

Learning and teaching with video games:

Toward theoretical progress and educational practice

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Abstract

Learning with video games has been related to several beneficial educational effects, indicating that teaching with video games could also be a promising teaching approach to foster student learning. However, more theoretical guidance and more insights from educational practice are needed to better evaluate potentials of learning and teaching with video games. Therefore, this dissertation presents a reference framework that aims to support theoretical progress in the field of e-learning and the general workflow of e-learning projects (Article 1). Then, with a focus on educational practice and teaching with video games, three field studies were conducted that illustrate how video games could be integrated into two different educational contexts. The results of these studies show that teaching with video games can foster students' dance skills (Article 2) and reflection processes (Article 3). Considering that teachers decide whether they teach with video games, pre-service teachers were surveyed to examine their intention to teach with digital games in their future school teaching (Article 4). The results indicate that teachers' intention to teach with video games is related to a small set of key personal characteristics that could be specifically considered in teacher education. Given pandemic restrictions, it was also outlined how video games could provide educational experiences at home and foster physical and mental health (Article 5). In addition, findings from experimental studies show that mobile learning with quiz apps can benefit student learning in terms of cognitive and metacognitive outcomes (Article 6). Overall, this dissertation emphasizes the relevance of theoretical progress and illustrates how learning and teaching with video games can be effective in educational practice.

Table of Contents

1. Introduction.....	2
1.1. Learning with video games	2
1.2. Teaching with video games	4
2. Synopsis and synergies of the articles	8
2.1. Article 1: The E-Learning Setting Circle: First steps toward e-learning theory development in e-learning research	9
2.2. Article 2: Exergames in formal school teaching: A pre-post longitudinal field study on the effects of a dance game on motor learning, physical enjoyment, and learning motivation	11
2.3. Article 3: Commercial video games in school teaching: Two mixed methods case studies on students' reflection processes	13
2.4. Article 4: Teaching with digital games: How intentions to adopt digital game-based learning are related to personal characteristics of pre-service teachers	15
2.5. Article 5: Educational and Social Exergaming: A perspective on physical, social, and educational benefits and pitfalls of exergaming at home during the COVID-19 pandemic and afterwards	16
2.6. Article 6: The effects of different feedback types on learning with mobile quiz apps	17
3. List of publications.....	19
3.1. Article 1: The E-Learning Setting Circle: First steps toward e-learning theory development in e-learning research	20
3.2. Article 2: Exergames in formal school teaching: A pre-post longitudinal field study on the effects of a dance game on motor learning, physical enjoyment, and learning motivation	21
3.3. Article 3: Commercial video games in school teaching: Two mixed methods case studies on students' reflection processes	22
3.4. Article 4: Teaching with digital games: How intentions to adopt digital game-based learning are related to personal characteristics of pre-service teachers	23
3.5. Article 5: Educational and Social Exergaming: A perspective on physical, social, and educational benefits and pitfalls of exergaming at home during the COVID-19 pandemic and afterwards	24
3.6. Article 6: The effects of different feedback types on learning with mobile quiz apps	25
4. General discussion	26
References	31
Statement	48

1. Introduction

This dissertation includes two conceptual and four empirical works that have been published in peer-reviewed scientific journals. In the following, I present the general theoretical background of these works and how they relate to each other.

1.1. Learning with video games

Learning with video games has been related to diverse educational benefits for years (e.g., Breuer & Bente, 2010; Kirriemuir & McFarlane, 2004; Malone, 1981; Mayer, 2019a; Squire, 2003). But what does *learning with video games* mean? *Video games* can be broadly defined as digital experiences in which players deliberately follow rules to achieve goals, and in which they receive feedback on their progress in terms of diverse game outcomes (Clark et al., 2016; Huizenga et al., 2017). In line with previous work (Arnseth et al., 2018), the term video games refers to all types of games that can be played on digital devices (e.g., computers, tablets, smartphones, and consoles). *Learning* can be understood as “the individual acquisition or modification of information, knowledge, understanding, attitudes, values, skills, competencies or behaviors through experience, practice, study or instruction” (UNESCO Institute of Statistics, 2012, p. 80). How learning takes place has been discussed in terms of various learning theories (e.g., Becker, 2017, Chapter 2; Dron & Anderson, 2016; Mayer, 2019b). Learning theories can also be found in video game design and in studies on learning with video games, including cognitive, motivational, and social approaches to learning (Becker, 2017; Plass et al., 2015). The definition of learning also shows that learning can be related to various cognitive processes. For instance, Bloom’s taxonomy of educational objectives includes six categories of cognitive processes (e.g., remembering, analyzing, and evaluating) (Anderson & Krathwohl, 2001). All these categories can be associated to learning mechanics and game mechanics, for instance, analyzing (cognitive process) can be related to observing (learning mechanic) and feedback (game mechanic) (Arnab et al., 2015). Moreover, learning with video games can support to achieve several educational objectives, such as knowledge acquisition, behavior change, and 21st century skills (critical thinking, creativity, communication, and collaboration) (Boyle et al., 2016; Clark et al., 2016; Qian & Clark, 2016). Learning with video games can also prepare students for self-directed learning (Toh & Kirschner, 2020), which is especially relevant to

control one's learning objectives and to meet one's personal goals and demands in adulthood (Morris, 2019). Hence, there are strong links between video games and learning so that learning with video games can also be understood comprehensively.

Video games have become a cultural good and an established medium that is used by around 3 billion people of all ages worldwide (Newzoo, 2021). More specifically, video games are frequently used by school-aged children in their leisure time (e.g., Media Educational Research Association Southwest, 2020, 2021; Pew Research Center, 2018; Rideout & Robb, 2019) and have also been used in school teaching (e.g., Hainey et al., 2016; Squire, 2008). Still, the integration of video games is not a common practice in schools as indicated, for instance, by a 35% adoption rate for game-based learning reported by school administrators (Project Tomorrow, 2019). This low adoption rate might be partly due to a lack of technological infrastructure, but with increasing access to digital technologies, several forms of e-learning can be integrated into school teaching (e.g., European Commission, 2019; NewSchools Venture Fund, 2019). However, the question of how to integrate gaming into formal education remains a key challenge (cf. Mayer, 2019a). Some effects of video games might not simply transfer to formal learning contexts, such as the appeal and motivational effects of video games (Persico et al., 2019). Consequently, it is important to understand possible benefits and pitfalls of learning and teaching with video games in and related to formal learning contexts (institutionalized, intentional, and planned education; cf. UNESCO Institute of Statistics, 2012). Taken together, it is of particular interest to gather a more solid understanding of effects that video games could unfold in school teaching.

Against this background, a substantial part of this dissertation is related to learning with video games in school teaching. Several benefits and barriers of learning with video games have been discussed (e.g., Becker, 2017, Chapter 2). Relatedly, meta-analytic findings indicate that students who learned with video games performed better compared to traditional instruction that did not include video games (Hedges' $g = 0.33$; Clark et al., 2016), and that using simulations and gaming was found to be the most effective way of teaching as facilitator (Cohen's $d = 0.32$; Hattie, 2009). Still, the effect sizes are rather small and do hardly allow (general) practical implications as well as specific recommendations so that further evidence on teaching with video games from formal learning contexts is needed.

