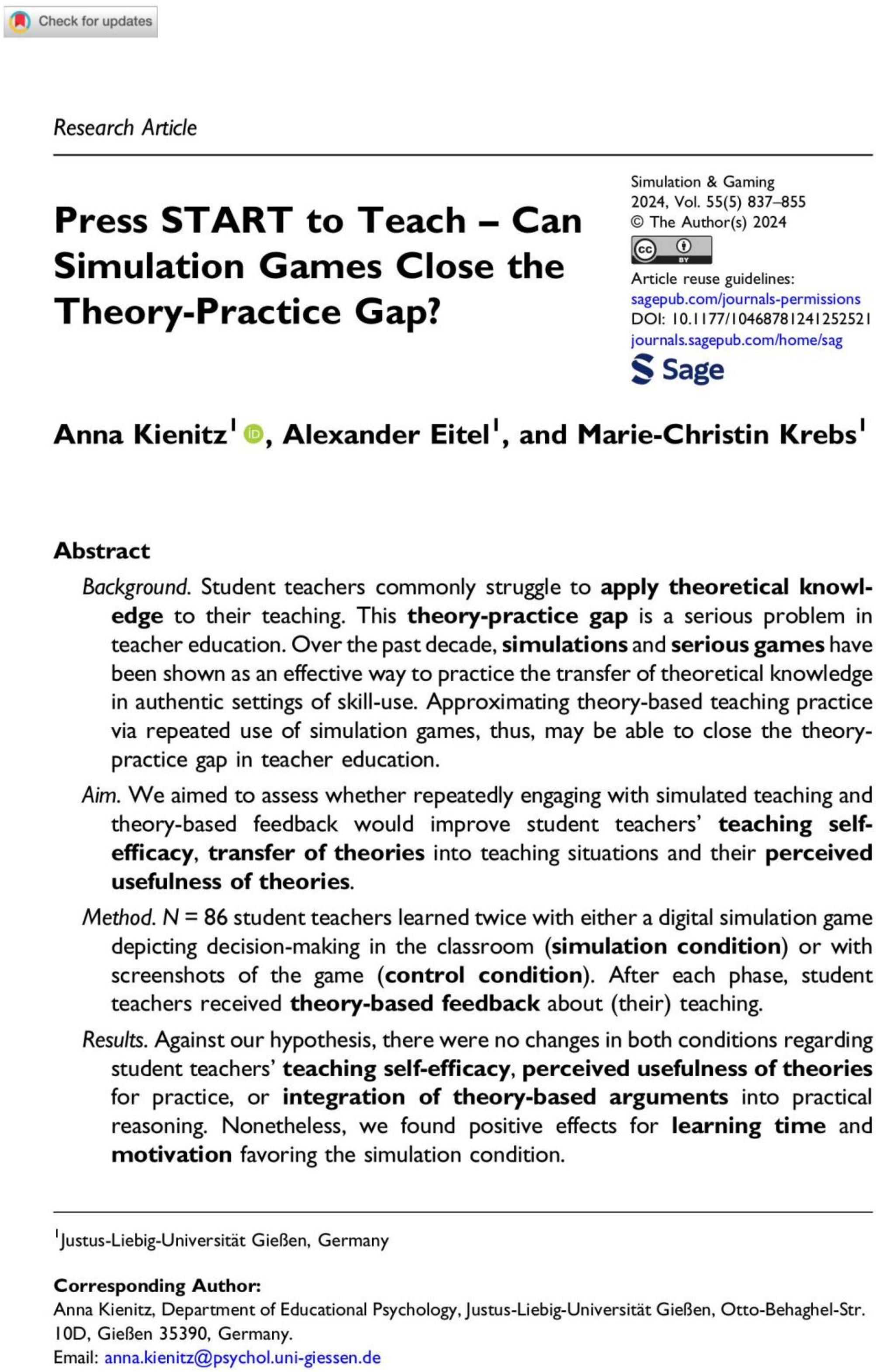
Study 1 of this dissertation (Kienitz et al., 2024) focused on the game's effects for practicing the application of prior knowledge on theories from educational psychology in advanced student teachers ($M_{\text{semester}} = 6$). In the study we used the simulation game *Me as a teacher*, a game that allows learners to practice decision making in authentic critical teaching scenarios (e.g., dealing with disruptions during group work). The decisions depicted are reduced in complexity with respect to aspects that are not central for learners to train theory-based decision-making. For instance, the game highlights when a decision is needed, gives learners time to think about their decisions, and by provides them with options to choose from. After completing a level, learners receive literature-based feedback on their decisions, explaining possible consequences of their actions and suggesting courses of action. We conducted the experiment during a session of an advanced lecture on educational psychology in order to assess the game's effects in an authentic setting in teacher education. During the lecture, student teachers learned twice with either one level of *Me as a teacher* (simulation condition) or a screenshot sequence (screenshot condition) depicting a predetermined course of the level based on the average decisions of five advanced student teachers. Prior to learning, participants did not receive learning materials about theories from educational psychology or any instructions on how to approach the learning materials. We assessed how playing or reading respectively influenced participants' perception and use of theoretical knowledge as well as their teaching self-efficacy and intention to reuse the learning material.

The study revealed that participants in both conditions used a similar amount of theory-based arguments in a transfer task and reported similar levels of teaching self-efficacy and perceived usefulness of theoretical knowledge after learning. However, participants in the game condition studied significantly longer and reported higher intentions to reuse the learning materials because they were fun and because they wanted to learn from them. One factor hampering the training of knowledge application in our study may be that student teachers in our sample were hardly able to spontaneously name or describe theories from educational psychology prior to learning ($M < 1$ theory). If participants did not have sufficient prior knowledge to apply in the game or if their prior knowledge was too inert to use, they would not have been able to practice the transfer of theoretical knowledge in the game.

Based on this observation, Study 2 examined the effects of the same game when used to practice the application of new knowledge after its initial acquisition (Kienitz et al., 2025). Our sample consisted of novice student teachers in their first weeks of teacher education. After reading the text, participants (similar to Study 1) learned twice either with the game (simulation condition) or with a screenshot sequence (screenshot condition). We conducted the study in lab to gain insights into how participants interacted with the materials by capturing their screens as they learned with the game or screenshot sequence. Our results showed that participants in both conditions used more theory-based arguments after learning, with participants in the screenshot condition outperforming those in the simulation condition. There were no significant differences between conditions concerning how useful participants perceived theoretical knowledge to be. Although participants in the simulation condition were less able to use their theoretical knowledge, they reported higher teaching self-efficacy for classroom management and instructional strategies, a topic they did not learn about. Similar to Study 1, participants who played the simulation game learned longer than participants in the screenshot condition and reported higher intentions to re-learn because the materials were fun and because they wanted to deepen their knowledge. However, screen recordings revealed that participants in the simulation condition did not engage with the feedback as long as participants in the control condition. Since the feedback was a core feature designed to facilitate connections between theory and practice, participants in the simulation condition seem to have approached the game ineffectively.

The overall implications of our findings will be addressed in the general discussion.

STUDY 1



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Press START to Teach – Can Simulation Games Close the Theory-Practice Gap?

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Abstract

Background. Student teachers commonly struggle to **apply theoretical knowledge** to their teaching. This **theory-practice gap** is a serious problem in teacher education. Over the past decade, **simulations** and **serious games** have been shown as an effective way to practice the transfer of theoretical knowledge in authentic settings of skill-use. Approximating theory-based teaching practice via repeated use of simulation games, thus, may be able to close the theory-practice gap in teacher education.

Aim. We aimed to assess whether repeatedly engaging with simulated teaching and theory-based feedback would improve student teachers' **teaching self-efficacy**, **transfer of theories** into teaching situations and their **perceived usefulness of theories**.

Method. N = 86 student teachers learned twice with either a digital simulation game depicting decision-making in the classroom (**simulation condition**) or with screenshots of the game (**control condition**). After each phase, student teachers received **theory-based feedback** about (their) teaching.

Results. Against our hypothesis, there were no changes in both conditions regarding student teachers' **teaching self-efficacy**, **perceived usefulness of theories** for practice, or **integration of theory-based arguments** into practical reasoning. Nonetheless, we found positive effects for **learning time** and **motivation** favoring the simulation condition.

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Conclusion. Our results point towards the **motivating potential** of simulation games that was, however, not sufficient to close the **theory-practice gap**. It seems that the theory-practice integration within the simulation game needs to be even stronger to reveal the desired effects, which needs to be subject to further research.

Keywords
adult learning, improving classroom teaching, serious games, simulations, teacher professional development

Background

Teachers tend to consider what they have learned in university as being separate from their everyday teaching practice, which is known as the theory-practice gap (for an overview, see Korthagen, 2010). Up to now, there has been little quantitative-empirical research about whether and how digital simulation games for teaching as approximation of practice (for a discussion, see Grossman et al., 2009; McGarr, 2021) may affect student teachers' perceived usefulness and use of theory for teaching practice. The present study seeks to close this gap by investigating the effect of playing a digital simulation game on student teachers' conceptions and use of theory.

Theory and Practice: Mind the Gap

In Germany, as well as other countries, teacher education consists of two phases: university courses that focus on learning theoretical knowledge and school phases that focus on observing and participating in teaching practice. Student teachers often struggle to connect the lessons learned in both phases. One reason for this is a lack of communication between university-based and school-based instructors. Mentor-teachers may either not know which theoretical knowledge student teachers have learned (Velija et al., 2008), or their priorities for teaching are inconsistent with knowledge learned in university (Moore, 2003). Both factors can be detrimental for effectively instructing student teachers to apply theoretical knowledge to real teaching. The resulting fragmentation of student teachers' professional knowledge is known as the theory-practice gap (for an overview, see Korthagen, 2010). The influence of this gap can be seen in their *perception of theory and practice* as well as their ability to *integrate theoretical knowledge into teaching* (see e.g. Allen, 2009; Cramer, 2013).

Student teachers often do not perceive theory and practice as *equally* important for teaching (Bråten & Ferguson, 2015). They tend to struggle seeing the use of theories for their pedagogical practice, as they seem disconnected from real teaching (Velija et al., 2008). This attitude seems to persist over their studies, shown by the perceived importance and usefulness of their theoretical knowledge decreasing over time

(Cramer, 2013). Consequently, student teachers primarily base their teaching on knowledge gained from prior practice (Bråten & Ferguson, 2015). Their emphasis on the importance of practice-derived knowledge crosses into teaching practice, especially in the early phase of teachers' careers (Allen, 2009; Conway, 2012). This perceived gap further affects the *integration of theoretical knowledge into teaching practice*. When entering the workplace, novice teachers commonly experience difficulties integrating theoretical knowledge into their teaching (Allen, 2009; Cochran-Smith et al., 2015; Cramer, 2013). Theoretical knowledge then loses relevance compared to routines of experienced colleagues. This lack of transfer of theoretical knowledge into teaching practice, however, may lead to the preservation of inefficient teaching strategies in the long run.

Closing the Gap

Despite the reported struggles, knowing about theories of teaching has been shown to positively influence teachers' professional development (Kulgemeyer et al., 2020) as well as the quality of their teaching (Blömeke et al., 2014; König et al., 2014). Although it is therefore desirable to integrate theoretical knowledge with practice, it remains unclear how best to close the theory-practice gap.

Different approaches focus on strengthening the role of student teachers as reflective practitioners (e.g., Schön, 1983). Reflective practice includes bringing together theory and practice by making conscious decisions in practice (*reflecting in action*) as well as reflecting on passed practice (*reflecting on action*). Further, Grossman et al. (2009) suggest the frequent integration of manageable portions of practice in teacher education before teachers enter real classrooms. Their framework comprises different perspectives that can be used to access practice in teaching: *representations of practice*, *decompositions of practice* and *approximations of practice*.

Representations of practice illustrate real teaching situations in form of e.g., videos or case studies. They allow novices to focus on specific aspects of practice. *Decomposing practice* requires instructors to break up teaching-sequences into the single units of skills and processes that compose them. After understanding them in isolation, they can then integrate them into more complex sequences of teaching. *Approximations of practice* allow closer interaction with authentic teaching by providing scenarios derived from practice with reduced complexity (e.g., role-play, simulations). Student teachers can apply their theoretical knowledge in these scenarios and experience the consequences of their actions. Depending on their use-case, authenticity can be adapted on different dimensions (e.g. linearity of time in the simulation Howell & Mikeska, 2021). Approximating practice has two advantages. First, student teachers can apply new knowledge in a safe setting, because failure is not sanctioned. Second, after receiving feedback, they can apply the lessons learned by reengaging with the same situation.

Serious games and simulations as approximations of practice allow student teachers to participate in authentic (teaching) situations mimicking the pacing of a classroom and experiment using their theoretical knowledge. Studies focusing on their effects show their potential for building up long-term skills and knowledge (Lamb et al., 2018; Raupach et al., 2021; Riopel et al., 2019; Wouters et al., 2013). Specifically the use of teaching-simulations showed significant increases in classroom management skills (Theelen et al., 2019), perceived preparedness for practice (Theelen et al., 2020), and use of reflective practice (Yeh, 2004). In sum, digital simulation games may be a promising method for bridging the theory-practice gap.

To fully use their potential, they have to be embedded effectively. Their general design should be based on theory, depict authentic situations and offer feedback as well as opportunities to reflect (De Coninck et al., 2019). Aligning with cyclical coaching approaches for (simulation) trainings (e.g., Darling et al., 2005), repeated use combined with feedback can be argued as a key factor, and thus a boundary condition for effective learning with simulation games (De Coninck et al., 2019; Dieker et al., 2014).

Research Questions

The current study aims to observe short-term effects of digital simulation games on self-efficacy and behavioural intentions as well as perception and transfer of theoretical knowledge. We compared participants learning twice with either (1) a simulation game (simulation condition) or (2) with a sequence of screenshots from the same game (control condition).

We investigated the following hypotheses:

1. H_1 *(Replay hypothesis):* Participants learning with the simulation game should feel more motivated to engage with the materials, due to actively taking part in the depicted events (see Deci & Ryan, 2000). Thus, they should report higher intentions to reuse the learning materials compared to participants in the control condition.
2. H_2 *(Usefulness hypothesis):* Participants learning with the simulation game can better apply their theoretical knowledge to authentic teaching situations for which they receive theory-based feedback. We expect higher gains in perceived usefulness of theoretical knowledge for participants in the simulation condition compared to the control condition.
3. H_3 *(Self-efficacy hypothesis):* Participants learning with the simulation game can make own decisions and experience their consequences. This agency should lead to significantly higher gains in teaching self-efficacy in the simulation condition compared to the control condition.
4. H_4 *(Transfer hypothesis):* By applying their theoretical knowledge in authentic situations and actively engaging with the provided feedback, we expect participants in the simulation condition to increase their use of theory-guided reasoning. We expect a significantly weaker increase of theoretical arguments in the control condition.

Methods

Participants and Design

$N = 86$ student teachers (71 women, 13 men, 1 other, $M_{\text{age}} = 23.35$, $SD = 3.03$) completed the experiment simultaneously during one session of the lecture *Basics of teaching and learning with media* at a German University. Because the experiment was didactically embedded in the session on "learning with computer simulations", participants did not receive extra compensation, for which they provided informed consent. The study was approved by the local ethics board (LEK FB06 2022-0013).

Participants were randomly assigned to either the *simulation condition* ($n = 37$) or the *control condition* ($n = 49$). In both conditions, participants learned twice with either a simulation game depicting common teaching situations (simulation condition) or a screenshot-sequence of the games' content (control condition).

Material and Experimental Manipulation

In the simulation condition, participants learned with a scenario from the simulation game *ICH ALS LEHRKRAFT* (*ME AS A TEACHER*), developed by Darya Frantskevich as part of the project Serious Games in Teacher Education. The visual style of the game resembles comic-styled illustrations of teachers and students in front of photographs of real classrooms (see Figure 1). The simulation game requires participants to make decisions in common, sometimes critical, teaching situations. For this, participants can choose from different options. Their decisions then influence the further course of the simulated lesson. At the end, they received feedback for their decisions. A more detailed description of the simulation game can be accessed via the Files of the following OSF-project: https://osf.io/e4vh6/?view_only=97415efb53234d23962d50d0e597a766.

Participants in the control condition learned using a sequence of screenshots from the same game-scenario. Because of the games' adaptive nature, we based the comics' content on the average in-game decisions of five advanced student teachers. The comic contained no depictions of the in-game decision-screens. Instead, it showed the direct consequences of the teachers' decisions. On a separate page, participants received feedback regarding the comic-teacher's actions. Participants received the same comic in both learning-phases.

