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Discussion on Value Logic and Practical Dilemmas of Interaction Design for Digital-Media Games from the Perspective of Digital Education

Yining Mi

No. 21, Shijin Huayuan Hutong, Dongcheng District, Beijing, P.R.China

Abstract: This paper studies the value logic and practical problems of interaction design for digital-media games from the perspective of digital education. Rather than considering digital games as neutral forms of entertainment, this paper incorporates game interaction design into the discussion of digital game-based learning to explore learning principles embedded in games and present empirical results from serious games and game-based learning outcomes. Based on classical and contemporary literature in digital game-based learning, gamification and learning analytics for educational games, this paper investigates how interaction design can promote meaningful learning, assessment and engagement, and also identifies problems related to curricular alignment, assessment validity, data practices and equity. It is concluded that the value of digital-media game interaction design in education depends on the integration of pedagogical goals, interaction mechanisms and evidence-based optimisation, but no effects beyond those supported by current research are guaranteed.

Keywords: Digital game-based learning; interaction design; digital education; serious games; learning analytics; gamification.

1. Introduction

Digital-media games have gradually entered the field of current discussions on digital education. Educational institutions, policymakers and designers are now exploring all kinds of ways to apply game-based environments in supporting learning, motivation and assessment for various subjects at different ages. At the same time, there are also problems of distraction, superficiality and unequal access.

Interaction Design in digital-media games is not a neutral technical problem from the perspective of digital education. It refers to the organisation of learning activities, the way feedback is provided, the distribution of agency, and the embedding of educational values in gameplay. When the Design of interaction aligns with educational goals, digital-media games can serve as environments for situated practice, formative feedback and reflective exploration. They may be out of sync and reduce the learning experience, or even block learners.

This paper studies the value logic and practical problems of interaction design for digital-media games in a digital education environment. Research has been conducted on how value claims for game-based learning have advanced, how research on serious games and game-based learning has informed interaction design, and what structural dilemmas exist in practice at the intersection of educational, technical and institutional constraints.

2. Value Logic of Digital Game-Based Learning

Prensky's early research on digital game-based learning proposed that these games could be used to combine serious study with interactive entertainment, and he believed that speed, feedback and graphics could be incorporated into educational materials to motivate learners [1]. Based on the change in learners' expectations and attention, especially for students accustomed to interactive media, digital-media games will be introduced.

Gee's analysis identifies learning principles in well-designed games to provide this value logic [2]. He presents how games can support situated learning, identity exploration and problem-solving cycles, and proposes that game interaction structures can create a good learning environment. Therefore, the purpose of interaction design is to organise learning problems, feedback, identity and exploration in a way that is consistent with learning theory.

Systematic reviews and meta-analyses have shown that, although cautiously, they are generally favourable. Connolly and others have studied the empirical evidence for computer games and serious games, finding connections between gaming and a number of cognitive, affective and motivational outcomes [3]. Byun and Joung's meta-analysis of digital game-based learning for K-12 mathematics, and Serrano's literature review on digital game-based learning, have also reported small to moderate positive effects on learning outcomes when game design and instructional design are carefully integrated [4][5]. Based on the above analysis, interaction design for educational games can be used to add value; however, this value is not guaranteed.

Recent meta-analytic studies on digital game-based STEM education have also supported this conditional value theory. Wang and others have found that digital game-based STEM interventions are moderately effective overall in improving learning outcomes compared with other ways of teaching [6]. However, they have also found moderator effects related to subject, level, platform and intervention duration. Therefore, the effect of interaction design is not uniform; rather, it depends on a particular combination of mechanisms, content and environment.

At the same time, the studies on gamification are also varied. Deterding and others have defined gamification as the application of game design elements to non-game contexts, and it is not a complete game [7]. Therefore, it can be seen that adding points, badges and leaderboards to an educational interface is not enough to motivate students to learn

voluntarily. For digital-media games in education, this means that the design of interaction should be judged not only by the surface-level game elements but also by deeper structures of challenge, feedback and meaningful activity.