1.2. Teaching with video games

Teaching with video games and learning with video games can be related to diverse (complementary) pedagogical approaches and learning theories (Becker, 2017). Focusing on teaching with video games, pedagogical approaches can relate to different didactical aims: for instance, one can teach *with* games, *about* games, and *through* game design, whereas games are considered as a teaching method, cultural phenomenon, and design object, respectively (Hanghøj, 2013). Teachers who aim to successfully integrate video games into school teaching need to complete several pedagogical activities from planning to reflection (Kangas et al., 2017). Also, teachers can play different roles when they teach with video games (Becker, 2017, Chapter 8; Hanghøi, 2013). For instance, teachers can act as *instructors* in terms of a strong adherence to the curriculum and to the educational purpose of video games. Moreover, teachers who know the video game can act as *playmakers* by giving students advice on how to play the game and by telling students what to look for in the game. For the context of school teaching, meta-analytic studies found that several teacher characteristics play a key role for student learning (Hattie, 2009; Hattie, 2012, Chapter 3), and that teacher support is key for learning with video games (Clark et al., 2016). Overall, teaching with video games includes several pedagogical activities whereby teachers can support student learning.

Not surprisingly, several projects aimed to outline possible benefits and pitfalls of teaching with video games (Klopfer et al., 2009), also by means of case studies (Fishman et al., 2015). How often teachers teach with video games, however, can only be approximated. For instance, teacher survey data indicate an increase in the adoption of game-based learning in school teaching from 30% in 2012 ($n = 53,947$) to 48% in 2015 ($n = 35,909$) (Project Tomorrow, 2015). Still, only 35% of the surveyed school administrators ($n = 2,190$) reported that game-based learning is used in their school, which is far from being an established way of learning (Project Tomorrow, 2019). Also, surveys on teaching with games indicate that most teachers used simple forms of video games, such as drill-and-practice, trivia, and puzzle games (Takeuchi & Vaala, 2014). Moreover, recent data suggest that most teachers experienced critical technological and infrastructural issues when teaching with video games (Jesmin & Ley, 2020). Taken together, some teachers have already used video games in school teaching, but teaching with video games has not yet reached its full potential.

Due to the high practical effort, data from field studies are particularly sparse. Indeed, the enormous effort and high costs were identified as some of the highest barriers of teaching with games (Jean Justice & Ritzhaupt, 2015). Hence, one focal aim of this dissertation is to scrutinize potentials of school teaching with commercial video games. But why could commercial video games be appropriate media for school teaching? In a nutshell, because most benefits of learning with video games also apply to learning with commercial video games (Becker, 2017, Chapter 4). However, “because commercial games were not designed to teach content, none will be sufficient on its own as a teaching tool” (van Eck, 2009, p. 13). So, do commercial video games *work* in school teaching? This question could be answered more generally as follows: “It is vital to understand that games do not ‘work’ or ‘not work’ in classrooms in and of themselves. They possess no causal agency” (Chee, 2016, p. 4). Still, various effects of teaching with commercial video games were examined (e.g., Arnab et al., 2015; Becker, 2017, Chapter 4; Boyle et al., 2016; Plass et al., 2015). Relatedly, examples of *potential* benefits and challenges of teaching with (commercial) video games can be found in Table 1. But then, how to assess whether the effort associated with (challenges of) integrating video games into school teaching translates into benefits? Indeed, “the efficacy of games for learning depends largely upon teachers’ capacity to leverage games effectively as learning tools and on students’ willingness to engage in game play and other pedagogical activities – such as dialogic interactions for meaning making – so that game use in the curriculum can be rendered effective for learning. Put differently, teachers and students need to work to make pedagogically informed game-based learning curricula work” (Chee, 2016, p. 4). Moreover, “applying principles from situated cognition suggests that research should focus on the complex interaction of player–game–context” (Young et al., 2012, p. 84). Taken together, the use of commercial video games *can* benefit student learning, yet more empirical insights from school teaching are needed to better understand *how* to teach with games.

So, how could teachers use commercial video games in their school teaching? With respect to (the quality of) teaching with video games, relevant processes can be found in models of instructional design (ID) (Becker, 2017, Chapter 8). For instance, the comprehensive and applied Game-based learning ID process model outlines instructional processes in terms of the following seven components: (1) determine needs and learner characteristics, (2) determine instructional objectives, (3) determine acceptable evidence, (4) design and conduct predictive evaluation of games, choose games, and plan and develop tech support, (5) plan time, space, and

resources, (6) select instructional strategies, and (7) plan and develop instruction, learning experiences, reflection, and game sessions (Becker, 2017, Chapter 8). Similar processes and related supportive information can be found in guidelines on teaching with technology (e.g., Bates, 2019, Chapter 12) and on teaching with commercial video games (e.g., van Eck, 2009). Further, pedagogical resources include various examples of teaching with commercial video games (e.g., Becker, 2017; Klopfer et al., 2009; Schrier, 2014; Shapiro et al., 2014) (in German, e.g., Federal Agency for Civic Education, 2019; Foundation of the German games industry, 2019; Media Authority of North Rhine-Westphalia, 2010). Overall, several resources could help teachers to integrate commercial video games into their school teaching.

Against this background, it seems feasible to integrate video games into regular school teaching. Still, considering *potential* effects of teaching with video games (see Table 1), how to evaluate the actual effects? Several aspects regarding the evaluation of game-based learning (All et al., 2016, 2021) can also serve for evaluation of game-based learning in school teaching (Becker, 2017, Chapter 6; R uth, 2017; van Eck, 2009). In one of my works (R uth, 2017), I focused on the two most common types of evaluation that aim at improving processes (formative evaluation) and at understanding overall effects (summative evaluation) (cf. Becker, 2017; Stufflebeam & Coryn, 2014, Chapter 1). I emphasized three levels that can be considered when planning evaluations: (1) the *educational context* in which learning takes place (consistent with situated cognition), (2) the *type of game-based learning* being used, and (3) *learning processes* associated to game-based learning (R uth, 2017). For instance, school teaching with video games is a way of formal learning that is intentional, takes place in classrooms, is related to curricular guidelines, and is being assessed (*educational context*). Second, commercial video games primarily intended for entertainment can be used in school teaching (*type of game-based learning*). Third, learning and teaching can be related to an initial situation (baseline), whereupon implicit and explicit goals and rules provide students with game experiences and lead to game outcomes that can be assessed (*learning processes*). With respect to formal education, I also consider what education authorities expect students to learn (*intended curriculum*), how this can be translated into educational practice using video games (*implemented curriculum*), and what students acquire from teaching with video games (*attained curriculum*) (UNESCO International Bureau of Education, 2021). Taken together, this dissertation investigates benefits of learning and teaching with games, specifically with commercial video games in school teaching.