Measures

Prior Knowledge. We assessed participants' prior knowledge via one open question (*Which theoretical concepts do you spontaneously recall on the following topics? Classroom management, lesson planning, coping strategies (stress), forming work groups, time management, dealing with classroom disturbance*). Answers were scored based on four categories: theoretical concepts from educational psychology, methods, subject-didactic concepts and experience-based answers. Participants received one

Comic: The daily life of a teacher

On this page, you will find a comic that depicts the daily life of a teacher, teaching a double lesson in the seventh grade. Read the comic from left to right (mind the arrows). If you have read one row, read the one below from left to right.
Enjoy your reading!

Figure 1. Translated example-screenshots from the simulation game that was used as learning material in the simulation condition (upper part) and the comic used in the control condition (lower part).

Note. The game materials show examples for screens focusing on narration (left) and decision screens (right). The comic sequence (lower part) is composed of screenshots depicting the game screens, excluding decision screens. Participants were instructed to read the sequence from left to right, indicated by the arrow in the lower right corner.

point in the corresponding category for stating or describing a correct concept. If participants did not state any concept or exclusively stated them incorrectly, they did receive zero points in the corresponding category. A second rater scored all statements, achieving sufficient interrater-reliability (Cohen's κ = .75).

Transfer. We assessed participants' ability to apply their theoretical knowledge from educational psychology to teaching-situations with a decision-task. For this, participants received a description of a teaching scenario and were asked to choose one of three options, as well as to explain the reasons for their choice in an open format. Their reasoning was rated by two independent raters for the number of arguments based on theoretical knowledge (category one), using teaching methods without further reasoning (category two) or experiences from being a teacher or student (category three). For each argument, they received one point in the respective category. Participants received two decision-tasks at three times (pre, intermediate, post). One decision-task remained constant in all phases while the other varied, describing different types of teaching situations. A second rater scored all answers, reaching a sufficient inter-rater reliability (Cohen's κ = .68).

Self-Efficacy. We measured participants' trait self-efficacy using the general self-efficacy short scale (Cronbach's α = .74) by Beierlein et al. (2014). The scale comprises four items (e.g., *I am able to solve most problems on my own.*) answered on a 5-point Likert-scale (from 1 *Does not apply at all* to 5 *Applies fully*).

To assess participants' teaching self-efficacy, we used the subscales instructional strategies (Cronbach's α = .69) and classroom management (Cronbach's α = .86) from the short form of the Ohio State Teacher Efficacy Scale (Tschannen-Moran & Hoy, 2001). Both subscales comprised four items (e.g., *To what extent can you use a variety of assessment strategies?*, subscale: instructional strategies; *How much can you do to get children to follow classroom rules?*, subscale: classroom management), answered on a 9-point Likert-scale (from 1 *Not at all convinced* to 9 *Fully convinced*).

Perceived Usefulness of Theoretical Knowledge. We assessed participants' *perceived usefulness of theoretical knowledge* with a self-constructed questionnaire focusing on perceived use of theories for practical teaching (e.g., *Theory and practice are difficult to unite in everyday teaching.*). The scale included six self-constructed items (Cronbach's α = .77), answered on a 5-point Likert-scale (from 1 *Does not apply* to 5 *Does apply*) (see Appendix A.1).

Intention to Replay the Learning Material. To measure participants' intention to reuse the learning materials, we used a scale of five self-constructed items (Cronbach's α = .85), answered on a 4-point Likert-scale (from 1 *Does not apply at all* to 4 *Does apply fully*). Items in both conditions were worded similarly, with items in the simulation condition referencing the game and items in the control condition referencing the screenshot-sequence (e.g., *I would like to replay the game* vs. *I would like to reread the comic*). Additionally, two items were used to assess the reasons for participants to reuse the learning material (e.g., *I would like to replay the game because I enjoyed it* and *I would like to replay the game to reinforce my knowledge*).

Procedure

After providing informed consent, participants first answered demographic questions, as well as questions regarding prior teaching experience. Then they answered the open recall task on prior knowledge, questions concerning self-efficacy, and perceived usefulness as well as the transfer-tasks for theoretical knowledge. Then, they learned using either the simulation game or the screenshot-sequence. Thereafter, they again answered the questions regarding self-efficacy, perceived usefulness and transfer-tasks for theoretical knowledge as well as their intention to reuse the presented learning material. In the second learning-phase, they learned with the same material they received in the first learning-phase. They were instructed to integrate the feedback they just received into their learning. After learning, they answered questions on self-efficacy, perceived usefulness and transfer-tasks for theoretical knowledge for a third time and indicated their intention to reuse the learning material for a second time. Lastly, they answered control questions for faithful participation. Participants completed this procedure within a time-limit of 45 minutes.

Results

We conducted a series of mixed ANOVAs to test the hypotheses. For an overview of the means and standard deviations of our main variables, see Table 1. Due to non-plausible learning times in the first learning-phase (< 60 seconds), we excluded one participant from further analyses.

Replay Hypothesis

We entered *intention to reuse the learning material* as dependent variable in a 2x2 mixed ANOVA with learning-phase (1 vs. 2) as within-subject factor and experimental condition (control vs. simulation) as between-subject factor. There was no significant interaction between learning-phase and condition, $F < 1$. We observed a significant main effect of learning-phase, $F(1, 83) = 28.54$, $p < .001$, $\eta_p^2 = .26$. The main effect of condition missed significance, $F(1, 83) = 3.14$, $p = .080$, $\eta_p^2 = .04$. Contrary to our hypothesis, intention to reuse decreased to a similar degree in both conditions.

Additionally, we analysed two single items assessing *why* participants intended to reuse the material. Regarding wanting to reuse the material because it was *fun*, we observed no significant interaction for learning-phase and condition, $F(1, 83) = 1.50$, $p = .223$, $\eta_p^2 = .02$. Main effects for learning-phase, $F(1, 83) = 19.72$, $p < .001$, $\eta_p^2 = .19$, and condition, $F(1, 83) = 23.46$, $p < .001$, $\eta_p^2 = .22$ were significant. Partially supporting our hypothesis, participants in the simulation condition reported higher reuse-intention because of fun than participants in the control condition. In both conditions, we observed a similar decrease in reuse-intention because of fun over time. With respect to wanting to reuse the material to *learn*, the interaction between learning-phase and

Table 1. Means (and standard deviations) of main variables across both experimental conditions,

	Control condition (*n*=49)		Simulation condition (*n*=36)		All participants (*n*=85)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Teaching self-efficacy (classroom management) (Scale: 1 – 9)						
Prior to learning	6.32	1.09	6.36	1.29	6.34	1.17
Learning phase 1	6.54	1.14	6.48	1.34	6.51	1.22
Learning phase 2	6.63	1.22	6.48	1.39	6.57	1.29
Teaching self-efficacy (instructional strategies) (Scale: 1 – 9)						
Prior to learning	6.83	0.94	6.57	1.02	6.72	0.98
Learning phase 1	6.81	1.02	6.70	1.10	6.76	1.05
Learning phase 2	6.90	0.93	6.85	0.99	6.88	0.95
Perceived usefulness of theoretical knowledge (Scale: 1 – 5)						
Prior to learning	3.51	0.70	3.41	0.55	3.47	0.64
Learning phase 1	3.61	0.59	3.41	0.59	3.52	0.60
Learning phase 2	3.56	0.74	3.46	0.68	3.52	0.71
Transfer: % of experience-based arguments						
Prior to learning	60.88%	28.68	64.35%	30.64	62.35%	29.40
Learning phase 1	75.64%	22.63	73.96%	28.05	74.93%	24.92
Learning phase 2	69.57%	29.83	78.57% †	20.44 †	73.32% †	26.57 †
Transfer: % of theory-based arguments						
Prior to learning	18.37%	18.08	17.13%	16.66	17.84%	17.40
Learning phase 1	21.12%	22.07	21.88%	14.49	21.44%	22.98
Learning phase 2	22.00%	24.66	18.81% †	18.78 †	20.67% †	22.33 †
Intention to reuse learning material (Scale: 1 - 4)						
Learning phase 1	2.94	0.71	3.18	0.67	3.04	0.70
Learning phase 2	2.61	0.71	2.88	0.79	2.72	0.75
Intention to reuse (fun) (Scale: 1 – 4)						
Learning phase 1	1.82	0.88	2.53	0.91	2.12	0.96
Learning phase 2	1.33	0.52	2.25	1.13	1.72	0.95
Intention to reuse (knowledge) (Scale 1 – 4)						
Learning phase 1	2.49	1.06	3.08	1.02	2.74	1.08
Learning phase 2	1.76	0.90	2.70	0.97	2.16	1.04
Learning time in seconds (Phase 1)	609.96	173.62	855.14	258.36	713.80	244.72
Learning time in seconds (Phase 2)	171.86	89.41	351.31	117.79	247.86	135.30

†*N* = 84 \| *n* (simulation condition) = 35.

condition missed significance, $F(1, 83) = 3.77$, $p = .056$, $\eta_p^2 = .04$. Main effects of learning-phase, $F(1, 83) = 32.39$, $p < .001$, $\eta_p^2 = .28$, and condition, $F(1, 83) = 15.97$, $p < .001$, $\eta_p^2 = .16$, reached significance. Participants learning with the simulation game reported higher intention to replay to learn compared to participants in the control group (see Figure 2). This motivation also decreased over time. Yet, the results partially support our hypothesis.

We further observed changes in learning times across both learning-phases. Between both conditions, we compared learning times in the second learning-phase as the percentage of decrease in learning time compared to the first learning-phase. In line with our hypothesis, an independent samples t-test revealed that participants in the simulation condition ($M = 56.13\%$, $SD = 18.42$) reduced learning time to a smaller degree than participants in the control condition ($M = 71.39\%$, $SD = 13.94$), $t(83) = 4.35$, $p < .001$.

Usefulness Hypothesis

We entered perceived usefulness of theoretical knowledge as dependent variable, and experimental condition (simulation vs. control; between-subjects factor) as well as the time of measurement (pre, intermediate, post; within-subjects factor) into a mixed 2x3 analysis of covariance (ANCOVA). Participants' trait self-efficacy and prior knowledge on teaching methods were entered as covariates. Against our hypothesis, analyses revealed no significant interaction between time of measurement and condition, $F < 1$. There were also no main effects for either time of measurement, $F(1.79, 145.25) = 2.16$, $p = .124$, $\eta_p^2 = 0.03$, or experimental condition, $F < 1$.

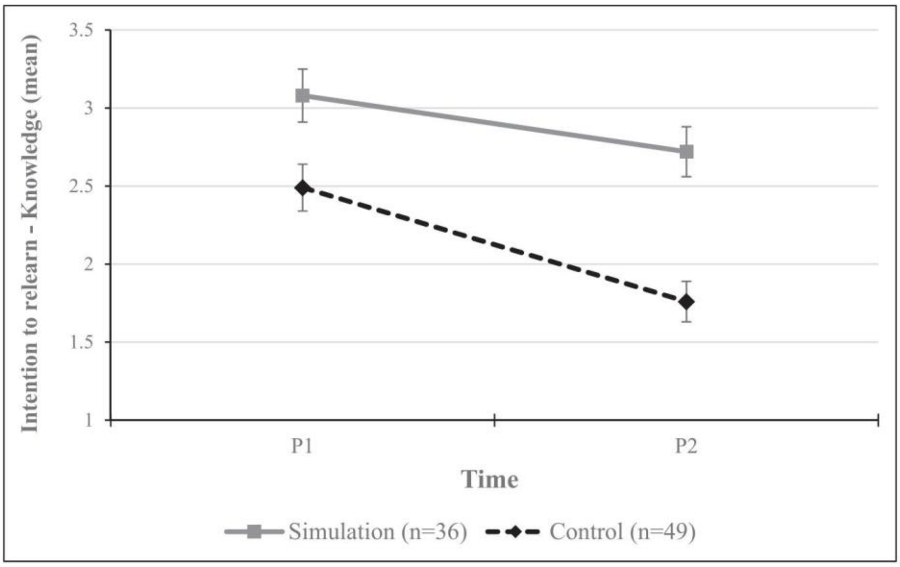

Figure 2. Results for participants' intention to relearn (means) with the learning material across both experimental conditions and over time (Scale: 1 – 4). Error bars represent standard errors of mean.

Note. Error bars represent standard errors of mean. Full range of the scale was 1 (*Does not apply at all*) to 4 (*Does apply fully*).

Self-Efficacy Hypothesis

We entered the two types of teaching self-efficacy (concerning instructional strategies, and classroom management) as dependent variables, and experimental condition (simulation vs. control; between-subjects factor) as well as time of measurement (pre, intermediate, post; within-subjects factor) within two separate 2x3 mixed ANOVAs. Trait self-efficacy was entered as a covariate. For self-efficacy concerning instructional strategies, we observed no significant interaction between time and condition, $F(2, 164) = 1.51$, $p = .224$, $\eta_p^2 = 0.02$. The main effects of time, $F(2,164) = 1.98$, $p = 0.142$, $\eta_p^2 = 0.02$, and condition, $F < 1$, did not reach significance. Results regarding self-efficacy in classroom management were similar, showing no significant interaction of time and condition, $F < 1$, as well as no main effect of time, $F(1.56, 128.05) = 1.28$, $p = .277$, $\eta_p^2 = 0.02$ or condition, $F < 1$.

Transfer Hypothesis

To assess the effects of time of measurement (pre, intermediate, post; within-subjects factor) and experimental condition (simulation vs. control; between-subjects factor) on participants' theory-based reasoning in our transfer-tasks, we entered both factors into a 2x3 mixed ANOVA. Participants' theory-based reasoning prior to learning was entered as a covariate. There was no significant interaction of time and condition, $F < 1$, speaking against our transfer hypothesis. We did also not observe significant main effects of either time or condition, both $F < 1$. Our findings on transfer show that neither condition nor time influenced participants' theory-based reasoning in decision tasks. The trend in our data suggests that theory-based reasoning decreases over time in the simulation condition and increases in the control condition.

Exploratory Analyses

To assess the influence of using the teaching simulation game on student teachers' experience-based reasoning, we entered time (within-subjects factor) and experimental condition (between-subjects factor) with participants' experience-based reasoning prior to learning as a covariate into a 2x3 mixed ANOVA. Our analysis revealed a trend towards an interaction between experimental condition and time, $F(1, 81) = 2.92$, $p = .091$, $\eta_p^2 = 0.04$. There were no main effects of time, $F(1, 81) = 1.79$, $p = .195$, $\eta_p^2 = 0.02$, and condition, $F < 1$. The trend suggests that over time, experience-based reasoning tended to increase in the simulation condition and to decrease in the control condition (see Figure 3).

Discussion

We investigated the effects of a teaching simulation game on student teachers' perceived usefulness of theories, self-efficacy and knowledge transfer, as possibility to

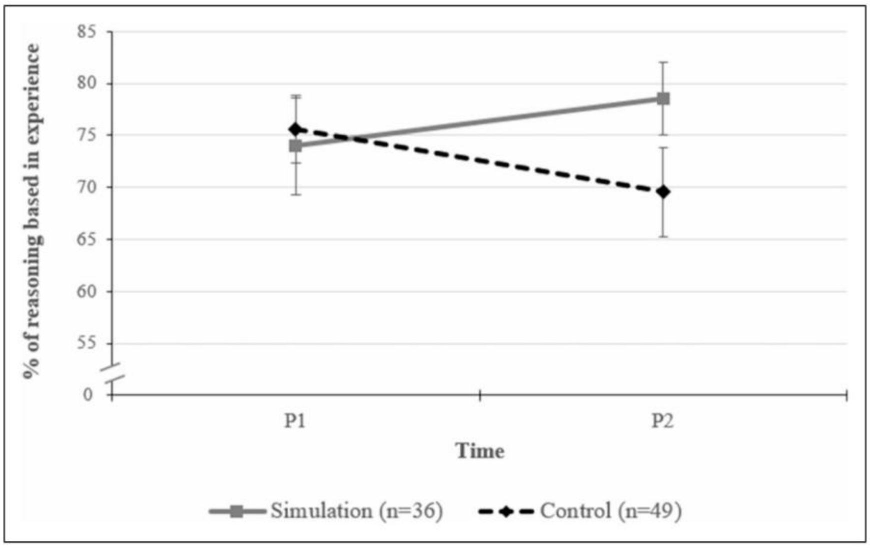

Figure 3. Results for the amount of participants' arguments on the transfer task based in experience (means) across both experimental conditions and over time. Range of possible scores: 0% - 100%. Error bars represent standard errors of mean.
Note. Range of possible scores was 0% to 100%. Error bars represent standard errors of mean.

close the theory-practice gap. Even though our results showed no beneficial effects on their perception and integration of theoretical knowledge into practice or their teaching self-efficacy, they did indicate benefits nonetheless.