In short, the above studies indicate that a value logic for digital-media game interaction design should be adopted when it can help achieve clear learning objectives, incorporate strong learning principles and demonstrate empirical effectiveness. They also suggest being cautious about making claims regarding game-based learning, avoiding promises of universal effectiveness, and concentrating on conditional values that depend on design and environment.

3. Interaction Design and Educational Alignment

The first problem of digital-media game interaction design in education is alignment with curricular and pedagogical goals. Gee believes that games can serve as semiotic spaces where learners interact with systems of signs, identities and practices [2]. Interaction Design, therefore, should be based on the conceptual structures, practices and inquiry forms of the subject domain to create game mechanics, rules and feedback systems that are relevant to it, rather than being unrelated mini-games.

Connolly and others have found that serious games are more successful when they integrate content knowledge with appealing interaction modes, such as exploration, problem-solving and feedback [3]. If the design of interaction does not serve educational purposes, students will be more interested in learning how to win the game than in learning. There will be a discrepancy in educational goals between the interaction design and the fun-factor of the game.

Meta-analytic research on mathematics and STEM game-based learning has shown that they are closely aligned. Byun and Joung have reported that digital game-based learning in mathematics has shown good results when games are designed to integrate mathematical tasks into the main gameplay rather than adding them as separate quizzes [4]. Wang and others believe that, to achieve good results, subject-specific design and close cooperation with teachers are required [6]. Interaction design in digital-media games should therefore pay attention to how game actions and feedback express domain-specific thinking.

Serrano's study of digital game-based learning for K-12 students suggests that, in terms of design, collaboration, choice and feedback can be employed to motivate students [5]. Interaction Design refers to how players cooperate, make choices and receive information in a game; thus, it is also a necessary component of the game. However, the same review also points out that not all added features, such as instructions or feedback, have an easy positive effect; therefore, design must be tested rather than assumed.

Shute and Ventura propose stealth assessment to add an evaluation mechanism in digital games without disrupting the game [8]. Their work shows that interaction design can carry embedded assessment structures and have learners' actions serve as evidence of competencies. Therefore, although supporting value claims for formative assessment, problems of validity, transparency and data protection have also emerged. Therefore, in the context of digital education, the design of interaction that includes assessment should be transparent about its purpose and methodological limitations to prevent the creation of false expectations of measurement accuracy.

In short, the design of interaction for digital-media games in education should align game mechanics with curriculum objectives, structure assessments to promote meaningful demonstration and feedback, and avoid making excessive promises about the guaranteed effects of such design.

4. Learning Analytics, Data Practices and Design Refinement

One stream of research explores how learning analytics can guide interaction design and assessment for educational games. Caballé and others have studied the application of learning analytics in educational video games, and data on how players interact can be used to assess learning content, progress and results [9]. They intend to use the general interaction traces and a scalable learning analytics system to support assessment without having to redesign all the game-specific evaluations from the ground up.

Alexandris and others have studied the strengths and weaknesses of learning analytics in educational games in their research [10]. Learning analytics can be used to support iterative game design, personalisation and formative assessment by analysing trajectories of in-game behaviour and learning needs. At the same time, they have also found technical and data-management problems, as well as ethical issues such as privacy, consent and interpretability.

Shute and Ventura's work on stealth assessment shows how to use interaction data to infer abilities in game environments [8]. They are to define evidence models and task models that connect in-game actions with constructs of interest. Interaction Design should therefore be designed to turn mechanics and telemetry into structured opportunities for collecting evidence, rather than merely serving as sources of interest. They have also put forward the idea of verifying the accuracy of such assessments and presenting them as supporting evidence rather than as absolute norms.

Research on game-based learning has been extended, and now interaction design can be optimised with data. Connolly and others have shown that many studies on serious games are also iterative in design, incorporating players' feedback and performance data into subsequent editions [3]. Serrano believes that the aims of design are cooperation and choice, and analysis can help determine whether these goals support or hinder learning [5]. Therefore, learning analytics is best viewed as a tool for continuous design reflection rather than as evidence of general efficacy.