Table 1*Examples of potential benefits and challenges of teaching with video games*

Potential benefits	Potential challenges
Personal dimensions	
Games can foster affective, behavioral, cognitive, social, physiological, and media competences	Students/Teachers might lack competences for using games
Games can allow different roles when teaching about games, with games, and through game design	Students/Teachers might not prefer learning/teaching with games
Game dimensions	
Games can offer guidance, immediate feedback, and continuous assessment (learning mechanics)	Games might not fit the curriculum
Games can provide stories, cooperation, collaboration, and simulation/realism (game mechanics)	Effects of specific games might be unclear Gaming might have undesired effects
Context dimensions	
Games can be played locally and remotely	Curricular guidelines might constrain teaching with games
Games can be used at different speed as well as interrupted/saved	Teachers might lack technological, time, and financial resources
Games can allow to play dangerous and impractical scenarios	
Games can be affordable given education licenses	

Note. The information contained in this table is based on considerations of previous works (e.g., Arnab et al., 2015; Becker, 2017; Boyle et al., 2016; Plass et al., 2015).

2. Synopsis and synergies of the articles

This dissertation includes two conceptual and four empirical articles. At the beginning of this dissertational project, I conducted an extensive literature review of theoretical and practical work in the field of e-learning and recognized the increasing complexity of the field. To support systematic progress in the field and the development of e-learning theories, I then developed a reference framework, the E-Learning Setting Circle. This conceptual model highlights eleven common yet critical issues of e-learning projects (Article 1). Then, I focused on game-based learning and how possible related effects could be evaluated in school teaching (Rüth, 2017). Following these conceptual works, three field studies were conducted to evaluate different ways in which video games can be integrated into school teaching (Articles 2 and 3). Both articles were realized as part of a research project at the Grimme Research College (for which I was co-applicant). Complementary to this work with in-service teachers, I surveyed pre-service teachers as the future generation of teachers on teaching with digital games. The survey data provide insights into the relation between pre-service teachers' intentions to teach with digital games and their personal characteristics (Article 4). In view of the special pandemic situation in 2020, I also delineated how video gaming at home could promote physical and mental health and education, specifically to alleviate detrimental effects of the pandemic (Article 5). Finally, I also contributed to the development of a mobile quiz app that provides core game functionalities and enables students to engage in self-regulated and mobile learning. In this context, one lab experiment and one online experiment were conducted to evaluate the effectiveness of the app with a focus on feedback effects (Article 6).

2.1. Article 1: The E-Learning Setting Circle: First steps toward e-learning theory development in e-learning research

The first article is based on an extensive review of theoretical and practical work and focused on the importance of theory development in the field of e-learning. The field of e-learning is continuously growing (e.g., Choudhury & Pattnaik, 2020; Tibaná-Herrera et al., 2018; Valverde-Berrocoso et al., 2020). Much evidence has been accumulated that can support decision-making on how digital interventions could support learning effectively (e.g., Clark & Mayer, 2016; Mayer, 2019b), but the field also becomes harder to overlook (Lai & Bower, 2019). It is known that theory and practice can benefit from reciprocal relations (Brieger et al., 2020; Ertmer & Newby, 2016). Also, theoretical considerations can be specifically important for decision-making (Mayes, 2019). In this regard, several theories have been related and adapted to e-learning contexts (Mayer, 2019b), and generalized theories have been discussed, for instance, for game-based learning (Plass et al., 2015; Ralph & Monu, 2015). Despite such efforts, theoretical relations were often not found in studies on e-learning (Hew et al., 2019) and game-based learning (Wu et al., 2012). Previous work also examined the self-reported methodological expertise of researchers and found a preference for basic descriptive research, indicating the need for methodological progress (Bulfin et al., 2014). Also, several problems were highlighted that can occur throughout the research process from the problem definition to the results report (Sarsa & Escudero, 2016). Against this background, the aim of the first article of this dissertation is to foster theory development and the comparability and generalizability of empirical findings in the field of e-learning. Therefore, I synthesized theoretical and practical considerations into a general and extensible model – the *E-Learning Setting Circle* (Rüth & Kaspar, 2017). The E-Learning Setting Circle comprises eleven elements that stand for issues of critical relevance to e-learning (research) projects and theory development. In the following, I shortly illustrate core elements of the model that emphasize the importance of goals (the *guiding element*) and decision-making (the *universal element*).

The *guiding element* of the E-Learning Setting Circle represents the importance of setting project objectives and the assessment of the goal attainment level for all e-learning projects. For instance, a review on online learning differentiated between three instructional design goals (goal specification), presented methods to reach each of these goals (goal attainment), and how to measure the effectiveness of these methods (assessment of goal attainment) (Mayer, 2019b).

Further, the review emphasized “the value of conducting research that has both a practical goal (e.g., to improve online instruction) and a theoretical goal (e.g., to understand how learning works)” (Mayer, 2019b, p. 157). The *universal element* of the E-Learning Setting Circle represents that decision-making processes and decision routes are key processes across e-learning projects. For instance, the design of empirical studies includes so-called researcher degrees of freedom. While degrees of freedom do not have to be a problem, it was found that when fifteen research teams were asked to test the same five hypotheses, the study results differed due to subjective choices of the researchers with respect to the study design and operationalization of constructs (Landy et al., 2020). As discussed by the authors of that study, a stronger focus on theoretical boundaries could help to reduce such subjective biases and to avoid that underspecified hypotheses are being tested. In other words, (underspecified) hypotheses can be considered as (poor) guiding elements for empirical studies. Further, the abundance of digital tools and features in the field of e-learning requires decision-makers to consider and weigh several criteria when they look for the most effective solution. In order to identify the most important factors for the success of e-learning, one can apply several methods such as multi-criteria decision-making (Naveed et al., 2020; Zare et al., 2016). For instance, five out of twenty-five factors were identified as highly influential for the success of e-learning, three of which are more administrative in nature (financial, technological, and infrastructural readiness) and two of which are more related to personal characteristics of learners (attitude toward e-learning, commitment to study online) (Naveed et al., 2020). Taken together, these examples illustrate the need of more solid goals and more systematic decision-making to foster comparability and generalization of e-learning (research) projects.

The model (Rüth & Kaspar, 2019a) and an associated digital tool that I developed (Rüth & Kaspar, 2021a) were also presented at peer-reviewed conferences. Similar issues as outlined in the E-Learning Setting Circle have been reported since the publication of this article, such as the absence of theoretical references (Hew et al., 2019) and terminological considerations (Bower, 2019; Passey, 2019), which underlines the relevance of the model. Notably, the model does not take the role of an overarching theoretical framework, but it can facilitate the general workflow and improve the overall quality of e-learning (research) projects. Hence, in the context of this dissertation, the E-Learning Setting Circle has been served as a valuable resource for planning, realizing, and evaluating the work that is presented in the following.

2.2. Article 2: Exergames in formal school teaching: A pre-post longitudinal field study on the effects of a dance game on motor learning, physical enjoyment, and learning motivation

This article reports the results of one of the field studies that I conducted as part of the research project at the Grimme Research College. To gain new insights into potential benefits and challenges of video games in school teaching, the goal of that project was to evaluate the effectiveness and efficacy of commercial video games in school teaching. First, I considered available guidelines on integrating commercial video games into school teaching (e.g., Becker, 2017; van Eck, 2009). Throughout the project, I closely collaborated with a sports teacher who was interested in using exergames in school teaching. Exergames are “entertaining video games that require players to carry out light to moderate intensity physical activity” (Rüth & Kaspar, 2020, p. 1). Previous research has already discussed that exergames can function as sport promoters (Ramírez-Granizo et al., 2020). This seems to be particularly important because school-aged students worldwide have not met the recommended physical activity guidelines for years (Guthold et al., 2020) (for Germany, e.g., Woll et al., 2021). Moreover, exergaming was found to be related to a variety of psychological effects that can be assessed using available survey instruments (Lee et al., 2017). While the idea to integrate exergames into school teaching is not new (e.g., Ennis, 2013; Meckbach et al., 2013), there has been a lack of longitudinal data from regular school teaching. Therefore, Article 2 presents a longitudinal field study that outlines how dance exergames could serve as a learning tool in regular sports lessons for sixth grade students (Rüth & Kaspar, 2020). Results related to this article were also presented at peer-reviewed conferences (Rüth & Kaspar, 2019b, 2019c).