Student Teachers are Motivated to Play and Learn

In accordance with the replay hypothesis (H_1), our results partially show higher intention to relearn for participants in the simulation condition. More specifically, these participants indicated that they want to reuse the simulation game not only because it is fun, but also because they want to learn with it. This is in line with prior studies showing enjoyment as a predictor for motivation to use simulations (Baptista & Oliveira, 2019). This motivation to relearn could potentially support repeated learning, which has been stated as a boundary condition for effective learning with simulation games (Dieker et al., 2014; Matsuda, 2008; Wouters et al., 2013). Additionally, participants in the simulation condition learned significantly longer compared to the control condition, and their learning times decreased less between learning-phases.

In sum, our results suggest that simulation games motivate student teachers not only to play, but also to learn. Further research is needed to investigate whether student teachers put their intention for reuse to action with the same persistence when learning more self-directed.

Simulated Teaching did not Influence Theory-Based Reasoning

Contrary to our usefulness hypothesis (H_2), there were no meaningful changes in participants' perceived usefulness of theoretical knowledge. Moreover, in contrast to our transfer hypothesis (H_3), there were also no significant change in student teachers' integration of theories into their practical reasoning after playing the simulation game. The non-significant trend in our data even showed increasing experience-based reasoning over time in the simulation-condition. Although these findings speak against the meta-finding of serious games and simulations being effective for sustainably teaching diverse skills (e.g., Gegenfurtner et al., 2014; Wouters et al., 2013), they are in line with previous findings that they are generally less effective when used in higher education (Lamb et al., 2018).

One reason might be that participants did not apply their theoretical knowledge while learning because we did not explicitly instruct them to do so. Consequently, they might have fallen back on their experience-based knowledge. Two observations in our data support this assumption. First, in line with previous research (Baier et al., 2021; Bråten & Ferguson, 2015), participants' argumentation in the transfer-tasks prior to learning primarily relied on their experience-based knowledge (see Table 1). As the transfer-task format was similar to the decision-task in the simulation game, participants likely relied on their experience rather than on theory while playing. This could, in part, be facilitated by theoretical knowledge not being sufficiently integrated into the games' design. While the feedback utilizes theories on teaching, the actual gameplay of making decisions does not explicitly feature theoretical knowledge. Stronger intrinsic integration (see Habgood & Ainsworth, 2011) of theoretical knowledge into the gameplay could, for example, take the form of classroom preparation units rehearsing theoretical knowledge at the start of the game. Second, prior knowledge about theories from educational psychology was relatively low in our sample (see Table 2). This could be explained either by participants having sparse knowledge on those theories, or their existing knowledge remaining inert, thus not being available for retrieval (for an overview, see e.g., Renkl et al., 1996). If, for either reason, participants were not able to access their theoretical knowledge, it was likely not mentally available for integrating it into their argumentation. Both observations support the assumption that decisions in the game might have been mainly been experience-based. Rehearsing experience-based knowledge instead of theoretical knowledge could consolidate their use of experience-based arguments when making teaching decisions. Such trend is reflected in our data. In addition to self-report measures, more fine-grained measures about participants' behavior and cognitive processing during learning (e.g., think-aloud) are needed to test this explanation.

Simulated Teaching did not Influence Teaching Self-Efficacy

Based on previous research (Bandura, 1996; Gegenfurtner et al., 2014; Song et al., 2022; Theelen et al., 2019), we expected that experiencing competence in the simulation should act as a form of enactive attainment, and thus foster teaching self-efficacy. Against our hypothesis (H_4), we observed no meaningful changes in teaching self-efficacy. This finding might be explained by the fact that in our sample teaching self-efficacy was, on average, already high ($M_{\text{classroom management}} = 6.34$, $M_{\text{instructional strategies}} = 6.72$, Scale: 1 – 9). Our participants were advanced student teachers with prior experience in teaching through internships and work in school (see Table 2). Their teaching self-efficacy was likely shaped by these experiences, and may have been too fixed to be changed through a one-time intervention. Concerning potential effects on teaching self-efficacy, the situations and consequences depicted in the simulation may have been too easy for advanced student teachers to act as meaningful enactive attainment. Adding (adaptive) difficulty options to the game could support the selection of adequately challenging scenarios. Future studies focusing on beginning student teachers learning with simulation games are necessary to investigate their potential for fostering teaching self-efficacy.

Limitations and Further Research

Some limitations arise from our setting of data collection. We collected data for all participants simultaneously in one session. There was limited time for learning and participants had to learn in two phases despite their actual intentions to reuse the learning material. This constraint in autonomy could have impaired their motivation for learning, aligning with self-determination theory (Deci & Ryan, 2000).

Table 2. Means (and standard deviations) of participants' entry variables across both experimental conditions.

	Control condition (*n* = 49)		Simulation condition (*n* = 36)		All participants (*n* = 85)	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age (in years)	23.43 †	3.37 †	23.26 †	2.59 †	23.36 †	3.05 †
Current study semester	6.39	1.30	6.36	1.15	6.39	1.23
Teaching experience (in months)	8.74 ‡	11.68 ‡	7.61	8.17	8.26 ‡	10.28 ‡
Completed internships	1.92	0.67	1.86	0.76	1.89	0.71
Trait self-efficacy (Scale: 1 – 4)	4.07**	0.39**	3.70**	0.56**	3.92**	0.50**
Prior knowledge (theories)	0.92	1.10	0.89	1.04	0.91	1.07
Prior knowledge (experience)	0.49	0.94	0.56	1.00	0.52	0.96
Prior knowledge (method)	1.24	2.08	1.47	1.78	1.34	1.95

†*N* = 81 | *n* (control condition) = 47 | *n* (simulation condition) = 34.
‡N = 84 | *n* (control condition) = 48
** Significant difference between simulation condition and control condition, $p < .001$.

Our results seem to support this reasoning, because intentions to relearn decreased between the learning-phases in both conditions. Nonetheless, we observed clear motivational benefits in favour of the simulation condition. To make effective use of the setting of playing the game in a group, future studies could feature playing and later discussing individual game experiences in dyads to potentially facilitate reflection.

We cannot rule out that low mental availability of theoretical concepts influenced the transfer of these concepts to teaching decisions. Future studies should focus on how the didactic context of playing may influence their effects as a tool for learning. For example, embedding game playing into the concept of a seminar or combining the use of simulation games with a prior learning-session (re-)teaching core theoretical concepts could have greater effects on student teachers' perceptions and integration of theory. Using longer game sessions or games with longer playtimes could also enhance the learning effects of playing a simulation game, as learners can train knowledge-application for a longer time (e.g. Wouters et al., 2013). Especially more experienced learners, as present in our sample, may benefit from enhancing the authenticity and complexity of the material (e.g. by using Virtual Reality Games). Future research should especially focus on how feedback processing in such games may affect theory-practice integration.

Conclusions

The current study adds to the literature on simulation games in teacher education by obtaining quantitative data about the effects of a simulation game within a typical lecture setting for student teachers. Against our expectations, the simulation game in our setting did neither make student teachers perceive theories as more relevant nor make them integrate theories more frequently into their decision-making. Overall, the practical benefits of playing the simulation game appeared to be small when applied within a single lecture session. Yet, our results indicate that simulation games can motivate student teachers to learn about teaching, pointing towards the benefits of simulation games for timely teacher education.

Appendix

Table A1. Full list of items for the scale Perceived usefulness of theoretical knowledge.

Items	No.
Applying my knowledge about theories from educational psychology will make it easier for me to quickly find a solution in challenging teaching situations.	1
Theory and practice are difficult to unite in everyday teaching.†	2
Knowing about theories from educational psychology will help me to notice critical teaching situations.	3
My knowledge about theories from educational psychology is too abstract to be useful for my future work as a teacher.†	4
I struggle to see applications for my knowledge about theories from educational psychology in my future work as a teacher.†	5
My knowledge about theories from educational psychology will be useful for my future work as a teacher.	6

Note. Items are answered on a 5-point Likert-scale (from 1 *Does not apply* to 5 *Does apply*). Items marked with an † are inverted.

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STUDY 2

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Level one: Teaching practice – Does playing a digital teaching simulation game foster novice student teachers' perception and use of theoretical knowledge?

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ABSTRACT

Despite theoretical knowledge being an important source for well-founded teaching decisions, student teachers often struggle to put this knowledge into practice. One way to close this theory-practice gap could be digital teaching simulation games that enable theory-use in authentic critical teaching situation. To assess their potential for teacher education, we conducted a learning experiment with 126 novice student teachers. In this experiment, after reading an expository text on classroom management, student teachers either played a digital teaching simulation-game (simulation condition) or read a screenshot-sequence depicting the game's content (screenshot condition). We assessed the student teachers' ability to apply theoretical knowledge featured in the text, how useful they perceive theoretical knowledge, their self-efficacy and their motivation to reuse the learning material. Against our expectations, participants in the screenshot condition outperformed participants in the simulation condition in transfer tasks. Participants in the simulation condition, however, reported higher teaching self-efficacy for both classroom management and instructional strategies. Both learning materials similarly increased participants perception of theoretical knowledge as useful for teaching. Participants' learning times showed that participants in the simulation condition spent significantly less time reading the feedback presented at the end of the material than participants in the screenshot condition. Taken together, our results suggest that while student teachers want to learn with simulation games, they might not do so effectively if they are not instructed thoroughly. Further research is needed to explore this assumption.

1. Introduction

The main goal of teacher education is to equip student teachers with the professional knowledge and skills enabling them to teach effectively. However, many student teachers struggle to apply to their teaching practice what they have learned in university (see e.g., Allen, 2009). Simulated teaching has the potential to help student teachers to link theoretical knowledge to the context of its use in a manageable way, possibly bridging this gap between theory and practice (for an overview, see Korthagen, 2010b). Simulated teaching may be especially helpful when it is clearly integrated with theoretical instruction in teacher education. Simulation games make such integration possible: they can provide both theoretical knowledge and the opportunity to apply them in a simulated lesson, where

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teaching decisions are required. This may help student teachers to both transfer their theoretical knowledge to teaching practice and consider theoretical knowledge more useful to inform their teaching decisions in practice. The present study tests this hypothesis.

1.1. The theory-practice gap

The structure of teacher education across many European countries comprises a blend of two components: university-based courses focusing on learning theoretical knowledge about teaching, and school-based activities focusing on guided teaching-experience. Learning in both settings should enable student teachers to become reflective practitioners (Schön, 1983), using their theoretical knowledge to inform teaching decisions (*reflection in action*) and to reflect on past teaching experiences (*reflection on action*). Prior research suggests that, for example, pedagogical content knowledge has a positive influence on teaching quality and student outcomes (Baumert & Kunter, 2013; Blömeke et al., 2014; König et al., 2014) as well as teachers' professional development (Kulgemeyer et al., 2020; Kulgemeyer & Riese, 2018). Contrary to these findings, student teachers often fail to treat both components of their studies as equally important: While they tend to acknowledge the benefits of practice-derived knowledge (e.g., colleagues' routines, their own experiences), the same cannot be said about their theory-based knowledge (e.g., theories on learning, subject-didactic knowledge) (e.g., Bråten & Ferguson, 2015). This phenomenon in teacher education is discussed as the *theory-practice gap* (see Korthagen, 2010b). While different sources for this gap are discussed in research on teacher education, it is generally defined as student teachers not using theoretical knowledge learned in university in their teaching practice, consequently causing a disconnect between educational practice and theory (Hennissen et al., 2017). This gap can be described on two dimensions: Student teachers' *perception of theory and practice* and their ability to *apply theoretical knowledge*.

Past studies suggest that student teachers tend to *perceive* theories about teaching as disconnected from teaching practice (e.g., Standal et al., 2014; Velija et al., 2008). This, in turn, leads to the perception that their prior experiences and practice-derived knowledge do prepare them for teaching, but their theoretical knowledge does not (Allen, 2009; Markle, 2020). Prior research has repeatedly shown that this view leads to the gradual loss of theoretical knowledge's relevance in favour of practice-derived knowledge (Bråten & Ferguson, 2015; Ezer et al., 2010). This over-emphasis of practice-derived knowledge seems to persist when novice teachers enter the teaching workplace (Allen, 2009; Conway, 2012). Perceiving theoretical knowledge as disconnected from and irrelevant to the reality of teaching can then hamper the *transfer of theoretical knowledge into teaching practice*. After transitioning to the workplace, novice teachers often describe difficulties in effectively using their theoretical knowledge to teach (Allen, 2009; Cochran-Smith et al., 2015; Cramer, 2013). Especially under the pressure of joining an established community of practice, they tend to conform to routines suggested by their more experienced colleagues (McGarr & McCormack, 2014; Moore, 2003). Although it is not inherently bad for teachers' professional development to ask more experienced colleagues for advice, doing so without reflecting on *if* and *why* their suggestions (do not) work could create new problems (e.g., preserving ineffective or harmful methods). In the long run, this could lead to a real gap between theory and practice, as it removes theories as one of many potential sources of knowledge that enable teaching from the classroom (for a discussion, see Renkl, 2022). To effectively tackle this problem, however, we first must understand its roots.

1.2. Factors hampering theory-practice integration

Over the years, different factors contributing to the theory-practice gap have been discussed. In an overview, Korthagen (2010a) named the *learning process in teacher education* and the *complexity of teaching* as two factors connected to the way prospective teachers are taught how to teach.

As previously described, *learning in teacher education* across many countries is characterised by an interplay of university-based courses and school-based activities (e.g., internships). In theory, participating in both settings should enable student teachers to acquire knowledge about teaching and apply it during (guided) field experiences. In practice, however, connections between these two settings are often too weak to effectively promote theory-practice integration (Cramer, 2013; Moore, 2003; Velija et al., 2008). For instance, if university courses teach theoretical knowledge detached from teaching practice, they risk this knowledge to become inert (for an overview, see Renkl, 1996). Based on Whitehead (1929), Renkl et al. (1996) defined inert knowledge as knowledge acquired in a formal instructional setting which is, however, not used outside of this setting. By teaching theories without addressing how they are used in practice, student teachers will not know how or when to use them, thus making it difficult to apply them in everyday teaching. School-based activities are then often insufficient to bridge this gap between theory and practice as mentors and student teachers rarely discuss internship experiences in relation to theoretical knowledge (Cramer, 2013; Hegender, 2010; Moore, 2003). Without effective guidance by university instructors or mentoring teachers, student teachers must create the missing links between theory and practice themselves. This is significantly exacerbated by teaching's *complexity*. In the classroom, teachers need to make sense of vast amounts of information, interpret them on short notice and act accordingly (see *noticing*; van den Bogert et al., 2014). Student and novice teachers, however, frequently struggle to perceive enabling conditions during critical teaching situations, as they still lack effective cognitive scripts for classroom management (for an overview, see Wolff et al., 2021). Repeatedly engaging with practice is necessary, but that alone will not suffice to develop this skill (Ericsson, 2018). Instead, deeper engagement with teaching, as in reflective practice (Schön, 1983), is needed for (student) teachers to derive meaning from their experiences. When allowed to teach without guidance, student teachers may form inaccurate perceptions of enabling conditions because they fail to notice critical information. Considering a theoretical perspective on practice may foster script-building by providing teachers with frameworks that support them (retrospectively) in identifying boundary conditions of effective teaching and in taking appropriate action (for an overview see Renkl, 2022). To effectively develop these skills, student teachers need to engage with practice that is challenging but not overwhelming to enable the reorganisation of knowledge into adequate teaching scripts (Boshuizen et al., 2020; Ericsson, 2018; Wolff et al., 2021).

1.3. *Fostering transfer of knowledge to close the gap*

As a means to engage with aspects of practice productively, Grossman et al. (2009) suggest that student teachers engage regularly with small, manageable practice doses. Their framework incorporates three activities enabling simplified access to practice: *representations of practice, decompositions of practice and approximations of practice*. Each way to approach practice highlights different aspects of teaching for novices.