There are both strengths and weaknesses in the new area of digital education. On the one hand, learning analytics can be employed to provide rich feedback for designers, teachers and learners in the design of digital-media games, and thus identify bottlenecks, misunderstandings and design flaws. At the same time, the application of analytics will also bring new responsibilities for data governance, transparency and interpretability. To avoid misleading the public, the designers and educators should present the descriptive analysis, exploratory insights and verified evaluation indicators separately.

5. Practical Dilemmas in Educational Game Interaction Design

Although the value logic mentioned above is correct, there are practical problems with the application of digital-media

game interaction design in real educational situations. The other is a conflict between engagement and focus. Prensky's idea of fun and fast-paced interaction can inspire the design of continuously stimulating environments [1]. Gee's research on situated learning and reflective practice also shows that good learning may need to be slow and thoughtful [2]. Therefore, the designer needs to choose between quick feedback and continuous learning based on whether different subjects or groups of learners require one or the other.

Second, there are problems of evaluation and openness. Stealth assessment and embedded analytics promise less intrusive evaluation [8-9]. Learners and educators are not always aware of how their behaviour is perceived, so there is a fear of obscurity and unfairness. If the design of the interaction does not show the complex behaviour as a simple score, users will be unaware that this index is inaccurate or unreliable.

The third is fairness and equal opportunities. Based on the above meta-analyses, game-based learning can improve students' grades and motivation [3-6]. There are also different environments and groups of people. Not all learners have the same access to devices, networks or prior gaming experience, and interaction design that assumes a certain level of familiarity or physical ability may inadvertently exclude some users.

The fourth problem is integration into teaching practice. Serrano has shown that the effects of digital game-based learning are moderated by instructional design; that is, how teachers organise, support and conclude game activities [5]. Interaction design that works well in a controlled experiment may not be practical for classrooms due to time constraints, curriculum pressure and varying teacher abilities.

A Fifth Dilemma is scope and expectations. Meta-analysis has shown that digital game-based learning generally results in small to medium-sized effect sizes [3-4, 6]. Although this is encouraging, it indicates that games are only one good way and not all-encompassing solutions to the problems in education.

6. Development Directions from a Digital Education Perspective

Given these opportunities and dilemmas, several development directions emerge for interaction design in digital-media games under digital education conditions. First, the Design of interaction should be based on learning objectives rather than on engagement indicators. Gee's learning ideas and his later work on serious games have provided conceptual support for aligning game mechanics with educational goals [2][3]. Designers can use the above rules as design heuristics and then test them empirically.

Second, Interaction Design should be iterative and evidence-based. Learning analytics and studies of educational game evaluation have found that by analysing interaction data and learner feedback, design flaws can be identified and corrected [9-10]. However, the above processes should be presented as continuous design research rather than as conclusive evidence of efficacy.

Third, the direction of development should focus on transparency and learner agency in assessment. Stealth assessment and embedded analytics will not be effective unless it is clear what will be measured, how the data will be used, and what limitations apply to the data [8, 10]. It generally achieves the objectives of digital education for informed participation and critical data literacy.

Fourth, inclusive design should guide the interaction mechanism. Although most of the research has focused on average outcomes, digital education practice needs to consider all learners. Interaction Design should consider accessibility features, alternative control methods and adjustable difficulty, and should not assume uniform digital literacy.

Finally, the claims of value and policy for digital-media game interaction design should be based on available evidence. Systematic reviews and meta-analyses have found positive but context-dependent effects of digital game-based learning [3][4][6]. Therefore, designers and educators should not present game-based interaction design as an assured improvement over other ways. They can present it as an evidence-based option and, if well-designed, aligned with and implemented in a reasonable way.

7. Summary

Many Purposes for Using Digital-media Games in Digital Education. Interaction Design can support situated practice, feedback and engagement, but it may also have problems of alignment, assessment, equity and data practices.

Based on research in digital game-based learning, serious games, gamification and learning analytics, this paper has explored the value logic and practical dilemmas of interaction design for digital-media games. It has been pointed out that the basis for value claims should be documented evidence, that interaction design should align with educational goals, and that practical constraints and ethical considerations need to be considered.

In the future, digital education will integrate evidence-based interaction design and be implemented and evaluated in an iterative manner.

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