With respect to didactical facets of teaching with video games, this field study was aligned to the *intended curriculum* at the respective school. The *implemented curriculum* were four lessons that followed the same procedure: students danced in groups and completed a practice phase in which they danced in groups without the pressure to perform; students then completed a competition phase in which the game scores of the groups were compared. While the game was used as a learning tool, the teacher took the role of an instructor, observer, and evaluator (cf. Becker, 2017, Chapter 8). Regarding the *attained curriculum*, the results of the study provided several quantitative and qualitative insights into educational, social, and motivational facets of students’ exergaming experiences. With respect to educational facets, students’ dance skills increased both in terms of objective and subjective measures (game scores

and self-ratings). Interestingly, students' game scores increased significantly from lesson one to lesson two, while the self-rated dance skill increased significantly from lesson one to lesson four. With respect to social facets, students provided feedback to each other and played against each other in groups (cooperative competition), and they experienced a high attraction to their group. With respect to motivational facets, the results of this study indicate that students enjoyed the way in which playing commercial video games in school teaching was realized and that they found it motivating to learn how to dance. Overall, this article shows how exergaming could foster students' dance skills in the formal learning context of regular school teaching. In this regard, other findings suggest that teachers favor using exergames in school teaching (Lin & Zhang, 2011). Taken together, it seems promising that the results of Article 2 could be complemented by evidence from future field studies and that exergames could find their way into school teaching.

2.3. Article 3: Commercial video games in school teaching: Two mixed methods case studies on students' reflection processes

This article includes the results of two field studies conducted as part of the research project at the Grimme Research College. These field studies demonstrate how video games could serve as objects of reflection in biology and history teaching (Rüth & Kaspar, 2021b). Previous works discussed how video games could be used in biology teaching (Herrero et al., 2014; Leith et al., 2016) and in history teaching (Chapman, 2016; Schrier, 2014). Nevertheless, some commercial video games were found to represent information in inaccurate and technically incorrect ways (for details, see Rüth & Kaspar, 2021b). In addition, previous work found that the level of reflection regarding everyday video game experiences does not seem to be particularly high (Mekler et al., 2018). Therefore, integrating commercial video games into school teaching could foster students' reflection processes since teachers could provide instructional guidance and reflective support. More specifically, teachers could encourage dialogues to enable students to relate their game experiences to curricular topics and to allow students to take different perspectives on these topics (Arnseth et al., 2018). Hence, the field studies included in Article 3 illustrate the potential of commercial video games as objects of reflection in a biology course in tenth grade and in an advanced course on history in twelfth grade. Results related to this article were also presented at peer-reviewed conferences (Rüth & Kaspar, 2018, 2021c).

With respect to didactical facets of teaching with video games, these field studies were realized in close collaboration with the teachers and considered the *intended curriculum* at the respective school. The *implemented curriculum* was a regular double lesson. The first lesson served as development phase in which students were engaged in guided discovery learning with the game. The second lesson served as consolidation phase in which students reflected on their game experiences based on statements and questions of the teacher. The discussion allowed students to reflect on the goals of the game, the content of the game, and the appropriateness of video games for school teaching. While the games were used as objects of reflection, the teachers took the role of an instructor, guide, and subject matter expert (cf. Becker, 2017, Chapter 8). Regarding the *attained curriculum*, the field studies provide qualitative and complementary quantitative insights into educational and motivational aspects of students' game experiences. Interestingly, the most pronounced aspect in the discussions was that students offered constructive criticism of how the games conveyed the topics. These findings indicate that

teaching with video games as objects of reflection can also address cross-sectional media literacy skills. With respect to students' learning motivation, they overall provided moderate to high ratings with respect to their game experience, the game itself, and the subsequent discussion about their game experiences. Overall, these field studies provide examples of how commercial video games could be used as objects of reflection in regular school teaching. More generally, regarding several ways in which technology (e.g., Guggemos & Seufert, 2021) and video games can be integrated into school teaching (e.g., Squire, 2008), the field studies in Article 3 specifically illustrate how teaching with commercial video games as objects of reflection in regular school teaching could foster students' reflection processes.

2.4. Article 4: Teaching with digital games: How intentions to adopt digital game-based learning are related to personal characteristics of pre-service teachers

The presented field studies (Articles 2 and 3) were based on collaborations with in-service teachers. That said, even when more studies provide evidence on beneficial effects of teaching with digital games, teachers decide whether they teach with games or not (Ertmer et al., 2012; Farjon et al., 2019). Therefore, Article 4 focuses on understanding the relation between intentions of the future generation of teachers and their personal characteristics by means of a survey study (Rüth et al., 2022). Most assessed personal characteristics were adapted with reference to the technology acceptance model, which was found to explain substantial variance in the behavioral intention of in-service teachers (Bourgonjon et al., 2013). Additional personal characteristics were selected with reference to the conceptual framework of technological, pedagogical, and content knowledge regarding teaching with games (TPACK-G) (Hsu et al., 2020) and with reference to previous empirical findings. Referring to previous works, pre-service teachers were asked about their intention to teach with digital games as learning tools (e.g., Lämsä et al., 2018; Rüth & Kaspar, 2020) and as objects of reflection (e.g., Mekler et al., 2018; Rüth & Kaspar, 2021b). Because pre-service teachers lack teaching experience, it is important to provide them with such exemplary teaching contexts to increase the validity of the data. The study results show that pre-service teachers reported a moderate to high intention to teach with digital games in both educational contexts. Moreover, depending on the educational context, four (learning tools) or three (objects of reflection) personal characteristics were identified as significant factors in pre-service teachers' intention to teach with digital games. For both educational contexts, pre-service teachers' perceived usefulness of games and games' curriculum relatedness were significant factors in their intention to teach with digital games. These results complement similar findings on in-service teachers (Bourgonjon et al., 2013). Previous work also indicated that pre-service teachers intend to teach with digital games but miss relevant skills and knowledge (Hsu & Chiou, 2019). Still, intention does not always turn into behavior (e.g., Scherer et al., 2020) so that future research is needed to show whether intentions of pre-service teachers are also reflected in their future teaching practice. With respect to the generalizability of these findings, the study results are based on a large sample and refer to a broad understanding of digital games. Taken together, Article 4 provides novel insights that could, for instance, support teacher education programs in addressing the most important personal characteristics of teachers.