By observing *representations of practice* (e.g., videos, protocols or case studies), student teachers can notice different aspects of teaching situations and discuss them with their peers. Engaging with them repeatedly can signalise more subtle teaching aspects, thus allowing student teachers to make sense of teaching behaviour using their theoretical knowledge. When *decomposing practice*, teaching sequences are broken up into their basic components. By being studied in isolation, teaching components can be discussed or practised further. Once student teachers attain sufficient understanding of isolated components, they can be arranged into more complex sequences to comprehend their interplay. In line with these suggestions, training sessions involving case studies (Augsdörfer & Casper, 2018; Baier et al., 2021) and videos (see e.g., Blomberg et al., 2013; Plöger, Scholl, & Seifert, 2018) have been shown to effectively foster theory-practice integration or the acquisition of teaching skills in student teachers. Both approaches could benefit the transfer of knowledge, as they convey theoretical knowledge closely related to its later use. Still, they fall one step short to bridge the theory-practice gap. While both methods teach with transfer in mind, they do not allow learners to train knowledge-application itself. *Approximations of practice* go one step further by letting student teachers engage with simplified, yet authentic, practice sequences (e.g., roleplay, (digital) simulations). Interacting with simplified practice can introduce student teachers to the ill-defined task of teaching, where there is often little time or information to act purposefully. Taking this approach to prepare student teachers for teaching practice has advantages for instructors and learners. First, various characteristics of approximated practice are highly adaptable (e.g., amount of available information, complexity). They can, therefore, be closely tailored to the needs of their target audience as well as the knowledge or skills they aim to promote. For example, as it has been shown that bigger classroom size in digital simulated teaching scenarios can lead to learners experiencing more stress (Westphal et al., 2024), a scenario with smaller classroom size may be more suited for introducing a new skill to learners. Second, by participating in a dynamic but staged situation, student teachers immediately experience the consequences of their actions in a safe/an unthreatening environment. Under these conditions, learners can experiment and apply new knowledge while failure is not sanctioned, but instead is treated as an opportunity to learn. Simulations or serious games focusing their gameplay on simulation (simulation games) as a way to approximate practice give instructors even more ways to alter aspects of practice for effective learning. Prior research has repeatedly shown that approximating practice via simulations and serious games promotes the acquisition of knowledge and long-term skills in various professions (Chernikova et al., 2020; Lamb et al., 2018; Raupach et al., 2021; Riopel et al., 2019; Wouters et al., 2013). Current reviews likewise highlight the potential of these effects for the use of simulated teaching in teacher education (Huang et al., 2023; Lindberg & Jönsson, 2023; Wang & Li, 2024). Different properties make simulations and serious games especially promising for bridging the theory-practice gap.

1.4. *How can digital simulated teaching close the gap?*

Digital simulated teaching, as a way to approximate practice, enables widespread and replicable interactions with practice. Once created, simulation games can be used by many student teachers. By employing them repeatedly and regularly, they have a potentially broad impact on teacher education. Practicing knowledge-application is especially crucial if we assume the inertia of knowledge to influence student teachers' (in)ability to use their knowledge for teaching. If student teachers apply their theoretical knowledge in simulated scenarios, they may learn when and how to apply their knowledge, establish connections between declarative knowledge and its use-cases and promote flexible knowledge structures by not binding theoretical knowledge to a single, passive context. Renkl et al. (1996) suggest that all of the aforementioned factors possibly influence the application of already inert knowledge. The use of simulated teaching tasks during initial knowledge acquisition may, therefore, facilitate the development of flexible cognitive structures required for knowledge application.

The standardised nature of digital simulated teaching can furthermore benefit learning, as it allows learners to repeatedly engage with *the same* teaching scenario. While doing so, learners can apply lessons learned from prior failure (or success). Instructors and designers can support this process by integrating personalised elaborated feedback linking players' actions with theoretical knowledge into the scenario. Those links may be achieved when feedback demonstrates how theoretical knowledge can be applied to the depicted scenario and when it guides and encourages learners in reflecting their performance in the situations. The feedback's content could also feed forward by providing hints of possible alternative strategies to test when re-entering the same scenario, thus promoting reflection in action. Digital standardized feedback may especially foster these processes because its low costs once implemented allow to provide high-quality feedback to many student teachers without additional effort and because it can be adaptive to learners' actions.

Digital elaborated feedback has been shown to foster recall and transfer for learners with both high and low prior knowledge (Mertens et al., 2022). Both feedback and repeated use are known to be crucial to the success of learning with (simulation) games (De Coninck et al., 2019; Dieker et al., 2014; Gegenfurtner et al., 2014; Ravyse et al., 2017). In this context, past research suggests that student teachers are willing to repeatedly use simulation games for learning (Kienitz et al., 2024).

However, it might be not enough that teacher students are potentially able to apply their theoretical knowledge. Hence, in addition to teaching theories that student teachers *can* apply, learning with simulation games could teach theories so that student teachers *want* to apply them. Referring to situated expectancy-value theory (Eccles & Wigfield, 2020), student teachers should want to apply theoretical knowledge to teaching if their *expectation of success* and the *subjective task value* for doing so are high.

One factor influencing student teachers' *expectation for success* is their teaching self-efficacy. Based on a socio-cognitive perspective (Bandura, 1996, 1997), Hoy and Spero (2005, p. 343) conceptualise teaching self-efficacy as „teachers' judgements about their abilities to promote students' learning". Bandura (1989) posited self-efficacy to play a role in utilising cognitive skills because it influences cognitive and motivational processes relevant for skill-use. On the motivational side, self-efficacy is assumed to be associated with learners seeking more challenging goals and investing more effort to reach them (Bandura, 1997). These assumed motivational influences of self-efficacy are in line with the conception of expectancy for success in situated expectancy-value theory (Eccles & Wigfield, 2020) and have been repeatedly demonstrated in research on factors determining trainees' motivation to make use of skills after learning them (e.g., Ludwikowska, 2021; Wen & Lin, 2014). On the cognitive side, being sure that one can successfully complete a task is assumed to cause less task-irrelevant thoughts and affective states (e.g., worries, thoughts about failing) which could otherwise impair the cognitive resources necessary for performing the task (Bandura, 1997). Accordingly, teaching self-efficacy is positively associated with applying skills and knowledge to challenging practical situations (Gegenfurtner et al., 2014) and with student teachers using research-based practice for teaching (Georgiou et al., 2020).

Simulation games can foster teaching self-efficacy by offering mastery experiences in a setting of authentic skill-use (*enactive attainment*, see Bandura, 1997). Prior studies confirm that engaging with simulated teaching enhances teaching self-efficacy in student teachers, hinting at their potential as a form of effective enactive attainment (Christensen et al., 2011; Samuelsson et al., 2022). Simulated teaching could also influence the *subjective task value* of using theoretical knowledge. For example, when reflecting potential classroom decisions in simulated teaching scenarios based on theoretical knowledge, players may find their theoretical knowledge useful for that task. Even if they do not intrinsically enjoy it, they may be motivated to use theoretical knowledge in the future thanks to its *utility value*. Similar effects on utility value have been demonstrated in research on experiencing the positive impact of utilising the testing effect in a short learning unit (Hui et al., 2021).

Research on the impact of simulations and serious games in teacher education has revealed promising effects on learning different skills (Seufert et al., 2022; Theelen et al., 2019; Yeh, 2004). Most of this research focuses on their influence on procedural knowledge based skills, like classroom management and noticing (Huang et al., 2023; Wang & Li, 2024). To train those skills, different forms of teaching simulations typically allow learners to interact with simulated (semi-)autonomous students in instructional settings (e.g., dealing with classroom disruptions during teaching). These interactions allow them to, for example, practice applying classroom management strategies (e.g., using non-verbal signals) and to learn when (not) to use them. This simulated practice allows learners to derive possible actions from theoretical knowledge, experience the consequences of their actions and reflect on them to establish their own links between theory and practice.

While there is a vast amount of research demonstrating the positive effects of simulations and serious games for building those skills (e.g., Seufert et al., 2022; Theelen et al., 2019; Yeh, 2004), it is still unclear when using them in teacher education is most effective. For example, Kienitz et al. (2024) detected no significant learning effects from a simulation game on experienced student teachers' perception and use of theoretical knowledge or teaching self-efficacy. Participants' prior knowledge and teaching experiences in this study may have been a double-edged sword. On one hand, their prior knowledge should serve as a basis for making theory-based decisions in simulated critical situations. On the other hand, their experiences in teacher education may have led to inert knowledge structures and experiencing theoretical knowledge as disconnected from practice. As novice student teachers have not yet made such experiences, they are a potentially promising target audience for using digital simulated teaching to connect theories and practice from the beginning. Aligning with this idea, Schmidt and Rikers (2007) suggest that authentic problems should be approached early and repeatedly to foster the development of effective professional scripts. Despite this potential, there is currently a lack of research exploring how simulated teaching specifically influences novice student teachers during initial knowledge-acquisition.

In addition, only few studies to date investigated how simulations and serious games affect factors associated with learners' motivation to transfer their knowledge (for an overview, see Huang et al., 2023; Wang & Li, 2024). While some studies suggest simulated teaching to positively influence teaching self-efficacy (e.g., Samuelsson et al., 2022), there is almost no evidence concerning value-associated variables, like how useful participants perceive their knowledge to be. Yet, because the theory-practice gap in student teachers seems to be partially influenced by student teachers' perception of theoretical knowledge as disconnected from practice (e.g., Velija et al., 2008), knowing about the influence of simulated teaching on this perception is important when examining their potential to close the gap. To address both research gaps, we conducted a learning experiment with novice student teachers first learning new concepts on classroom management via text, and then applying this knowledge in a simulation game depicting decision-making in an instructional setting.

1.5. Research questions

In the current study, we examined the immediate effects of playing a teaching simulation game on first-semester student teachers' transfer knowledge, teaching self-efficacy, perception of theory-based knowledge, and the willingness to relearn. After reading a text about classroom management, participants learned twice 1) with a teaching simulation-game or 2) with a screenshot-sequence from the game. We investigated the following hypotheses.

H1. *(Transfer hypothesis):* Participants in the simulation condition can apply the text's content in the simulation-game by making informed teaching decisions and reflect on them afterwards using theory-based feedback. Their knowledge should be more transfer-adequate compared to participants in the screenshot condition, who learn via a screenshot-sequence from the game. Thus, we expect participants in the simulation condition to apply more theory-focused arguments than participants in the screenshot condition. We expect similar results for transfer tasks that describe situations close to the texts' contents (near transfer) and transfer tasks that require greater abstraction of knowledge from the text (far transfer).

H2. *(Usefulness hypothesis):* When using theoretical knowledge to decide how to act in the simulation game, participants in the simulation condition should experience the usefulness of the theoretical knowledge they learned in the text. Because this experience is unique to the simulation condition, we expect a significant positive effect on perceived usefulness of theoretical knowledge favouring the simulation condition.

H3. *(Self-efficacy hypothesis):* By applying their knowledge on classroom management while deciding in the simulation-game, participants in the simulation condition experience mastery, acting as a form of enactive attainment. This should influence their teaching self-efficacy for classroom management positively over both learning sessions. We expect less pronounced effects in participants in the screenshot condition, as they do not make their own decisions, instead observing a fictitious model teacher's actions in the screenshot-sequence. We do not expect effects on participants' teaching self-efficacy from instructional strategies, as they only learn about classroom management in the text.

H4. *(Replay hypothesis):* Playing the game (vs. reading the screenshot-sequence) should result in higher utility value (because participants receive feedback directly addressing their actions). Both should encourage the participants' motivation to reuse the materials. Therefore, we expect participants in the simulation condition to report a stronger intention to reuse the learning materials compared to the screenshot condition.

2. Method

2.1. Participants and design

A total of 129 student teachers participated in this study (101 women, 28 men, 0 non-binary, $M_{age} = 20.81$, $SD = 2.83$). Based on an a priori power-analysis via G*Power 3.1 (Faul et al., 2009) assuming a medium effect size (alpha = .05; power = 0.90, $f = 0.25$) we aimed to achieve a sample size of at least $N = 116$. All participants were in the first weeks of their first semester of teacher education. Participants were randomly assigned to either the screenshot condition ($n = 65$; 49 female, 16 male, 0 non-binary) or simulation condition ($n = 64$; 52 female, 12 male, 0 non-binary). We recruited participants by advertising the study through flyers and informing them about the study during lectures and seminars on psychology. In order to participate, student teachers had to be in the first semester of their studies, be at least 18 years old and speak German fluently. After reading a text about classroom management, participants in both conditions learned twice with either a simulation game depicting classroom decision-making (simulation condition) or screenshots of the game's content arranged in a comic-sequence (screenshot condition). For both conditions, we used materials from Kienitz et al. (2024).

2.2. Materials and experimental manipulations

Across both conditions, participants read a printed-out text explaining core concepts of classroom management. The text comprised 1607 words structured in five segments (e.g., *Preventing classroom interruptions*). In the text, participants learned different theories on effective classroom management, when to use them, and examples on how they are used. Because our sample of novice student teachers should have little to no prior knowledge of these topics, the texts aimed to provide an overview about theories on classroom management and to prepare participants to assess situations in the game (or screenshot-sequence) based on this knowledge. For example, the text teaches participants about nonverbal signals in classroom management. The text addresses these in the context of perceived presence in the classroom (*"The teacher signals presence in the classroom by sending non-verbal signals, for example by moving around the classroom or looking at disruptive pupils."*) and in the context of the principle of least intervention (*"First of all, in the event of a minor disruption [...], small reactions should be shown in parallel with the continuation of the lesson. For instance, the teacher can look at the affected students and briefly speak more slowly and/or quietly to trigger an orientation reaction."*). In both the game and the screenshot-sequence, these nonverbal signals are relevant, for example, in a situation where the teacher reacts to an increasing level of noise in one group during group work. In a pre-test, seven student teachers ($M_{semester} = 7.14$, $SD = 4.63$) rated the text as understandable ($M = 3.70$, $SD = 0.56$, Scale: 1 = *not understandable* to 5 = *very understandable*), medium-low difficulty ($M = 2.14$, $SD = 0.90$, Scale: 1 = *not difficult* to 5 = *very difficult*) and rather interesting ($M = 6.67$, $SD = 0.79$, Scale: 1 = *not interesting* to 9 = *very interesting*). An English version of the full text is available via OSF (https://osf.io/nbdzw/?view_only=1b0cfef9bd6b47f99fc8c49eff1438fd).

In the simulation condition, participants played the simulation-game ("Myself as a teacher") across two learning-phases. The game was developed for the subproject "Serious Games/Gamification in teacher education" as part of the project HessenHub from the centre for competence development and the centre for teacher education at Justus-Liebig university Giessen. The game's content is based on observations from reviewing literature on teaching (textbooks, guidebooks, content from teaching seminars), interviews with stakeholders from different stages of teacher education and systematically observing real classrooms. The situations were chosen to appear in the game because 1) they aligned with essential competencies and demands of teaching (based on Faust et al., 2016) and because the involved stakeholders identified them as situations student teachers frequently struggled with. In the game, participants experience critical teaching scenarios and make decisions, influencing the further course of the lesson. The game features comic-styled illustrations of teachers and students in front of photographs of real classrooms. The bottom of the screen features narration in blue text boxes as well as an arrow-button to continue the game (for an example, see Fig. 1).

Before entering the classroom-setting, players name their in-game character and choose one of three avatars (male-presenting, female-presenting, androgynous). In the following scenario, players encounter different teaching situations that require them to use their knowledge about classroom management to solve them. These include, for example, reacting to or preventing classroom disruptions (e.g., increasing noise level during group work), effective management of learning time (e.g., adapting the planned lesson when encountering delays) or conflict resolution between students during group work. When the game requires the player to decide in a critical situation, it shows two to four options describing different ways to act in that situation in blue text boxes. Players' choices on these decision-screens influence how the lesson proceeds. In the group work scene, for example, one of the groups keeps getting louder while the player is helping certain students with a question. The player can decide to (1) leave the students to check on what is going on in the other group, (2) glance at the loud group, or (3) loudly ask the group what is going on (see Fig. 1). This can lead to (1) the player taking their time to investigate a minor conflict in the loud group, (2) the group continuing to work quietly or (3) the player disrupting the whole class. The difficulty of decisions and the options from which to choose make it likely that learners engage in mastery experiences while playing. Players can encounter 12 to 16 decisions during one playthrough, depending on their actions. Six decisions have a 15-s time-limit, indicated by an animated stopwatch-icon in the top right corner. Players receive nine feedback texts based on literature about teaching, such as textbooks describing theories and concepts relevant to teaching (e.g., Urhahne et al., 2019) and guidebooks on teaching methods (e.g., Eichhorn, 2014), reviewing their decisions after playing (e.g., "You have chosen a verbal response. When you do so, be sure to act confidently and consistently and to use nonverbal responses as well. You can prevent interruptions by using elaborate nonverbal behaviours, presence and stop signals such as glances, subdued hand movements, or lowering your voice (Nolting, 2017)."). These feedback texts were expected to foster theory-practice integration because they demonstrate how theory applies to practice by directly addressing players' behaviour to then discuss it in the context of literature on teaching.

In the screenshot condition, participants received a comic composed of screenshots from a full playthrough of the same game scenario in both learning phases (see Fig. 1). Participants were not able to interact with this screenshot-sequence by choosing how to act during the scenario and could, thus, only read one pre-set course of the scenario. The screenshot-sequence shows the androgynous player character. Because of the game material's adaptable nature, we based the sequence of events depicted in the screenshot-

Comic: The daily life of a teacher

On this page, you will find a comic that depicts the daily life of a teacher, teaching a double lesson in the seventh grade. Read the comic from left to right (mind the arrows). If you have read one row, read the one below from left to right.
Enjoy your reading!