2.5. Article 5: Educational and Social Exergaming: A perspective on physical, social, and educational benefits and pitfalls of exergaming at home during the COVID-19 pandemic and afterwards

Compared to Articles 2, 3, and 4, the scope of this article (Rüth & Kaspar, 2021d) is beyond the context of school teaching. Referring to Article 2, I emphasize that several children have not been able to meet physical activity guidelines for years. During Covid-19 pandemic restrictions, 55% of the children in Germany reported that they lack physical activity (Media Educational Research Association Southwest, 2020), and people of all ages worldwide exhibited more unhealthy behaviors, such as reduced physical activity and increased media consumption (e.g., Ammar et al., 2020; Global Web Index, 2020). Other research discussed potentials of several physical and mental health interventions to alleviate adverse health outcomes (e.g., Hall et al., 2021; Ricci et al., 2020; Santos et al., 2021). Therefore, this article specifically illustrates how exergaming at home could support people in staying physically active and socially connected (Rüth & Kaspar, 2021d). To this end, I synthesized findings from an extensive literature review into the concept of Educational and Social Exergaming (EASE). In a nutshell, EASE expands the classic exergaming approach, which focuses on promoting physical health, by including social and educational aspects. With respect to the social aspects, this article focuses on how social exergaming (exergaming together with other people) can increase perceived social relatedness. With respect to educational aspects, it focuses on how social exergaming can enable discussions on different aspects related to exergaming experiences, such as media-driven, education-driven, and health-related aspects. I also highlight important directions for future research, particularly with respect to research approaches, measurement of dependent variables, and effects of exergaming elements (Rüth & Kaspar, 2021d, Supplementary Material). For instance, community-based, family-based, and school-based programs are structured approaches that could successfully promote exergaming on a larger scale (Baranowski et al., 2014). However, more valid and reliable data are needed to evaluate the effectiveness of such programs. Overall, this article provides a novel perspective on exergaming by outlining key physical, social, and educational effects that exergaming can have on people of all ages. Hence, it is hoped that Article 5 stimulates theoretical discussions as well as more empirical findings on the multifaceted effects of exergaming.

2.6. Article 6: The effects of different feedback types on learning with mobile quiz apps

Complementary to the presented field studies (Articles 2 and 3) and as part of a project for the development of a mobile quiz app, I conducted lab and online experiments to investigate the app's effectiveness as a tool for self-study (Rüth et al., 2020; Rüth et al., 2021). Previous work emphasized the relevance of student-centered learning approaches, such as self-directed learning with games (Toh & Kirschner, 2020) and the learning effectiveness of quiz-like tools (for details, see Rüth et al., 2021). Meta-analytic findings suggest that students who received various forms of additional feedback outperformed students who received corrective feedback (van der Kleij et al., 2015; Wisniewski et al., 2020), which commonly is the standard feedback type found in most quiz apps. However, these works also underlined the heterogeneity of additional feedback types so that it remained unclear to what extent students might benefit from concrete implementations of additional feedback in quiz apps. Therefore, this article evaluated whether students learn better with the standard feedback type implemented in quiz apps or with a feedback that also provides additional information related to the correct answer. The additional feedback type was selected based on previous work on formative feedback (e.g., Shute, 2008) and based on theoretical considerations about learning and memory processes when using quiz apps (for details, see Rüth et al., 2021). To ensure that the appearance and functionality of the quiz app were under full control for this research, I programmed the required quiz feature by myself. This approach allowed to disentangle the effect of feedback from other features of available quiz apps, such as graphics and audio (Wang & Tahir, 2020).

The related research process was twofold: First, a lab experiment was conducted in a non-formal learning context in which students participated in a formal university course and used the quiz app to prepare for a final course exam (Rüth et al., 2020). The results indicate a positive short-term effect on cognitive (quiz score) and metacognitive outcomes (response certainty) in the case of both feedback types. Then, it was checked whether these findings hold in informal (non-institutionalized) learning settings and given a larger sample size by conducting another lab experiment complemented by an online experiment (Rüth et al., 2021). By means of the online experiment, this article also provides insights into how students learn in more self-regulated mobile learning settings, which are a common context of use for quiz apps. Regarding the effectiveness of quiz apps as a tool for self-study, the results from both experiments in this article show that students retained substantial learning effects also after a week, when students

completed an unannounced follow-up quiz. Hence, these findings underline that mobile learning with quiz apps can be an effective way of self-study. Regarding feedback effects, students did not benefit more from feedback with additional information than from the standard feedback. Feedback effects were also not moderated by students' response certainty during learning, their prior knowledge, and the task difficulty. These results can inform future studies on feedback effects, a focal topic in education considering the plethora of studies that have already been published (e.g., Hattie & Timperley, 2007; Wisniewski et al., 2020). The results of this article also indicate that students perceived a moderate game experience even though the quiz app only had minimal game features. Investigating app versions with minimal game features seems to be important since, for instance, students who used a minimal version of a commercial digital game were found to achieve better learning outcomes than students who used the original commercial digital game (Chase et al., 2021). Moreover, meta-analytic results indicate that the integration of features which convey irrelevant information to students could hamper their learning performance (Sundararajan & Adesope, 2020). Hence, a good balance between game features and learning features could provide high appeal and solid learning effects. Overall, Article 6 expands previous research by showing that a self-regulated use of mobile quiz apps can increase cognitive and metacognitive outcomes of students and can provide them with enjoyable learning experiences.

3. List of publications

The presented E-Learning Setting Circle that comprises eleven issues of critical relevance to e-learning (research) projects and theory development, the field studies on the use of commercial video games in school teaching as a learning tool and as an object of reflection, the survey on pre-service teachers' intentions to use digital games in their future school teaching, the perspective on effects of educational and social exergaming, and the experimental studies on the learning effectiveness of quiz apps have been published as peer-reviewed journal articles:

1. R uth, M., & Kaspar, K. (2017). The E-Learning Setting Circle: First steps toward e-learning theory development in e-learning research. *Electronic Journal of E-Learning*, 15(1), 94–103. <https://www.academic-publishing.org/index.php/ejel/article/view/1822>
2. R uth, M., & Kaspar, K. (2020). Exergames in formal school teaching: A pre-post longitudinal field study on the effects of a dance game on motor learning, physical enjoyment, and learning motivation. *Entertainment Computing*, 35, 100372. <https://doi.org/10.1016/j.entcom.2020.100372>
3. R uth, M., & Kaspar, K. (2021). Commercial video games in school teaching: Two mixed methods case studies on students' reflection processes. *Frontiers in Psychology*, 11, 594013. <https://doi.org/10.3389/fpsyg.2020.594013>
4. R uth, M., Birke, A., & Kaspar, K. (2022). Teaching with digital games: How intentions to adopt digital game-based learning are related to personal characteristics of pre-service teachers. *British Journal of Educational Technology*. <https://doi.org/10.1111/bjet.13201>
5. R uth, M., & Kaspar, K. (2021). Educational and Social Exergaming: A perspective on physical, social, and educational benefits and pitfalls of exergaming at home during the COVID-19 pandemic and afterwards. *Frontiers in Psychology*, 12, 644036. <https://doi.org/10.3389/fpsyg.2021.644036>
6. R uth, M., Breuer, J., Zimmermann, D., & Kaspar, K. (2021). The effects of different feedback types on learning with mobile quiz apps. *Frontiers in Psychology*, 12, 665144. <https://doi.org/10.3389/fpsyg.2021.665144>

3.1. Article 1: The E-Learning Setting Circle: First steps toward e-learning theory development in e-learning research

Abstract

E-learning projects and related research generate an increasing amount of evidence within and across various disciplines and contexts. The field is very heterogeneous as e-learning approaches are often characterized by rather unique combinations of situational factors that guide the design and realization of e-learning in a bottom-up fashion. Comprehensive theories of e-learning that allow deductive reasoning and hence a more top-down strategy are missing so far, but they are highly desirable. In view of the current situation, inductive reasoning is the prevalent way of scientific progress in e-learning research and the first step toward theory development: individual projects provide the insights necessary to gradually build up comprehensive theories and models. In this context, comparability and generalizability of project results are the keys to success. Here we propose a new model – the *E-Learning Setting Circle* – that will promote comparability and generalizability of project results by structuring, standardizing, and guiding e-learning approaches at the level of a general research methodology. The model comprises three clusters – context setting, structure setting, and content setting – each of which comprises three individual issues that are not necessarily sequential but frequently encountered in e-learning projects. Two further elements are incorporated: on the one hand, we delineate the central role of objective setting and the assessment of the goal attainment level (guiding element); on the other hand, we highlight the importance of multi-criteria decision-making (universal element). Overall, the proposed circular model is a strategic framework intended to foster theory development in the area of e-learning projects and research.

Available at: <https://academic-publishing.org/index.php/ejel/article/view/1822>

3.2. Article 2: Exergames in formal school teaching: A pre-post longitudinal field study on the effects of a dance game on motor learning, physical enjoyment, and learning motivation

Abstract

Commercial exergames are popular entertainment games and beneficial for health and motivation. However, more evidence on their effectiveness in learning contexts is needed. The present pre-post longitudinal field study focused on whether and how a commercial dance exergame promotes student learning and on several experience factors when being integrated in formal school teaching across four regular sports lessons. In line with curricular guidelines, twenty students in sixth grade participated, practicing a dance choreography and competing against each other in groups. Motor learning was assessed in terms of changes in game scores and students' self-rated dance skills, as well as their experienced dance and game enjoyment, learning motivation, group cohesion, and acceptance of video games. The results show that students' objective and subjective measures of dance skills increased differently across the lessons, while their dance and game enjoyment did not change and was high across all lessons. Exploratory results indicate overall high learning motivation, group cohesion, and acceptance of video games for school teaching. Practical implications for school teaching are outlined, as well as prospects for further research on the educational effectiveness of exergames.

Available at: <https://doi.org/10.1016/j.entcom.2020.100372>

3.3. Article 3: Commercial video games in school teaching: Two mixed methods case studies on students' reflection processes

Abstract

Commercial video games are popular entertainment media and part of students' media reality. While commercial video games' main purpose is not learning, they nonetheless could and should serve as objects of reflection in formal educational settings. Teachers could guide student learning and reflection as well as motivate students with commercial video games, but more evidence from formal educational settings is required. We conducted two mixed methods case studies to investigate students' reflection processes using commercial video games in regular formal high school teaching. In a double lesson, 29 students of a 10th-grade biology course (Study 1) and 17 students of a 12th-grade advanced course on history (Study 2) played and discussed a commercial video game related to the current curricular topic. We examined the reflection processes of students in terms of their reactions to the teachers' game-related statements and questions. Regarding teachers' statements, students discussed several topics related to game enjoyment and the games' representation of topic-related content. Regarding teachers' questions, students discussed multiple goals in each game, how the games represented topic-related content, and how the games could be appropriate for learning. In Study 2, students additionally discussed emotions, stereotypes, violence, and the narrative related to the digital history game. We found that the discussions provided students opportunities to reflect on their game experiences and the current curricular topic as well as to practice media criticism. We further provide quantitative results on students' perceived topic knowledge, on several facets of their learning motivation, and on their acceptance of video games. Overall, our findings illustrate the educational value of using commercial video games as objects of reflection.

Available at: <https://doi.org/10.3389/fpsyg.2020.594013>

3.4. Article 4: Teaching with digital games: How intentions to adopt digital game-based learning are related to personal characteristics of pre-service teachers

Abstract

Despite many known educational benefits of digital game-based learning, teaching with digital games is not yet a common practice in formal education. The role that digital game-based learning might play in future school teaching can be explored by examining the behavioral intentions of pre-service teachers as the ultimate gatekeepers. In this survey study, 402 pre-service teachers from German-speaking universities had participated. Multiple regression analyses were applied to examine the role of pre-service teachers' personal characteristics in their intention to integrate digital games into two educational contexts. For both educational contexts, we identified perceived usefulness and curriculum relatedness of digital games as key factors in pre-service teachers' intention to teach with digital games. We also found differences in explained variance and relevant personal characteristics between educational contexts. Overall, we discuss how teaching with digital games could become a common practice if particular characteristics of pre-service teachers are already addressed in teacher education.

Available at: <https://doi.org/10.1111/bjet.13201>

3.5. Article 5: Educational and Social Exergaming: A perspective on physical, social, and educational benefits and pitfalls of exergaming at home during the COVID-19 pandemic and afterwards

Abstract

Physical inactivity and coronavirus disease 2019 (COVID-19) signify two pandemics with negative physical, mental, and economic consequences. Younger and older people have not reached the recommended physical activity level for years. Societal restrictions due to COVID-19 additionally reduce opportunities for physical activity, and they increase social isolation. Here, we outline how playing exergames with others (social exergaming) at home could foster physical and mental health and promote communication and discussions on exergaming. Accordingly, we highlight the educational and social benefits of exergaming at home and delineate the concept of Educational and Social Exergaming (EASE). We outline specific benefits and pitfalls of exergaming regarding its physical and nonphysical effects, including educational values of discussing exergaming experiences and related topics. Moreover, we discuss the relevance of practical guidelines for educational and social exergaming at home as well as prospects for future research. Overall, educational and social exergaming could alleviate several detrimental effects of both pandemics on the health and well-being of people of all ages.

Available at: <https://doi.org/10.3389/fpsyg.2021.644036>

3.6. Article 6: The effects of different feedback types on learning with mobile quiz apps

Abstract

Testing is an effective learning method, and it is the basis of mobile quiz apps. Quiz apps have the potential to facilitate remote and self-regulated learning. In this context, automatized feedback plays a crucial role. In two experimental studies, we examined the effects of two feedback types of quiz apps on performance, namely, the standard corrective feedback of quiz apps and a feedback that incorporates additional information related to the correct response option. We realized a controlled lab setting ($n = 68$, Study 1) and an unsupervised mobile setting ($n = 150$, Study 2). In the learning phase, participants used the quiz app and received feedback. They also completed a subsequent test as well as a follow-up test 1 week later by using the same quiz app. Irrespective of feedback type and setting, cognitive outcomes (quiz scores) and metacognitive outcomes (response certainty) increased similarly in the short term and long term. Feedback effects were not moderated by participants' overall response certainty during learning, their prior knowledge, and the difficulty of quiz items. Moreover, we found that participants perceived the quiz app to be similarly attractive, interesting, and enjoyable in both feedback conditions and that they spent slightly more time to process quiz items in the lab setting. We discuss these results in detail, including the role of moderating and mediating factors and prospects for further research and practice. Overall, the results of this article underline that quiz apps are useful and effective tools that can support the acquisition and retention of semantic knowledge in different learning settings.