Fig. 1. Translated example-screenshots depicting the simulation game used in the simulation condition (left) and the screenshot-sequence used in the screenshot condition (right).

sequence on the average in-game decisions of five advanced pre-service teachers. The screenshot-sequence depicts 12 challenging situations without showing the decision screens. Instead, the screenshot-sequence shows the consequences of the in-game teacher's decision. On the next page, participants received feedback texts reviewing the actions of the depicted teacher. The texts were the same feedback-texts that participants would have received when making the same decisions as the depicted teacher.

2.3. *Measures*

2.3.1. *Knowledge-test*

We drafted three single-choice questions with four options to assess how much participants learned from reading the text on classroom management (e.g., *Which of the following is not a factor causing classroom disturbances?*). Participants earned one point for each correctly answered question, (Range: 0–3). In our analyses involving prior knowledge, we relied on the participants' last test-score before continuing to the learning-phase.

2.3.2. *Transfer*

We devised a decision-task to assess participants' ability in applying their theoretical knowledge from the learning materials to critical teaching situations. Each decision-task consisted of a short text describing a critical teaching scenario and three options for handling the situation. Participants were tasked with choosing one option and then explain the reasons for their choice in an open text box. We rated their open answers to the number of arguments based on theoretical knowledge from the text (category one) or based on experiences from teaching or being a student (category two).

Participants solved two decision-tasks at three timepoints (prior to learning, after the first learning-phase, after the second learning-phase). Both tasks described situations in which knowledge about classroom management from the text could be applied. The closeness to the knowledge learned in the classroom management text varied between tasks. While one task was presented repeatedly and described a situation closely linked to the learning text (near transfer), the other task varied and described scenarios requiring participants to stronger abstract from the text's content (far transfer). We excluded the far transfer-task prior to learning because knowledge about classroom management was not applicable here.

2.3.3. *Self-efficacy*

The participants' trait self-efficacy was assessed via the general self-efficacy short scale (McDonald's $\Omega = .68$) by Beierlein et al. (2014). Its four items (e.g., *I'm able to solve most problems on my own.*) are answered on a 5-point Likert-scale (from 1 = *Does not apply at all* to 5 = *Fully applies*).

We relied on the instructional strategies (McDonald's $\Omega = .71$) and classroom management (McDonald's $\Omega = .81$) subscales from the Ohio State Teacher Efficacy Scale (Tschannen-Moran & Hoy, 2001) to measure participants' teaching self-efficacy. The scales comprise four items (e.g., instructional strategies: *To what extent can you use a variety of assessment strategies*; classroom management: *How much can you do to get children to follow classroom rules?*) answered on a 9-point Likert-scale (from 1 = *Not at all convinced* to 9 = *Fully convinced*).

2.3.4. *Perceived usefulness of theoretical knowledge*

We assessed whether participants viewed theoretical knowledge from educational psychology as useful for teaching applying a scale from Kienitz et al. (2024) (McDonald's $\Omega = .68$). This scale comprises six items (e.g., *Knowledge about theories from educational psychology will be useful for my future teaching*) answered on a 5-point Likert-scale (from 1 = *Does not apply at all* to 5 = *Does apply*).

2.3.5. *Intention to replay the learning material*

After each learning phase, we used five items from Kienitz et al. (2024) (e.g., *I'd like to play other game-scenarios*), answered on a 4-point Likert-scale (from 1 = *Does not apply at all* to 4 = *Does apply fully*) to assess participants' intention to reuse the learning materials (McDonald's $\Omega = .71$). Two additional items targeted the reasons why participants wanted to reuse the learning materials (*I'd like to replay the game because I enjoyed it* and *I'd like to replay the game to reinforce my knowledge*).

2.3.6. *Mental effort*

Participants' mental effort invested in integrating the feedback with the screenshot-sequence or simulation game was assessed via an adapted version of the Mental Effort Scale by Klepsch and Seufert (2021). We kept the single-item measure for passive mental effort (*Connecting the feedback with the teaching situations was exhausting*) separate from the single-item measure for active mental effort (*I tried hard to connect the feedback with the teaching situations*). Both were answered on a 7-point Likert-scale (from 1 = *Does not apply at all* to 7 = *Does apply*).

2.3.7. *Process measures*

Screen-recordings of participants' activities during both learning-phases were used to assess their learning times. We coded the time spent on *reading the instruction*, *viewing either learning material* and on *reading the feedback* in seconds.

2.4. Procedure

The experiment took place in lab with the questionnaire hosted online via Questback by Unipark on convertible laptops. Up to five student teachers could participate simultaneously. After providing informed consent to participate in the study, participants provided demographic information and listed their prior teaching experiences. They then answered measures on self-efficacy, perceived usefulness and transfer of theoretical knowledge. They were then given 10 min to read the printed-out text on classroom management, during which they could take notes and mark text passages. In both conditions, participants could access their text during later learning-phases. After reading, participants answered three single-choice questions about the text's content. They were then given adaptive and elaborative feedback for their answers which consisted of screenshots of each question as well as a short text describing the single-choice option they had picked and whether their choice was correct. If their answer was correct, they were told where in the text they could learn more about the topic. If it was incorrect, participants were given a hint about which section in the text covered that particular topic. If they had not answered all questions correctly, they were given 5 min to restudy the text r and then had to re-answer the same three questions. After restudying, or answering all questions correctly during the first reading-phase, participants proceeded to the first learning-phase, learning from either the simulation game (experimental group) or the screenshot-sequence (screenshot group). Participants were explicitly instructed to apply their knowledge from the text while learning from the game or screenshot-sequence. Participants were allowed to use the printed-out text while learning. In both learning-phases, we used screen-recordings to accurately track participants' learning times with the simulation game or screenshot-sequence.

After the first learning-phase, participants answered questions on self-efficacy, perceived relevance and transfer of theoretical knowledge again, as well as a scale targeting their intention to reuse the provided learning materials. They then learned with the same materials they had been given in the first learning-phase a second time. During the second learning phase, we instructed participants to utilise the feedback when rereading/replaying the learning material. After the second learning phase, they answered questions on self-efficacy, the perceived relevance of theoretical knowledge and transfer of theoretical knowledge a third time. They also indicated again their intention to replay/reread the learning material. In the last step participants created a personal code. Participants could use this personal code to revoke their consent to participate and request deletion of their data after the experiment ended. They completed the experiment, on average, in 64 min ($SD = 10.08$ min). After finishing the experiment, participants were thoroughly informed about the study's purpose and background, and compensated with course credit for their participation: This study was granted approval by our local ethics board (LEK FB06 2022-0013). For a visualisation of the study's procedure, see Fig. 2.

3. Results

Our analyses were structured in two phases. In the first phase, we conducted a series of one-way ANOVAs and χ^2-tests for both groups to assess equal distribution of participants' entry variables and a priori differences in our dependent variables. We also examined possible covariates for our analyses. In the second phase, we used mixed ANOVAs to test our hypotheses. All reported p-values are based on two-way testing. If sphericity was violated, Greenhouse-Geisser correction was used for the corresponding analyses. For an overview of our dependent variables across all times of measurement, see Table 1.

3.1. Preliminary analyses

We observed no significant difference between groups in participants' age, final school grade and the self-efficacy trait-, all $F < 1$ (for an overview of participants' entry variables, seeTable 2). There were no significant differences concerning gender $\chi^2(1) = 0.66$, $p = .419$ or school branch $\chi^2(4) = 3.99$, $p = .407$. We observed no significant a priori differences in perceived usefulness of theoretical knowledge, $F < 1$, transfer performance $F(1,124) = 3.19$, $p = .077$, $\eta_p^2 = .03$, or in teaching self-efficacy for instructional strategies $F(1,127) = 1.01$, $p = .317$, $\eta_p^2 = .01$, and classroom management $F < 1$. Two participants from the simulation condition were excluded from further analyses because they failed to follow the instructions and reread the learning text on classroom management when they were supposed to be playing the simulation, which led to exceptionally long learning times.

We examined meaningful correlations between entry variables and dependent variables in our data to check for potential

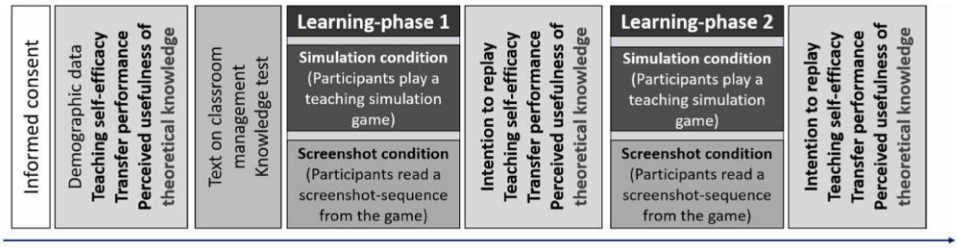

Fig. 2. Overview for the studies' experimental procedure (completion time ca. 60 min).

Table 1
Means (and standard deviations) of dependent variables across both experimental conditions.

	Simulation condition ($n = 62$)		Screenshot condition ($n = 65$)		All participants ($n = 127$)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Teaching self-efficacy (classroom management) (Scale: 1–9)						
Pre	6.58	1.10	6.68	1.05	6.63	1.07
Intermediate	7.21	0.87	6.88	1.10	7.04	1.00
Post	7.46	0.80	7.06	1.11	7.26	0.99
Teaching self-efficacy (instructional strategies) (Scale: 1–9)						
Pre	7.02	0.84	7.15	0.99	7.09	0.92
Intermediate	7.18	0.82	7.06	1.02	7.12	0.92
Post	7.46	0.82	7.21	0.99	7.33	0.92
Perceived usefulness of theoretical knowledge (Scale: 1–5)						
Pre	3.80	0.54	3.87	0.51	3.83	0.52
Intermediate	3.93	0.49	4.00	0.54	3.97	0.52
Post	3.90	0.58	4.00	0.66	3.95	0.62
Transfer: % of theory-based arguments (near)						
Pre	10.93[a]	22.34[a]	18.65[a]	28.27[a]	14.85[a]	25.71[a]
Intermediate	37.08[b]	38.95[b]	50.48[b]	40.30[b]	43.89[b]	40.05[b]
Post	38.11[c]	37.37[c]	44.15[c]	38.75[c]	41.23[c]	38.05[c]
Transfer: % of theory-based arguments (far)						
Intermediate	0.00[d]	0.00[d]	5.75[d]	18.35[d]	2.80[d]	13.13[d]
Post	9.56[e]	26.95[e]	27.82[e]	34.93[e]	18.98[e]	32.52[e]
Intention to reuse learning material (Scale: 1–4)						
Intermediate	3.21	0.53	3.04	0.48	3.12	0.51
Post	2.95	0.66	2.80	0.52	2.87	0.60
Intention to reuse learning material (fun) (Scale: 1–4)						
Intermediate	2.90	0.74	2.06	0.70	2.47	0.83
Post	2.40	0.86	1.65	0.65	2.02	0.85
Intention to reuse learning material (knowledge) (Scale: 1–4)						
Intermediate	3.32	0.78	2.62	0.93	2.96	0.93
Post	2.87	1.00	2.02	0.84	2.43	1.01
Learning time in seconds (Phase 1)						
Time on learning material	503.71[e]	113.68[e]	320.45[e]	75.85[e]	409.91[e]	132.81[e]
Time on feedback	247.70[e]	142.78[e]	374.06[e]	111.58[e]	311.66[e]	142.16[e]
Learning time in seconds (Phase 2)						
Time on learning material	284.43[e]	67.38[e]	196.55[e]	86.22[e]	239.10[e]	89.04[e]
Time on feedback	94.61[e]	81.92[e]	72.55[e]	10.90[e]	83.23[e]	85.44[e]

[a] $N = 124 \mid n_{\text{simulation condition}} = 61 \mid n_{\text{screenshot condition}} = 63$.
[b] $N = 122 \mid n_{\text{simulation condition}} = 60 \mid n_{\text{screenshot condition}} = 62$.
[c] $N = 122 \mid n_{\text{simulation condition}} = 59 \mid n_{\text{screenshot condition}} = 63$.
[d] $N = 118 \mid n_{\text{simulation condition}} = 60 \mid n_{\text{screenshot condition}} = 58$.
[e] $N = 126 \mid n_{\text{simulation condition}} = 61 \mid n_{\text{screenshot condition}} = 65$.

Table 2
Means (and standard deviations) of participants' entry variables and mental effort for processing the feedback across both experimental conditions.

	Simulation condition ($n = 62$)		Screenshot condition ($n = 65$)		All participants ($N = 127$)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age (in years)	21.03	3.36	20.58	2.24	20.8	2.84
Abitur grade	2.33[a]	0.58[a]	2.27[a]	0.56[a]	2.30[a]	0.57[a]
Prior knowledge (Last Test) (Scale: 1–4)	2.26	0.79	2.42	0.79	2.34	0.79
Trait self-efficacy (Scale: 1–5)	3.77	0.51	3.80	0.43	3.78	0.47
Active Mental Effort (Scale: 1–7)	5.00	1.48	4.69	1.59	4.84	1.54
Passive Mental Effort (Scale: 1–7)	3.32	1.52	3.14	1.44	3.23	1.48

[a] $N = 118 \mid n_{\text{simulation condition}} = 56 \mid n_{\text{screenshot condition}} = 62$.

covariates. Following our findings, we included the self-efficacy trait as a covariate in our analyses on both teaching self-efficacy scales (classroom management, Pre: $r = .22$, $p = .011$; instructional strategies, Pre: $r = .22$, $p = .012$; Intermediate: $r = .31$, $p < .001$).

3.2. Transfer hypothesis

We conducted separate analyses for both types of transfer tasks: tasks describing scenarios similar to the text (near transfer) and tasks describing scenarios less close to the text (far transfer). In our analysis on near transfer, we entered time as within-subject factor and experimental condition as between-subject factor into a 2x3 mixed ANOVA. Mauchly's test revealed that the assumption of sphericity was met, $\chi^2(2) = 0.90$, $p = .638$. We noted significant main effects for time, $F(2,230) = 37.44$, $p < .001$, $\eta_p^2 = .25$, and condition $F(1,115) = 4.60$, $p = .034$, $\eta_p^2 = .04$. Time and condition did not interact significantly, $F < 1$. For our analysis on far transfer, we conducted separate one-way ANOVAs for the number of theoretical arguments in each task (intermediate and post). Our analyses of both tasks revealed a significant group difference favouring the screenshot condition, $F_{\text{intermediate}}(1,116) = 5.89$, $p = .017$, $\eta_p^2 = .05$, $F_{\text{post}}(1,124) = 10.69$, $p = .001$, $\eta_p^2 = .08$.

3.3. *Usefulness hypothesis*

We conducted a 2x3 mixed ANOVA on the perceived usefulness of theoretical knowledge. In so doing, we entered time as within-subject factor and experimental condition as between-subject factor. Mauchly's test indicated that the assumption of sphericity was met, $\chi^2(2) = 4.66$, $p = .097$. Our analysis revealed a significant main effect for time, $F(2,250) = 7.54$, $p < .001$, $\eta_p^2 = .06$, but not for condition, $F < 1$. The time-and-condition interaction was not significant, $F < 1$. Partially supporting our hypothesis, we observed a significant rise in the perceived usefulness of theoretical knowledge in both the simulation and screenshot condition over time.

3.4. *Self-efficacy hypothesis*

We conducted 2x3 mixed ANOVAs for both subscales of teaching self-efficacy (instructional strategies, classroom management) using the self-efficacy trait as a covariate. In both analyses, we entered time as within-subject factor and experimental condition as between-subject factor. Mauchly's test revealed that the assumption of sphericity was violated for the subscale classroom management, $\chi^2(2) = 30.79$, $p < .001$. Regarding the classroom management subscale, we found a significant main effect for time, $F(1.64, 203.04) = 3.77$, $p = .033$, $\eta_p^2 = .03$, but no main effect for condition, $F(1,124) = 1.91$, $p = .169$, $\eta_p^2 = .02$. Furthermore, our results showed significant interaction between the two factors $F(1.64, 203.04) = 7.22$, $p = .002$, $\eta_p^2 = .06$. Group-differences were only significant after the second learning-phase (Post), $p = .023$. Supporting our hypothesis, effects of time were stronger in the simulation condition, $F(1.46, 88.94) = 30.39$, $p < .001$, $\eta_p^2 = .33$, than in the screenshot condition, $F(1.82, 116.26) = 10.02$, $p < .001$, $\eta_p^2 = .14$ (see Fig. 3).