Available at: <https://doi.org/10.3389/fpsyg.2021.665144>

4. General discussion

The conceptual and empirical works included in this dissertation address key issues of e-learning and game-based learning. The conceptual works provide guidance for future research by highlighting potentials for theoretical progress and educational practice. The first conceptual work presents a general reference framework composed of critical issues in the continuously growing field of e-learning (Article 1). The second conceptual work emphasizes educational, social, and physical benefits of exergaming at home (Article 5). The empirical works focus on learning potentials of school teaching with video games (Articles 2, 3, and 4) and of self-study with a mobile quiz app (Article 6). For the formal learning context of school teaching, two of the empirical works demonstrate positive cognitive consequences of teaching with video games on students in terms of increased dance skills (Article 2) and promoted reflection processes (Article 3). Considering that teachers ultimately decide whether and how they teach with games, survey results complement these findings with novel insights into relations between pre-service teachers' personal characteristics and their intention to teach with digital games as learning tools and as objects of reflection (Article 4). For non-formal and informal learning contexts, results from experimental studies show that mobile quiz apps are effective tools for self-study and that the effort to formulate and provide additional feedback does not necessarily result in higher learning outcomes (Article 6). Since the individual works have already been discussed in the respective published articles, their broader significance is discussed hereafter.

First, referring to the E-Learning Setting Circle (Article 1), decision-making is the universal element for progress in research and teaching (Lloyd, 2019; Phillips et al., 2021; Sarsa & Escudero, 2016). Therefore, several challenges that may hamper decision-making should be addressed. For instance, with respect to feedback effects (Article 6), there are several models about how feedback could affect learning (e.g., Thurlings et al., 2013), yet there seems to be no consensus on a most appropriate model (van der Kleij et al., 2015). More generally, several biases can severely hamper decision-making and progress in the field of educational psychology (Patall, 2021). For instance, in a meta-analysis on feedback effects it was observed that “feedback effects seem to be less likely to be published when they are low or even negative” (Wisniewski et al., 2020, p. 12). While meta-analyses can partly address publication bias using statistical analyses (e.g., Adesope et al., 2017; Wisniewski et al., 2020), decision-making may

remain suboptimal without knowledge about relevant positive, negative, and null findings. However, since such biases may persist at least to some extent, it is important to raise further awareness of them and their impact on decision-making.

Second, as also outlined in the E-Learning Setting Circle (Article 1), the formulation and assessment of solid theoretical and practical goals likely remains a cornerstone for progress in the field of e-learning and regarding game-based learning (Mayer, 2019b; Plass et al., 2015). Interactive media such as video games can allow for different and new ways of learning (de Freitas, 2018) so that also educational objectives may be subject to change. New ways of learning have also been highlighted in the concept of educational and social exergaming (Article 5). Nevertheless, further work is required to investigate the multifaceted potential benefits and challenges of learning and teaching with video games. For instance, (more) explicit references to theoretical frameworks could support the development of related yet diverse theoretical frameworks such as for exergames (e.g., Baranowski et al., 2014; Kooiman & Sheehan, 2015; Thompson, 2015). Indeed, previous works proposed to converge existing theories (Bower, 2019; Plass et al., 2015) and to discuss the appropriateness of frequent terms such as technology-enhanced learning (Passey, 2019). Also, a review on e-learning suggested a revised definition of e-learning (Rodrigues et al., 2019), which still serves as an umbrella term for related keywords (Choudhury & Pattnaik, 2020). In this regard, theoretical and empirical works should be based on a clear terminology to facilitate judgments about effectiveness, for instance, whether and to what extent synthesized results from reviews and meta-analyses apply to specific learning interventions and vice versa. Related efforts can be observed for video games, where standardized lists of labels and attributes have already been developed to enable a more systematic documentation of video games (e.g., Göbel et al., 2018). Such resources could support efforts to provide relevant and more (accurate) information about the video games used in research (cf. Nadolny et al., 2020). Overall, the E-Learning Setting Circle emphasizes critical issues that should (continue to) be addressed more vigorously, also to foster theory development.

Third, with respect to theory development, I would also like to emphasize that several theoretical considerations on learning are included in the presented works. In the case of teaching with exergames (Article 2), students learned by observing others and by receiving feedback from others, which can be related to social learning theories (Bandura, 2006). In the case of teaching with video games as objects of reflection (Article 3), the core learning activities were guided

discovery learning and collective reflection, which can be related to social learning and constructivism (social constructivism) (Becker, 2017, Chapter 2). Moreover, both studies provide insights into aspects related to students' learning motivation based on a conceptual framework (Keller, 2016). Thereby, it was considered that student learning and student motivation are thought to contribute to effective instruction (Slavin, 1994). Further, several theoretical frameworks were referenced regarding physical, social, and educational effects of exergaming (Article 5). For instance, based on self-determination theory, in Article 5 I emphasize the importance of social relatedness and social support in alleviating detrimental effects of social isolation and physical inactivity due to pandemic restrictions. The studies on learning with quiz apps (Article 6) can be related to associative information processing which was found to be abundant in human brain networks and to be an effective and biologically plausible way of information processing (Crawford et al., 2016; Dudai et al., 2015). Overall, these theoretical contributions are intended to support future research and theory development.

Fourth, some of the presented empirical works can be related to cognitive consequences research (Articles 2 and 3) and value-added research (Article 6) as common strands of game research (Mayer, 2019a). Moreover, the focus of the presented studies is on evaluating instructional methods, since “instructional media – even computer-based media – do not cause learning but rather instructional methods cause learning” (Mayer, 2019b, p. 153). How video games could be used in school teaching is demonstrated in terms of two educational contexts: as learning tools and as objects of reflection (Articles 2 and 3). While the field studies included in this dissertation were realized together with individual teachers, findings from a survey study including a large sample of pre-service teachers indicate that teachers intend to teach with digital games in both educational contexts (Article 4). In this regard, the integration of digital games into school teaching could offer several possibilities. For instance, letting exergames demonstrate dancing instead of the teacher (Article 2) can free up time for teachers which allows them to perform other pedagogical activities to support student learning (Hsia & Hwang, 2020). More ways to integrate digital games into school teaching are conceivable, such as the creation of own games (Kafai & Burke, 2015) as well as the integration of game-like elements into school teaching (Huang et al., 2020) and into online teaching (Nieto-Escamez & Roldán-Tapia, 2021). Also, the use of commercial exergames can be adapted to different contexts, for instance, by introducing game-like elements (Quintas et al., 2020) and pedagogical strategies (Hsia &

Hwang, 2020; Kramarova & Youmans, 2012). Still, game experiences may include desired and undesired (side) effects, such as novelty effects and frustrating experiences, also due to inappropriate use (e.g., Breuer, 2017; Greipl et al., 2020; Kaspar, 2017; R uth & Kaspar, 2021d). Hence, one should weigh potential benefits and pitfalls of teaching with digital games.