Concerning the subscale instructional strategies, the results of Mauchly's test indicated that the assumption of sphericity was violated, $\chi^2(2) = 10.68$, $p = .005$. We observed a significant main effect for time, $F(1.85, 228.95) = 7.01$, $p = .001$, $\eta_p^2 = .05$, but no main effect for condition, $F < 1$. We again observed significant interaction between time and condition, $F(1.85, 228.95) = 6.32$, $p = .003$, $\eta_p^2 = .05$. Group differences were not significant at any measurement timepoint t. Against our hypothesis, we observed a significant effect for time only in the simulation condition, $F(1.74,106.37) = 15.29$, $p < .001$, $\eta_p^2 = .20$ (see Fig. 4).

3.5. *Replay hypothesis*

We entered participants' intention to reuse the learning material into a 2x2 mixed ANOVA with time as within-subject factor and experimental condition as between-subject factor and identified a significant main effect for time, $F(1,125) = 37.02$, $p < .001$, $\eta_p^2 = .23$, but not for condition, $F(1,125) = 3.33$, $p = .070$, $\eta_p^2 < .03$. The interaction between time and condition was not significant, $F < 1$. Against our hypothesis, participants in the simulation condition reported a similar intention to replay as did participants in the screenshot condition. We observed that participants in both conditions demonstrated similarly less intention to re-use learning material.

To investigate the reasons *why participants wanted to reuse* the material, we conducted analyses on two single-item measures asking whether they wanted to reuse the material because 1) it was fun or 2) they wanted to consolidate their knowledge. For both items, we conducted 2x2 mixed ANOVAs with time as within-subject factor and experimental condition as between-subject factor. Our analysis of 1) the fun-item revealed significant main effects for time, $F(1,125) = 52.52$, $p < .001$, $\eta_p^2 = .30$, and condition favouring the simulation condition, $F(1,125) = 48.14$, $p < .001$, $\eta_p^2 = .28$. We observed no significant interaction between time and condition, $F < 1$.

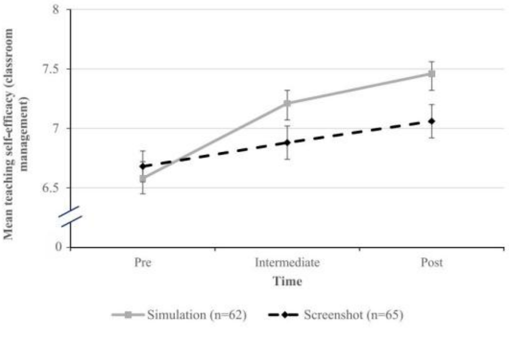

Fig. 3. Results for participants teaching self-efficacy on the subscale classroom management (means) across both experimental conditions and over time (Pre = Prior to learning; Intermediate = After learning-phase one; Post = After learning-phase two).
Note. Error bars represent standard errors of mean. Full range of the scale was 1 (*Not at all convinced*) to 9 (*Fully convinced*).

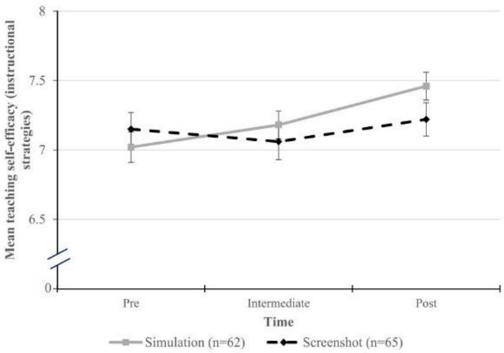

Fig. 4. Results for participants teaching self-efficacy on the subscale instructional strategies (means) across both experimental conditions and over time (Pre = Prior to learning; Intermediate = After learning-phase one; Post = After learning-phase two).
Note. Error bars represent standard errors of mean. Full range of the scale was 1 (*Not at all convinced*) to 9 (*Fully convinced*).

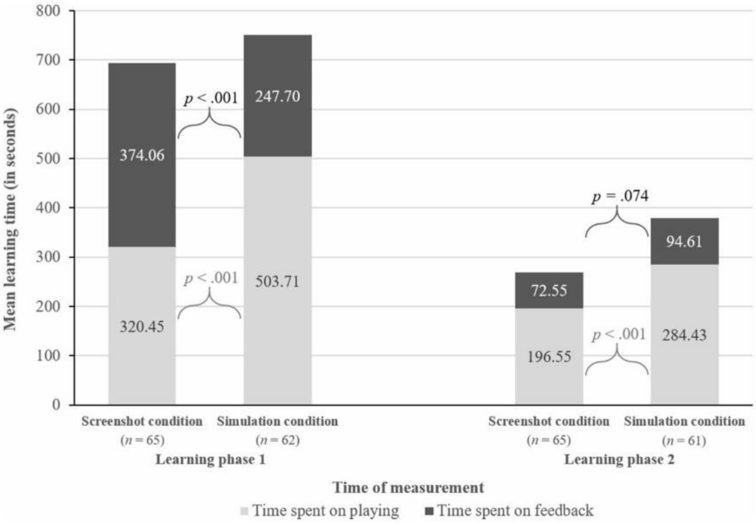

Fig. 5. Overview of participants amount of time spent on the learning material (playing) and reading the feedback for learning-phase one and two (in seconds).

We observed significant main effects for time, $F(1,125) = 41.01$, $p < .001$, $\eta_p^2 = .25$., and condition, $F(1,125) = 33.31$, $p < .001$, $\eta_p^2 = .21$ regarding 2) the knowledge-item. Our analysis revealed no significant interaction between time and condition, $F < 1$. The participants expressed a stronger intention to use the learning material for both reasons. However, their intention to re-use the material became weaker over time in both conditions.

3.6. Additional analyses of learning times

To compare participants' learning behaviour in both conditions, we compared the time spent interacting with the learning materials and the time spent reading the feedback in each condition (see Fig. 5). Participants in the simulation condition in learning-phase one, $F(1,125) = 115.18$, $p < .001$, and learning-phase two, $F(1,124) = 40.27$, $p < .001$, spent more time interacting with the simulation than participants in the screenshot condition did reading the screenshot-sequence. While participants in the screenshot condition in learning-phase one spent significantly more time reading the feedback, $F(1,125) = 31.96$, $p < .001$, the time spent reading feedback was similar in both groups in learning-phase two, $F(1,124) = 2.12$. $p = .148$.

4. Discussion

In the present study we investigated whether digital simulated teaching fosters student teachers' ability and willingness to apply theoretical knowledge about classroom management in teaching situations (theory-practice integration). Novice student teachers learned either with text and a simulation game, or they learned with text and a screenshot-sequence depicting the game's content. In a nutshell, our results revealed that student teachers in the *screenshot condition* applied their theoretical knowledge in scripted teaching situations more frequently, while students in both conditions perceived theoretical knowledge to be similarly useful. By contrast, student teachers in the simulation condition exhibited a stronger rise in teaching self-efficacy and stronger intentions to reuse the learning materials because of finding them fun or wanting to learn from them. Our findings suggest that even if student teachers are motivated to learn with simulation games, the games appear to be less effective than learning with multimedia materials if learners play without having been thoroughly instructed.

4.1. Digital simulated teaching did not influence perception or use of theory

According to our transfer hypothesis (H_1), student teachers in the simulation condition should perform better on subsequent (near and far) transfer tasks after having practiced the transfer of theoretical knowledge via in-game teaching decisions. Although our findings reveal that the number of theory-based arguments regarding near transfer tasks increased in both conditions, we also noted that for both near and far transfer, student teachers in the screenshot condition significantly outperformed participants in the simulation condition. This finding contradicts previous research data demonstrating the effectiveness of simulations and serious games in skill-acquisition (Chernikova et al., 2020; Lamb et al., 2018; Raupach et al., 2021; Wouters et al., 2013). A straightforward reason for this finding is that student teachers in the screenshot condition spent more time reading feedback during the first learning-phase than did those in the simulation condition. Feedback is important when learning with simulations (e.g., Ravyse et al., 2017). The feedback in this study featured theoretical knowledge that was not elaborated on in the initial learning text on classroom management. Student teachers who read the feedback more carefully thus probably knew more about classroom management than those who only remembered information from the initial text. Furthermore, the feedback discussed situations resembling those featured in the far transfer tasks (e.g., methods to form groups for group work), making its content a relevant source of theory-based arguments for far transfer tasks. The screenshot group might have also profited from reading an example about a fictitious teacher's classroom management instead of making their own decisions. Learning from such worked examples is thought to be particularly effective in initial skill-acquisition (for an overview, see Renkl, 2014). Regarding the development of transfer-performance over time, we observed the greatest increase in both conditions after the first learning-phase. Unlike the evidence of repeated use being crucial to the effectiveness of simulation-based learning (e.g., De Coninck et al., 2019; Gegenfurtner et al., 2014), transfer performance in our sample stagnated after the second learning-phase. Nevertheless, compared to prior research with experienced student teachers by Kienitz et al. (2024), the increase in theory-based arguments was stronger in our sample of novice student teachers.

According to our usefulness hypothesis (H_2), we expected participants in the simulation condition to perceive theoretical knowledge as being more useful because making their own decisions in critical situations would make them experience theory-based decision-making as useful. Against our hypothesis, both the screenshot-sequence and simulation yielded a similar increase in perceived usefulness of theoretical knowledge after reading the initial learning text. Kienitz et al. (2024) observed similar results on the perceived usefulness of theoretical knowledge among advanced student teachers learning with a teaching simulation game. On one hand, these findings could be attributable to learners in the simulation condition utilising their knowledge on classroom management but not finding it useful. While low perceived usefulness could be the result of inadequate knowledge application, other potential explanations with focus on the learning process are volitional deficits or the high costs of applying newly acquired knowledge instead of experience-based reasoning (for an overview, see Renkl, 1996). On the other hand, our results on transfer performance and the perceived usefulness of theoretical knowledge suggest that participants in the simulation condition did not apply their knowledge from the text well enough in the game. By not applying their knowledge on classroom management while playing, student teachers failed to experience the usefulness of such knowledge. To counteract this, we instructed student teachers before each learning-phase to apply their newly learned knowledge when engaging with the subsequent learning material. Participants were also able to look in their printed-out learning texts on classroom management during the learning phases to facilitate knowledge application. Nevertheless, we cannot rule out that participants simply failed to know how or when to apply the knowledge featured in the text while deciding. Future studies should aim to more closely assess learners' cognitive processes while learning with the game, focusing especially on the knowledge their decision relies on, for example by using self-report measures (see Baier, 2021), think-aloud, or cued retrospective reporting.

4.2. Positive effects on teaching self-efficacy

In line with our self-efficacy hypothesis (H_3), we had expected to observe teaching self-efficacy in classroom management to increase more in the simulation condition as opposed to the screenshot condition. Making decisions in the game by utilising knowledge on classroom management from the text should enhance the teaching self-efficacy of participants in classroom management by acting as a form of enactive attainment (Bandura, 1996). We expected no changes in the subscale instructional strategies, since participants did not acquire the knowledge to apply regarding this topic. Partially supporting our hypothesis, teaching self-efficacy in classroom management increased more among participants in the simulation condition. Contrary to our hypothesis, however, teaching self-efficacy in instructional strategies also increased exclusively in the simulation condition. These findings concur with research showing that simulations and serious games foster teaching self-efficacy (e.g., Christensen et al., 2011; Samuelsson et al., 2022). They also reinforce prior research showing no changes in teaching self-efficacy in advanced student teachers (Kienitz et al., 2024) by suggesting their potential in fostering teaching self-efficacy in novice student teachers. Nonetheless, our findings on teaching self-efficacy reveal the overconfidence of learners engaging with digital simulated teaching in their teaching skills. Participants playing the simulation seem more confident in both facets of their teaching abilities even though they failed to integrate theories within their teaching more effectively and had not been taught about instructional strategies. This overconfidence may be partly attributable to the difficulty of the digital simulated teaching scenarios. The design of our materials aimed to foster mastery experiences. One way to achieve this was to provide learners with a pool of decision options that would not lead to serious negative consequences. While this design allows learners to experiment without hesitation, it also carries the risk that learners could find themselves succeeding not thanks to their well-founded decisions but rather to not having had the opportunity to fail. Such a situation could trigger overconfidence in their teaching skills. As teaching self-efficacy improved until after the second learning phase (while transfer performance stagnated after the first), we suspect that learning once with a simulation game (rather than twice) might counteract this overconfidence in short one-time learning sessions.

4.3. *Student teachers are motivated to (Re-)learn*

According to our replay hypothesis (H_4), we expected participants in the simulation condition to be more willing to reuse the material than those in the screenshot condition. Our results partially support this hypothesis. While participants in the simulation condition did not report a stronger general intention to replay the game, they expressed a stronger intention to replay because they found the materials fun to use and they wanted to consolidate their knowledge. Our findings replicate findings by (Kienitz et al., 2024), in which advanced student teachers were also motivated to play and learn via a teaching simulation game. Our data reveals that participants' motivational intentions are partially reflected in their learning times. Aligning with them feeling more motivated to play, participants in the simulation condition spent significantly more time playing the game than those in the screenshot condition did reading the screenshot-sequence. However, contradicting their intention to consolidate their knowledge, student teachers in the simulation condition spent significantly less time reading the theory-based feedback in the first learning-phase than student teachers did in the screenshot condition. Studying the feedback would be an important information source from which to learn, especially in the simulation condition, where the feedback directly informs and reflects on their in-game decisions. Participants' motivation to learn and their actual learning behaviour could imply that they overestimate the learning effects that play alone has while underestimating the effect that feedback and reflection exert on learning. While they are aware of their desire to learn, they might not know how to best achieve this goal. Future studies could explore this idea further.

4.4. *Limitations and further research*

When interpreting our findings, limitations resulting from the sequence of our procedure should be kept in mind. We assessed most of our dependent variables initially before participants had read the text on classroom management (Pre) and for the second time, after they had completed the first learning-phase (Intermediate) with either the screenshot-sequence or the simulation game (for an overview see Fig. 2). It is thus unclear how many of the effects over time between those measurement timepoints result from reading the text about classroom management. We therefore focussed the interpretation and discussion of our results on differences between the simulation and screenshot condition and their interaction with the measurement timepoint. Future studies could expand on our results by featuring additional experimental conditions focusing exclusively on learning with text material (without additional materials) to examine its isolated effects.

Furthermore, the effectiveness of learning via the teaching simulation game might have been limited by how we instructed participants to learn. Before engaging with either learning material, participants were instructed to apply their knowledge from the text on classroom management in the following learning unit. To enhance the mental availability of theoretical knowledge in the learning units, participants could access their text while learning with the screenshot-sequence or simulation game. While the time spent giving instructions in both conditions suggests that participants read and understood the instruction adequately it is unclear whether our instruction promoted the application of theories in the learning units effectively. Although student teachers knew that they were supposed to apply their theoretical knowledge while learning, they might not have known when or how to do so. Our finding that time spent on feedback was shorter when learning with the simulation game supports the assumption that student teachers possibly did not know how to effectively employ the game to improve their theory-practice application. Stronger instructional support might be necessary to foster theory-practice integration in digital simulated teaching. Intrinsically integrating theoretical knowledge within the game's structure (e.g., in-game preparation-units or hints originating from theory, feedback during teaching scenarios) could additionally support theory-practice integration by making connections between theory and practice transparent in the game's structure (see Habgood & Ainsworth, 2011, for the concept of intrinsic integration). Future studies should explore the effects of such instructional designs on learning with digital simulated teaching.

As established in many other studies on teaching simulations (for an overview, see Huang et al., 2023), we used a transfer task with low authenticity compared to real teaching (explaining classroom decisions) because our sample possessed little experience in or knowledge about teaching. This design added a new layer of task complexity compared to decisions in the simulation game while not overwhelming participants with a more authentic (consequently more complex) task format. It remains unclear whether participants' performance in those transfer tasks translates to knowledge-application in situations more akin to real classroom teaching. There is a need for additional studies examining the effect on simulations on performance in situations closer to real teaching to address this question.

Based on the situated expectancy-value theory (Eccles & Wigfield, 2020), our study mainly aimed to promote learners' motivation to utilise theoretical knowledge for teaching by influencing their expectations of success (teaching self-efficacy) and utility value (perceived usefulness of theoretical knowledge). Future studies could design teaching simulation games to foster motivation for theory-application by targeting other facets of value such as intrinsic value (e.g., by making theory-use more fun) or attainment value (e.g., via personalisation, connecting informed practice with teachers' occupational identity).

4.5. *Implications*

Taken together, our results support the conception of the theory-practice gap as a multi-causal problem in teacher education. To close the gap, interventions not only need to enhance student teachers' motivation to use their knowledge but also impart them the ability to do so. While it is promising that a low-immersion simulation game like the one used in this study is able to influencing the gap's motivational side, the game still did not effectively address its cognitive side. The finding that participants were more motivated to use the game and learn from it, yet did not engage deeply with the feedback that would support their learning, has some implications for how student teachers can be supported to learn in simulated teaching.

Our observations of how participants used the game suggest that novice student teachers may not be aware of effective strategies for learning in a simulated learning environment. Even when design and use elements beneficial for learning across different games and simulations are present (e.g., feedback, repeated practice), learners still might not know their importance or how to use them to their best effect. In our case, strategies of deeply engaging with the feedback, like reflecting on past or generating new strategies, were possible but not required to advance or succeed in the game. It may be possible to reduce the likelihood of learners using ineffective approaches to learning if simulations and serious games are designed to integrate the use of effective learning strategies into their core mechanics (see intrinsic integration, Habgood & Ainsworth, 2011). To achieve this, designers should make features and strategies central to learning vital for succeeding in the game. Future research needs to apply more fine-grained measures of motivation not only broad measures of motivation while learning (e.g., Did learners want to generate strategies for further playthroughs based on feedback?) in addition to more broad measures (e.g., Did learners experience flow while playing?) to investigate learners' willingness to engage in those favourable behaviours or while using a simulation or serious game. A more fine-grained way of addressing motivation might be necessary if research wants to address the question whether a simulated learning environment causes learners to want to do what they should do in order to learn effectively.

An alternative approach to enhance learning with a simulated learning environment might be to teach learners how to approach a specific game or simulation to facilitate learning. This might also involve instructors discussing with students how they approached a simulated learning environment after learning in a simulated teaching environment. This might be especially relevant to do as our data hints towards overconfidence in their teaching abilities occurring due to playing. Collectively reflecting on experiences in the simulation game and discussing its events in relation to theoretical knowledge might be able to counteract this overconfidence.

CRediT authorship contribution statement

Anna Kienitz: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Marie-Christin Krebs:** Writing – review & editing. **Alexander Eitel:** Writing – review & editing, Supervision.

Declaration of competing interest

None.

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Appendix A

Overview of correlations between study variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1. Abitur grade	-																							
2. Teaching experience	-.19*	-																						
3. Trait self-efficacy	-.19*	.08	-																					
4. Prior knowledge (last test)	-.18	.15	.09	-																				
Transfer: % of theory-based arguments (near)																								
5. Pre	-.08	-.06	-.03	.11	-																			
6. Intermediate	-.21*	.06	-.05	.05	.19*	-																		
7. Post	-.14	.05	.06	.11	.21*	.49**	-																	
Transfer: % of theory-based arguments (far)																								
8. Intermediate	-.25**	.01	-.03	.06	.19*	.08	.05	-																
9. Post	-.11	.11	.09	.08	.10	.06	.05	.18	-															
Perceived Usefulness of theoretical knowledge																								
10. Pre	-.11	-.01	.06	.10	-.02	.28**	.16	-.06	.03	-														
11. Intermediate	-.12	.02	-.13	.14	-.07	.23*	.14	-.10	.03	.69**	-													
12. Post	-.12	.06	-.09	.12	-.05	.37**	.18*	-.13	.08	.69**	.77**	-												
Teaching self-efficacy (classroom management)																								
13. Pre	.05	-.15	.22*	-.01	.06	.06	.02	.11	-.16	.18*	.03	.08	-											
14. Intermediate	-.06	.03	.13	.09	.04	.07	.02	.11	-.15	.16	.14	.19*	.60**	-										
15. Post	-.06	.05	.12	.09	.07	.11	.04	.06	-.20*	.15	.17	.24**	.60**	.83**	-									
Teaching self-efficacy (instructional strategies)																								
16. Pre	-.03	.09	.21*	.00	.13	.10	-.09	.09	.05	.29**	.09	.18*	.43**	.34**	.35**	-								
17. Intermediate	-.06	.10	.31**	.06	.07	.18*	.03	.03	.02	.33**	.15	.27**	.42**	.56**	.51**	.77**	-							
18. Post	.06	.07	.12	.10	.04	.08	-.07	.02	-.03	.24**	.15	.24**	.37**	.50**	.58**	.72**	.83**	-						
19. Active Mental Effort	-.20*	.10	.04	.09	.15	-.02	.08	.08	.06	-.11	-.02	-.07	-.14	.00	-.01	.01	.04	.04	-					
20. Passive Mental Effort	.07	-.06	-.13	-.14	.03	.00	-.08	.01	.03	-.11	-.05	-.17	-.12	-.06	-.11	.07	-.03	.02	.24**	-				
Learning time in seconds (playing)																								
21. Phase 1	.22*	-.03	-.16	-.09	-.04	-.12	.00	-.13	-.18*	-.08	-.07	-.09	-.03	.11	.17	-.13	-.06	.05	.08	.08	-			
22. Phase 2	.03	-.01	.03	-.19*	-.11	-.00	.14	-.09	-.16	-.03	.02	-.04	-.04	.11	.13	-.04	-.05	-.06	.14	.11	.51**	-		
Learning time in seconds (feedback)																								
23. Phase 1	.07	-.11	-.05	-.16	.11	.21*	.12	.03	.08	.07	.03	.04	-.01	.01	-.02	-.01	-.05	-.05	-.07	-.08	-.07	-.03	-	
24. Phase 2	.02	.06	.065	.09	.10	.07	-.01	-.16	-.12	.09	.06	.07	-.06	.02	.02	.120	.16	.07	.00	-.05	.08	.13	.05	-

*Correlation significant at the .05 level (two-tailed)

**Correlation significant at the .01 level (two-tailed)

Data availability

Data will be made available on request.

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General Discussion

At the start of this dissertation, I asked the question whether simulation games can close the theory-practice gap in teacher education. From a theoretical perspective, simulation games are promising to close the gap because they should be able to affect transfer of knowledge by fostering focused cognitive processing as well as motivation, both to engage in said processing and to use theoretical knowledge while teaching. However, the results of our studies in different instructional settings show that achieving those effects needs more than merely providing the opportunity to learn with a simulation game.

On one hand, using a simulation game should foster student teachers' ability to apply theoretical knowledge to teaching by practicing in simulated teaching situations with reduced complexity. On the other hand, experiencing mastery when using theoretical knowledge in simulated teaching scenarios should increase teaching self-efficacy and how useful student teachers perceive these theories to be for teaching. Increases in teaching self-efficacy and perceived usefulness of theory application could foster student teachers' motivation to teach based on theoretical knowledge. Both studies in this dissertation observed how using the same simulation game in different instructional settings (applying pre-existing knowledge in Study 1 vs. applying newly acquired knowledge after pre-learning with a text in Study 2) would affect these motivational prerequisites and outcomes and student teachers' ability to transfer theoretical knowledge. To additionally assess how the timing of this intervention may affect its outcomes, both studies were carried out in different stages of teacher education (advanced student teachers in Study 1 vs. novice student teachers in Study 2). As student teachers in both studies differ greatly in their prerequisites for learning (prior knowledge, teaching experience, etc.), we assumed that playing same game may affect both samples differently. Screen recordings in Study 2 allowed us to gain further insights into which parts of the game student teachers allocate their learning time to.

Participants in both studies learned twice with either the game (simulation condition) or a screenshot-sequence of the game's content (screenshot condition). In both studies, we expected participants playing the game to report higher transfer performance, teaching self-efficacy and perceived usefulness of theoretical knowledge. Additionally, we expected that participants in the simulation condition would be more willing to reuse the learning materials compared to participants in the screenshot condition. While the results of both studies are largely inconsistent with these hypotheses, our data on participants' interactions with the game in both instructional settings suggest possible reasons for the observed effects. The mechanisms and learner characteristics underlying these reasons can provide insights into boundary conditions for effectively implementing serious games into a learning unit. They also point to certain potentials of using a game when it is implemented effectively. I will first discuss these potentials and boundary conditions reflected in our data, and then discuss their theoretical and practical contributions to the broader field of simulations and serious games.

Playing a simulation game has the potential to motivate student teachers to learn

One goal of both studies was to assess whether learning about theoretical knowledge with a simulation game would motivate student teachers 1) to learn about theories and 2) to apply them when teaching. Our overarching findings support the first of those assumptions: simulation games can *motivate teachers to learn about theories about teaching*.

In both Study 1 and Study 2, we assessed participants' intention to reuse the provided learning materials after each learning phase. In both studies participants in the simulation condition reported higher intention to reuse the game because it was fun and because they wanted to deepen their knowledge compared to participants in the screenshot condition. Student teachers, both novice and advanced, not only wanted to use the game because they liked to play, but also because they wanted to learn from it. These intentions are reflected in their general learning behavior, with learning times in the simulation condition being significantly higher than in the in the screenshot condition. While these effects were similar between both levels of instruction and cohorts of student teachers, they may be especially relevant for advanced student teachers. As discussed at the beginning of this dissertation, advanced student teachers may be less motivated to learn about theories because they tend to perceive theoretical knowledge as detached from and irrelevant to real teaching (Allen, 2009). In this context, the observed motivational benefits of *Me as a teacher* suggest a particular advantage of simulation-based learning materials, as the game successfully fostered advanced student teachers' motivation to learn about theoretical knowledge more than more traditional multimedia learning materials.

To further assess the motivational potential of simulation games in teacher education, future studies should investigate their effects in instructional settings that require learners to engage in self-directed learning. The present research may underestimate these motivational effects because the conditions provided by the settings of both studies (during a lecture and in lab) might have influenced participants' willingness to interact with the learning materials (e.g., lower opportunity costs, lower demands on self-regulation). Like the setting of a game, the context of a seminar or lab experiment can create a contextual framing that temporarily motivates participants to care about things they would not otherwise care about. For example, even if participants' lacked motivation to interact with the screenshot-sequence, the controlled setting of both studies may have created a contextual frame that encouraged players to do so. Further studies are necessary to assess the ecological validity of the observed effects, for example by assessing them in settings of self-directed learning.

A First Boundary Condition Of Learning with Simulation Games: The Role of Productive Engagement

On an optimistic note, we observed that participants were willing to engage with a simulation game that taught theoretical knowledge about teaching because they wanted to learn from it. Contrary to this intention, both studies found that playing the game did not improve transfer performance and perceived usefulness of theories more than reading a screenshot-sequence of the game. For transfer, advanced student teachers in Study 1 performed similarly after playing the game compared to participants who read the screenshot-sequence. On a descriptive level, participants in the simulation condition used less theory-based and more experience-based arguments over time. There was no similar trend in the control condition where the amount of experience-based arguments decreased over time. While in Study 2, the transfer performance of novice student teachers in both conditions increased over time, participants in the screenshot condition still significantly outperformed participants in the simulation condition. Perceived usefulness of theoretical knowledge increased significantly only in Study 2 and did not differ between conditions in either study.

The effects on transfer performance observed in both studies are surprising against the vast backdrop of research demonstrating the effectiveness of (repeated) learning with serious games and simulations in promoting skill acquisition and transfer (e.g., Chernikova, Heitzmann, Fink, et al., 2020; Gegenfurtner et al., 2014; Lamb et al., 2018). Our overarching findings suggest that simply providing the opportunity to use knowledge in a game does not necessarily have this effect, even if learners are motivated to use the game to learn. This finding has several possible explanations. For one, the content of *Me as a teacher* may simply not be a suitable for improving these variables. However, this explanation seems unlikely as the screenshot-sequence derived from the game was shown to improve transfer performance in both studies. Another possible explanation is that the way in which participants interacted with the game did not promote learning. After all, participants' motivation to learn can only lead to actual learning if their processing is focused on productive interaction with content relevant to the learning goal. If participants did not know how to use the game effectively for learning, they may have instead focused their interaction with the game on processing that was irrelevant to the learning goal.

In order to learn from a game, learners need to engage with what Plass et al. (2012; 2013) call learning mechanics. These learning mechanics are defined as forms of interactivity within a game that form the core learning activity over the course of play. For example, core learning mechanics of Me as a teacher would be to reflect in action, by referring to theoretical knowledge when making decisions, and to reflect on action, by processing the content of the feedback in order to apply it when replaying a level. Our findings on learning times, as well as interviews with participants from Study 2, support the idea that the game and its implementation in both studies did not successfully support these processes. Thus, the first boundary condition for learning with serious games derived from the overall current findings is that learning with a serious game can only be effective if the game or its implementation supports learners to focus their processing on activities that are crucial to the learning goal. Two examples from our data are discussed to illustrate the relevance of this boundary condition in the context of “Me as a teacher”: Student teachers not using their time to process the provided feedback and them not using their theoretical knowledge while playing.

First, our data on learning times in Study 2 suggest that participants in the simulation did not process the content of the in-game feedback deeply. Although participants in the simulation condition learned for longer overall than participants in the screenshot condition, they still spent less time on processing the feedback provided. The finding that learners do not cognitively engage with the feedback provided in the game is particularly important as feedback is considered to be a key factor contributing to learning with serious games because it can promote various (meta-)cognitive processes relevant to learning (DeConinck et al., 2019; Gegenfurtner et al., 2014). For example, feedback can act as a form of instructional support by providing structural information about the task at hand which consequently reduces its complexity (see guided discovery learning, e.g., Kirschner et al., 2006; Moreno, 2004). For complex interactive materials like simulation games, novice student teachers with little prior knowledge may benefit most from this reduction in task complexity. Otherwise they may quickly become overwhelmed. Players can also profit from theory-based feedback because it expatiates knowledge and connections that are only conveyed implicitly when learning through playing (see Leemkuil et al., 2000). Reading the feedback in *Me as a teacher* after the first learning phase, could have supported players in the second learning phase to focus their attention on connections between theory and practice that they might have missed on their own. However, both effects of feedback can only come into play when learners cognitively engage with it. Study 2 demonstrated that, even when a game provides personalized, adaptive feedback to support players, they do not necessarily spend enough time with the feedback to make use of it. This lower focus on feedback might partially explain the differences in transfer performance observed in Study 2. Interviews with practicing teachers who played *Me as a teache*r conducted in a preliminary study for Study 1 provide additional tentative evidence that players did not process the in-game feedback deeply (Kunert, 2022). Here, five out of six teachers interviewed reported that they did not read the feedback thoroughly or only skimmed it (e.g., “How carefully did you read the feedback?” - “Not carefully. I skimmed it [the feedback]. I looked at the most important key points – mainly the bullet points. But I have read it. But I read it quickly and skimmed it.”). It is still unclear whether advanced student teachers in Study 1 also underused the feedback provided while playing. For advanced student teachers, we similarly observed longer learning times in the simulation condition. However, as participants used their own devices to take part in the study during a lecture session, we were unable to assess *how* participants spent their time learning.

A second example of how participants approached the game in a way that did not align with the learning goal is that participants likely did not use their theoretical knowledge while making teaching decisions in the game. If participants did not treat the game as an exercise in applying their theoretical knowledge to classroom scenarios, they would have missed the opportunity to practice theory-practice application and to experience the usefulness of theoretical knowledge. Consequently, learners not referencing theoretical knowledge in their decisions would severely hamper the game's potential to promote the ability to transfer and how useful they perceive theoretical knowledge to be. None of the collected data on in-game decisions in either study allows for clear conclusions about which kind of knowledge participants used while playing. However, in both of the current studies, there is evidence suggesting that participants may not have thought about theories while making decisions in the game. The reasons for this differ between both studies.

In Study 1, our data suggest that insufficient theoretical knowledge played a role in participants potential failure to use the game to practice applying theoretical knowledge. Despite completing courses about them in the past, advanced student teachers on average reported very little prior knowledge about theories from educational psychology in an open recall task. When asked to state or describe any theory from educational psychology, the majority of student teachers in Study 1 reported at most one theory (M = 0.91; Range: 0 – 5). If student teachers in our sample were not able to state or describe theories, they may not have been able to effectively use that knowledge in a more complex task, like the simulation game. This finding supports the idea that student teachers' knowledge about these theories may already be inert at this advanced point of their studies (see Allen, 2009). On one hand, this inert knowledge in advanced teachers suggests that they are a promising target audience for interventions aimed at reducing this inertia. On the other hand, this finding indicates that when knowledge is inert, learners may need additional support or preparation (e.g., reminders on relevant concepts) in order to benefit from interventions practicing knowledge-application. To further test the assumption that participants do not use their knowledge while playing the game, and to identify potential factors that impede them from doing so, Weisel (2024) conducted interviews with a subsample of participants from Study 2 (n = 14). In the interviews, participants viewed screen-recordings of some of their teaching decisions from the game to afterwards explain the reasons behind their decisions (see cued retrospective reporting, e.g., Bender et al., 2021). The interviews revealed that novice student often did not use their newly acquired knowledge in teaching decisions because they struggled to notice when or how to use it in the game. Six out of fourteen participants reported that they perceived no or only scarce connections between knowledge from the text and in-game decisions (e.g., “So when it came to the questions [in the game] […], I didn't think about what was in the text or look at it [the text]. I actually had it in front of me, but I actually based my decision more on my experience […] than on something I've just read, which I haven't really internalized yet, I would say. And, err, I think I would have included it [the knowledge] more if I had seen the direct connections. But somehow I didn't.”). This finding is particularly notable since the classroom management theories that participants had learned about before playing provided specific suggestions for managing concrete classroom events. As a result, they should have been relatively easy to connect to similar situations depicted in the game (e.g., dealing with an increasing noise level during group work).