Fifth, besides the common limited generalizability of empirical findings, I would like to emphasize some methodological aspects of this dissertation. The presented field studies were conducted in authentic learning environments so that, overall, pedagogical, technological, content-related, context-related, and space-related aspects could be considered (cf. Eyal & Gil, 2020). These studies were not only related to a substantial amount of effort to collect highly ecologically valid data, but they also satisfied a current need of research on how digital games could be integrated into formal education (Mayer, 2019a). Hence, while several related findings refer to informal learning contexts (e.g., Lee et al., 2017; Mekler et al., 2018), the results of the field studies expand the rather sparse evidence from teaching with video games in regular school teaching. In addition to these findings from field studies, this dissertation also includes results from non-formal and informal learning with quiz apps. The corresponding studies were conducted under similar experimental conditions to increase the comparability and generalizability of results. Utilizing this methodological advantage, in overall three experiments (R uth et al., 2020, 2021) beneficial effects of quiz apps on cognitive and metacognitive outcomes were found that were similar in lab and online experiments (R uth et al., 2021). These efforts addressed the demand for replication studies to obtain more robust results (Patall, 2021), and can provide practical guidance for selecting effective feedback types. In line with previous recommendations (Noesgaard &  rngreen, 2015), quantitative and qualitative measures were applied in the presented works to examine and to explore learning experiences and game experiences of students. Overall, advantages of different methodological approaches were used to address current research needs and to gain new insights from different learning contexts.

Finally, the presented works can be related to more practical considerations. While the presented field studies reported beneficial effects of commercial video games in school teaching (Articles 2 and 3), this should not be taken as advice for schools to buy commercial video games on a large scale. Rather, the video games were carefully screened in advance for crucial features and pedagogical guidelines as well as previous research were considered. Indeed, teachers and students could benefit from more supportive educational resources, such as pedagogical

guidelines and critiques regarding games as well as research on effects of video games (de Freitas et al., 2013). The findings of the presented field studies could also support future efforts regarding teaching with video games. Still, more efforts are needed to facilitate the appropriate use of video games and digital media in school teaching. For instance, that the time delineated in the curricula is insufficient to integrate games into school teaching is only one of several concerns and barriers that in-service teachers reported related to teaching with games (e.g., Jean Justice & Ritzhaupt, 2015; Jong, 2016; Koh et al., 2012). Moreover, the versatile possibilities of teaching with (interactive) digital media could require diverse competences, ranging from technological pedagogical knowledge to ethical considerations (Falloon, 2020; Gerhard et al., 2020). In this regard, video games have been integrated into higher education (Barr, 2017; Vlachopoulos & Makri, 2017), and could also be used to foster media literacy skills of teachers early and throughout teacher education (Stieler-Hunt & Jones, 2019). Relatedly, that only a small set of key personal characteristics was found to be related to pre-service teachers' intention to teach with digital games could support further development of teacher education programs (Article 4). Nevertheless, the integration of game-based learning into formal education might also remain a long-term process as, for instance, learning with games has already been emphasized to be a trend in higher education in 2005 and in 2014, yet with the same time-to-adoption of two to three years (New Media Consortium, 2005, 2014). The design and development of video games that are appropriate for school teaching could also facilitate teaching with games. For instance, purpose-built exergames were found to better foster specific motor skills of students than a commercial exergame (McGann et al., 2020). Taken together, several efforts are needed to improve and promote game-based learning in educational practice.

To conclude, the field of e-learning is multifaceted and dynamic. A variety of digital learning tools exist, and more are being (further) developed. Therefore, theoretical frameworks and empirical findings are key to inform and guide decision-making in the respective contexts. Overall, the importance of theoretical progress and instructional methods for appropriate uses of digital media and specifically video games were emphasized. Also, the presented empirical works show promising results and are intended to contribute to progress in the field. Hence, considering the wide range of possibilities offered by e-learning and video games, the presented works support efforts toward theoretical progress and educational practice to provide teachers and students with effective and enjoyable learning experiences.

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Statement

The articles contained in this dissertation have already been published in peer-reviewed scientific journals. Several works were also presented at peer-reviewed conferences (as mentioned in the synopsis of the respective articles above). Detailed author contributions to each article are outlined below. If not indicated otherwise, author contributions are listed according to their appearance in the published manuscript versions.

Article 1

- Reference: R uth, M., & Kaspar, K. (2017). The E-Learning Setting Circle: First steps toward e-learning theory development in e-learning research. *Electronic Journal of E-Learning*, 15(1), 94–103. <https://www.academic-publishing.org/index.php/ejel/article/view/1822>
- Author contributions: MR and KK conceptualized the manuscript. MR drafted and revised the manuscript. KK revised the manuscript. All authors contributed to the article and approved the submitted version. (This author contribution statement is not part of the published article due to journal standards.)

Article 2

- Reference: R uth, M., & Kaspar, K. (2020). Exergames in formal school teaching: A pre-post longitudinal field study on the effects of a dance game on motor learning, physical enjoyment, and learning motivation. *Entertainment Computing*, 35, 100372. <https://doi.org/10.1016/j.entcom.2020.100372>
- Author contributions: MR and KK designed the study and interpreted the results. MR conducted the literature review, organized and supervised the data collection, performed the statistical analyses, and drafted and revised the manuscript. KK supervised the statistical analyses, revised the manuscript, and acquired the funding. Both authors contributed to the article and approved the submitted version. (This author contribution statement is not part of the published article due to journal standards.)

Article 3

- Reference: R uth, M., & Kaspar, K. (2021). Commercial video games in school teaching: Two mixed methods case studies on students' reflection processes. *Frontiers in Psychology, 11*, 594013. <https://doi.org/10.3389/fpsyg.2020.594013>
- Author contributions: MR and KK designed the study and interpreted the results. MR conducted the literature review, organized and supervised the data collection, performed the statistical analyses, and drafted and revised the manuscript. KK supervised the statistical analyses, revised the manuscript, and acquired the funding. Both authors contributed to the article and approved the submitted version.

Article 4

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- Author contributions: MR, AB, and KK designed the study and performed the statistical analyses. AB performed data collection. MR supervised the data collection, and drafted and revised the manuscript. AB and KK revised the manuscript. All authors contributed to the article and approved the submitted version. (This author contribution statement is not part of the published article due to journal standards.)

Article 5

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Article 6

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- Author Contributions: MR, JB, and KK designed the studies. MR and DZ collected the data. MR organized and supervised data collection and data curation, and programmed the software. MR and KK analyzed the data, drafted and revised the manuscript. JB and DZ revised the manuscript. JB and KK acquired funding for the studies. All authors contributed to the article and approved the submitted version.

Declaration of the independence of the scientific work performed

The following people contributed to the creation of parts of the materials: Adrian Birke (Article 4), and Johannes Breuer and Daniel Zimmermann (Article 6). The following people contributed to the data collection: Sandra Schwab and Mareike Westfal (Article 3), Adrian Birke (Article 4), and Daniel Zimmermann (Article 6).

Beyond the declarations above, no one else was involved in the creation of content and material of this dissertation. Also, nobody has received from me, directly or indirectly, any monetary compensation for work related to the content of the submitted dissertation. Specifically, I have not made use of the paid help of consulting services (such as doctoral dissertation advisors or other persons).

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Marco R uth