In subsequent studies, Moser (2024) and Diemer (2025) similarly showed that newly acquired knowledge about classroom management was a less important in simulated teaching decisions than other sources of knowledge. Both studies with student teachers and psychology students found the trend that participants' decisions in a teaching simulation game were influenced more by their own experiences as students (M_{Moser} = 3.73 | M_{Diemer}= 3.88 | Range 1 - 5) and intuition (M_{Moser} = 3.93 | M_{Diemer} = 3.81) than the knowledge on classroom management they had learned before playing (M_{Moser} = 3.57 | M_{Diemer} = 3.36). All of the reported findings suggest that learners require stronger support in how and when to use their knowledge in the game in order to benefit from the opportunity to apply their knowledge while playing. Further research on the cognitive processes during in-game decision-making are necessary to examine if this struggle is unique to novices (e.g., due to little experience with teaching scenarios) or if advanced student teachers experience similar struggles when trying to apply new knowledge in the game. If advanced student teachers likewise do not to apply their theoretical knowledge, they might instead rely on their prior experiences in teaching to solve simulated situations. Consequently, solving simulated teaching scenarios by applying only experiential knowledge could foster the use of experience-based knowledge instead of theoretical knowledge in teaching situations. The data from Study 1 provides tentative hints for this happening, with experience-based reasoning increasing on a descriptive level after playing the game twice.

Both examples illustrate how learning with a simulation game can be ineffective despite varying levels of instructional support. For instructional support to foster learning with a game, the provided measures of support need to focus on processing that aligns with the game's core learning goal. On a similar note, previous research has argued that instructors need to be aware the fact that, even when simulation games provide opportunities to learn, learners do not always make effective use of these opportunities. For example, Wouters et al. (2017) argue that learners need to engage in complex cognitive processes to learn from a serious game and that instructors cannot automatically assume them to engage in these processes. McTigue et al. (2019) also emphasize the importance of providing thorough instruction before playing and guiding learners during play when using serious games. Doing so can ensure that learners focus on relevant content and apply adequate learning strategies when learning with a game. Asides from deriving broader boundary conditions, the results of this dissertation contribute to the field by identifying the deep processing of feedback and knowledge-application in the game as critical processes learners struggle with and, hence, need stronger support. Further research is needed to examine how these processes can be fostered effectively via instructional support (e.g., providing worked examples on gameplay) or the game's general structure (e.g., by linking learning-relevant actions to the game's incentive structure).

A Second Boundary Condition: Playing may lead to Overconfidence

A second goal of the current research was to promote student teachers' teaching self-efficacy in order to foster their motivation to use theoretical knowledge in the classroom. Due to their lack of teaching experience, we had expected novice student teachers in Study 2 to profit more in this regard than advanced student teachers. However, similar to learners' motivation only being beneficial if it is channeled towards processes relevant to the learning goal, a higher sense of teaching self-efficacy should only be beneficial if it is backed by an adequate level of skill. However, our results on teaching self-efficacy instead point towards the limitations of this approach: *Learning with a game can cause inexperienced learners to become overconfident in their abilities*.

This boundary condition is reflected in participants' increased teaching self-efficacy for classroom management and instructional strategies. Viewed in isolation, this finding is consistent with our hypothesis, this heightened sense of teaching self-efficacy is not backed by an increase in actual performance. Together with participants in the simulation condition performing worse on transfer tasks than those in the screenshot condition, this suggests that playing may have caused participants to overestimate their classroom management skills. Since feedback was the only source of information in the game that supported reflection on in-game actions, this overconfidence may be partly due to superficial processing of feedback. Furthermore, positive effects on teaching self-efficacy were not specific to content that was trained in the game. Against our hypotheses, playing the game increased not only teaching self-efficacy for classroom management but also for instructional strategies. Yet, student teachers in Study 2 only learned about classroom management prior to playing. Because novice student teachers did not learn about instructional strategies and should have no prior knowledge on that topic, we expected only their teaching self-efficacy for classroom management to increase. Further research is needed to determine whether this increase in teaching self-efficacy positively influences student teachers' motivation to apply theoretical knowledge if it does not stem from increased skills.

We did not observe similar changes in teaching self-efficacy for advanced student teachers in Study 1, neither in the simulation condition nor the control condition. This finding is consistent with socio-cognitive theory (Bandura, 1996, 1997) assuming that self-efficacy develops through mastery experiences. As those advanced student teachers were in their sixth semester and could rely on, on average, 8 months of teaching experience (*M* = 8.26; *SD* = 10.28), it is likely that they had already made different experiences of mastery (or failure) which shaped their sense of teaching self-efficacy. Adding short virtual teaching experiences to this repertoire might not affect their overall self-efficacy for teaching. Because novice student teachers have less experience in teaching, we expected that simulated teaching experiences would have a greater impact on their sense of teaching self-efficacy. Aligning with this assumption, Study 2 suggest that novice teachers seem to be especially prone to overconfidence, possibly due to the same reasons that make them a promising target audience to profit from the game. Instructors should keep this risk in mind and address it when teaching novices with simulation games.

Theoretical and practical implications of this work

The boundary conditions for effective learning with simulation games discussed above have various implications for both research on and the use of simulation games. On one hand, they point the way to effective support measures for learning with serious games and simulations by identifying specific learning processes where learners require additional support. Potential support strategies for these processes could be applied within a game's design or externally by instructors providing additional support or instruction to counteract the pitfalls of an ill-designed game. On the other hand, our findings highlight the need for further research on the processes at play during game-based learning in order to assess the effectiveness of different approaches to support learners. The following section will address the implications of the identified boundary conditions from both perspectives.

At a first glance, the implications of learning with a serious game being only effective if the game is implemented in a way that supports learners to focus their processing on activities crucial to the learning goal seem fairly straightforward. If learners need to engage in certain activities or to process certain parts of the provided content in order to learn with a game (learning mechanics), then either the game itself or its implementation must ensure that learners actually engage in these processes. However, the results of this dissertation suggest that this is more complicated than it seems. To create an instructional environment in which learners are able and willing to engage in those learning mechanics, they must first be identified and communicated to players. This could be done either implicit through the game's structure or through explicit instruction. In the example of Me as a teacher, learning mechanics were not successfully communicated to players, as they did not know how to apply their knowledge in simulated teaching situations. While the game aims to facilitate knowledge application by breaking down the task of noticing - the game mechanic of decision screens alleviates the decision when to act while offering pre-defined options to choose from, making decisions less complex - its simulation-focused approach still provides only little guidance on how players should engage with it (e.g., goals for decisions, importance of feedback). There are different approaches to how instructors or game designers might encourage engagement with learning mechanics in Me as a teacher, but also in simulation games in general. Depending on the scenario, different approaches might be appropriate or necessary.

First, when developing a new game or heavily adapting a pre-existing one, game designers should integrate relevant learning mechanics into the game's general structure (see intrinsic integration, Habgood & Ainsworth, 2011). If the game mechanics players interact with correspond with necessary learning mechanics (Plass et al., 2013), learners will inevitably engage in processes relevant to the learning goal while playing. For example, in Habgood & Ainsworth (2011), learners playing the intrinsically integrated version of the game *Zombie Division* need to engage in the core learning mechanic (division tasks) each time they engage in the core game mechanic (killing skeletons) because killing a skeleton requires them to solve the division task associated with it. This integration may have been insufficient in *Me as a teacher*. Here, the intended learning mechanics (deciding based on theoretical knowledge, processing feedback) were not intertwined with the game's mechanics (e.g., deciding on short notice), as they were not necessary in order to proceed or succeed in the game. Designing game mechanics with closer alignment to central learning mechanics (e.g., integrating feedback and reflection into the game's story, making replaying the same scenario mandatory) may positively influence its effects on learning. However, further research exploring the effects of intrinsic integration is necessary, as it is still unclear which mechanisms stand behind the benefits of intrinsically integrated materials. Multiple possible mechanisms behind these effects have been discussed in the past (for an overview, see Ninaus et al., 2023). For example, does stronger intrinsic integration motivate learners to engage with content relevant to the learning goal or does it focus learners' attention on those aspects, consequently lowering demands on working memory capacity? It is important to gain deeper insights into which mechanisms are caused by different forms of intrinsic integration in games with different kinds learning goals (e.g., reactivating prior knowledge vs. constructing new knowledge structures; for an overview, see Ke, 2016) in order to deliberately utilize their effects when designing a serious game.

A second approach to encourage engagement in learning mechanics might be to provide instruction that supports learners in doing so. It has been argued repeatedly that in order to be effective, complex tasks that require learners to discover (strategic) knowledge on their own should provide instructional guidance to support learners reach adequate conclusions (see guided discovery learning Alfieri et al., 2011; De Jong et al., 2023). For serious games, Wouters et al. (2017) postulate that they should feature instructional techniques (like prompts, personalization or reflection) to focus cognitive processing on the learning-goal. This is based on their metafinding that serious games are more effective for various cognitive and motivational outcomes when they incorporate such instructional techniques. For example, to improve the application of theoretical knowledge, a game could prompt players about strategies, concepts or theories relevant to that decision (for strategy prompts, see Kombartzky et al., 2010; Schlag & Ploetzner, 2011). Such prompts could reduce the complexity of applying knowledge to a new situation and focus student teachers' attention on relevant aspects of the task. Despite this theoretical potential, the available research on the use of instructional techniques in games offers little concrete guidance on when and how to use them. While Wouters et al. (2017) found that any constellation of instructional techniques in a game was beneficial compared to using none, research on the effects of individual techniques and their interactions is inconclusive. For example, in an overview on the use of prompts in serious games, Vandercruysse and Elen (2017) reported mixed effects. Chernikova, Heitzmann, Stadler, et al. (2020) observed mixed effects for using them in simulations. Similarly, a subsequent study to this dissertation did not find effects on transfer of knowledge when student teachers were prompted to use their knowledge in a teaching simulation game (Moser, 2024). There are similar mixed empirical findings for other instructional techniques, like segmenting (Nebel & Ninaus, 2024), in the context of games. Based on the integration of playing and learning in educational games, Ke (2016) suggests that when instructional techniques are applied in a game, they should be applied in a way that does not disrupt the game experience while providing meta-reflective moments for learners. Further research is needed to determine how different types of games (e.g., drill-and-practice vs. games that provide a more open problem space) can use instructional strategies to enrich, but not disrupt, learning goal relevant cognitive processes during play. Similar to intrinsic integration, future studies must therefore focus on the mechanisms triggered or altered by the implementation of different instructional techniques.

Lastly, instructors could increase engagement with learning mechanics by supporting learners outside of the game before, during or after playing. This approach may be particularly beneficial because it allows instructors to tailor the implementation of an existing game to the needs of their group of learners or to compensate its instructional weaknesses, like weak intrinsic integration, without changing the game. Before playing an educational game, they can prepare learners by teaching them the prior knowledge necessary to effectively engage with it. This can be necessary content knowledge, like knowledge about classroom management before playing a teaching simulation game. As discussed in the context of Study 1, this is particularly relevant if learners are supposed to practice knowledge-application in a game. In addition, instructors should teach learners strategic knowledge for how to effectively learn with the game at hand, like how to use its core learning mechanics. Instructors could, for example, use illustrated guides explaining the learning mechanics of a game as worked examples (for an overview, see van Gog & Rummel, 2010). Aligning with the concept of cognitive apprenticeship (see Collins & Kapur, 2014), they could also directly model the effective use of learning mechanics during gameplay by demonstrating and narrating their use themselves or through pre-recorded video modelling examples (see Hoogerheide et al., 2016). Providing this strategic knowledge may focus learners processing on activities relevant to the learning-goal and lower a game's complexity, as it informs learners about how to effectively learn from it. Supporting this idea, a review on their effects in serious games by Wouters (2017) found that using worked examples or modelling examples enhanced learning with serious games. To use game-based learning materials most effectively, Northrop and Killeen (2013) suggest that instructors should provide input on both content and strategic knowledge.

As learners play, instructors can support engagement with learning mechanics by monitoring *how* they interact with the game. For example, instructors can provide learners with external prompts on how to interact with the game, either fixed or adaptive when they notice ineffective interaction. Such external prompts have been shown to promote learning with a serious game as long as learners engage with them productively (Fiorella & Mayer, 2012). Instructors could also change the overall instructional context of a game to meet a certain learning goal. In the example of Me as a teacher, learners could be asked to play the game with a partner, each assuming the perspective of a different theory from educational psychology to consider in decisions while playing. In such an instructional context, the game shifts from its original purpose as a reflection tool for individual players to a tool for enabling discussions about the (sometimes conflicting) implications of different theoretical concepts for classroom decisions. The approach of purpose-shifting (Djaouti et al., 2011) can also be applied to the use of entertainment games for learning. Here, learning with a game is mainly enabled by the instructional context the game is implemented in.

After playing, instructors can use debriefing and reflection phases to monitor student teachers' learning progress and encourage reflective processes (see e.g., Jossberger et al., 2022; Leemkuil et al., 2000). These debriefing phases may address reflection on experiences in a game, when and how the skills and knowledge learned can be used outside of it and to what extent the situations in the game resemble real settings of skill-use. The latter may be particularly important, as it has been discussed that transfer from serious games is hampered if participants perceive the skills acquired in the game as specific to the game, rather than general (Leemkuil et al., 2000; Martinez-Garza & Clark, 2017). Providing conditional knowledge about skill-use and highlighting similarities between an educational game and the real-world context of skill-use may counteract knowledge staying inert to the game by providing metacognitive knowledge about when and how learners can use their knowledge (see Renkl, et al., 1996). Conversely, it may also be important to emphasize differences between an educational game and reality, given the boundary condition that learning by playing can lead to overconfidence. For Me as a teacher as an example, it might be important to discuss the differences in complexity between decisions in the game (e.g., increased time to think about choices, pre-defined options) compared to a real classroom (fast decisions needed, broader event horizon). Instructors should especially focus on these aspects if they choose to use the game for novices despite its potential for causing overconfidence. The general idea of providing pre-training before or debriefing after playing is in line with the meta-finding of serious games being most effective when they are used together with other forms of instruction (Sitzmann, 2011; Wouters et al., 2013). The critical role of a game's instructional implementation, however, is not well reflected in current research. While Wouters and van Oostendorp (2017) define combining serious games with other forms of instruction as an instructional technique for games (*context integration*), they do not address what this context integration should look like. Likewise, McTigue and Uppstad (2019) postulate a lack of research on the effects of how games are implemented instructionally. To address this issue, further research should assess how different forms of instructional implementation, like the ones outlined above, influence productive engagement with learning mechanics and learning. Without such research, it is hardly possible to derive informed suggestions for how instructors should effectively implement serious games into their lessons.

Concluding remarks

How did this dissertation, in conclusion, contribute to the question whether and how simulation games can help close the theory-practice gap? First, the current studies provide quantitative experimental data on the effects of a specific simulation game (Me as a teacher) in different contexts – a setting with high ecological validity (during a lecture session) and a controlled lab setting allowing the assessment of behavioral data. Both studies suggest that the game in its current state is not able to foster knowledge-application in student teachers more than traditional multimedia learning materials (a comic). At the same time, the game inspired student teachers' motivation to learn about theoretical knowledge. This deeper enthusiasm about the game, however, may have been a double-edged sword in certain demographics: novice teachers reported increased confidence in their teaching abilities which was not reflected in their actual ability to use knowledge. Second, by deriving boundary conditions of effective learning with serious games from learners' ineffective interactions with the game across both studies, this dissertation provides loose guidelines for those striving to create effective game-based learning opportunities. The boundary conditions can be broken down to learning with a serious game only being effective if it supports learners to engage in cognitive processing related to the aspired learning goal and learning by playing baring the risk of causing overconfidence in novice learners. Furthermore, I proposed various approaches instructors and game designers could use to account for these boundary conditions – either by adapting a game's design or its implementation. Even if the design of a game would allow for learning to occur, its effects can only be as effective as its implementation allows in relation to the current learning goal. While some suggestions for the implementation of serious games in this dissertation are grounded in positive evidence of their effectiveness, knowledge on the effects of instructional support for serious games is still scarce in many regards (e.g., under what conditions can prompts in a game effectively foster learning?). I encourage future research to test the current (or other) suggestions to determine how serious games and simulations can be implemented effectively.

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(Publications that are part of this dissertation are marked with an asterisk)

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Anna Kienitz