Advances in Game-Based Learning

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Game-Based Learning Across the Lifespan

Cross-Generational and Age-Oriented Topics

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Foreword

In 2015, I published *Players and their Pets: Gaming communities from beta to sunset*, which I co-wrote with Jason Begy. In the book, we recounted our experiences studying the players of a short-lived casual MMO (massively multiplayer online) game called *Faunasphere*. The game was launched in 2009 by Big Fish Games, known mainly for its single player hidden object games—but they were trying something new. Players entered the world as "Caretakers" of fauna, where small creatures could be cross-bred, hatched, raised, and played with by players around the world, throughout the changing world of *Faunasphere*. The game didn't last long—the core group of players engaged with the game loved it, but the company decided to shut it down for largely unexplained reasons in 2011. You can read more about the game itself and the players in our book. But the reason I bring up the game and its players is because of their uniqueness as well as their very commonness.

Faunasphere's core player base was composed of women—and in particular adult women over the age of 40. Older women—and retired women especially—made up a key element of the game's audience. When we conducted surveys and requested interviews of players, it was normal to have the vast majority of respondents be women, and not those who could be considered "young." Yet in another way, the players of *Faunasphere* were not at all unique. Many of them loved playing the game and played the game a lot. Despite it being a free to play game, lots of the women we surveyed told us they spent money (sometimes hundreds of dollars) on the game. And they considered it money well spent. When the game was announced as slated for closure, some of them also suggested doubling subscription costs for premium accounts—they were ready and willing to pay more to continue playing the game they enjoyed so much. And after the game did close, some of them went on to try other games together (a group migrated to *Glitch*, which flourished and then died a couple of years later) and others gathered on Facebook where they could swap stories and lament the game's loss. Some still post there, 5 years after the game's closure. Such accounts would not sound out of place in discussing almost any other game, and any other group of players—some are fiercely committed, some spend lots of money, and some get very upset if a game they adore ceases to exist.

What does this say about players, and older players in particular? To me it says that we need to think about them as players first, and as "older" second, if at all. The players I talked with for that research were a varied group—some of them admitted to playing games for hours at a time, every day of the week. Some had long histories of gameplay and loved to try lots of different games. For others, *Faunasphere* was their first foray into an MMO, but they were excited about the experience and determined to figure the game out. Some people talked about getting new computers so they could play the game without lag, and others were much more casual about the experience and didn't commit much to it beyond a surface interest.

Experiences like those demonstrate just how important it is to keep in mind older adults when designing games. Whether for serious games or entertainment-focused games, older players are a diverse and enthusiastic group of individuals. As the contributors in this volume demonstrate, they are not interested in a "narrative of decline" related to their age; instead, they want game experiences that are engaging and enjoyable and that will differ more than they will be the same. That means exploring design principles and techniques such as those presented in this volume. *Game-Based Learning Across the Lifespan* is useful for both what it does and what it doesn't do. It does give us thoughtful and tested techniques and principles for creating games that will appeal to a wide range of players. And it doesn't reduce older players to a stereotype or design *for* them without talking and testing game designs *with* them. In those ways, it is an extremely useful and inspiring volume to help all of us think about making games for everyone, in well-considered, well-researched ways.

Mia Consalvo

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Expanding the Game Design Play and Experience Framework for Game-Based Lifelong Learning (GD-LLL-PE)

Margarida Romero, Hubert Ouellet, and Kimberly Sawchuk

Abstract Digital games open new opportunities for engaging people from different ages and backgrounds in ludic activities. Sometimes, digital games are just played with players as the sole objective. In other cases, the game experience is combined with some other intentional purposes such as lifelong learning. We designate the use of digital games for Lifelong Learning (LLL) under the term Digital Game-Based Lifelong Learning (DGBLLL). In this chapter we introduce the Game Design for Lifelong Learning Playful Experience (GD-LLL-PE) including four perspectives (learning, storytelling, gameplay and user experience) and five phases (context and learner analysis, game design, pedagogical integration, play and experience) to study the pedagogical use of digital games across the lifespan.

Keywords Digital games • Game based learning • Lifelong learning • Game design • Gameplay • Game experience

Introduction

Digital games open new opportunities for engaging people from different ages and backgrounds in ludic activities. Sometimes, digital games are just played with players as the sole objective (Brown and De Schutter 2016). In other cases, the game experience is combined with some other intentional purposes such as lifelong learning. This book articulates two ideas, exploring their interconnection and their potential: the idea of lifelong learning (LLL) within the game-based learning (GBL) studies. For this reason, we designate the use of digital games for this purpose as an approach that we call Digital Game-Based Lifelong Learning (DGBLLL) (Romero 2015a, b). The goal of this collection of essays is to provide an overview of current

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ideas and experiments in DGBLLL across the lifespan with a focus on older adults as potential lifelong learners. This includes a consideration of the age-specific game design requirements and the technological devices that may address the hurdles faced by children and older adults in the use of digital game technologies. In addition to a consideration of the current state of the DGBLLL and the methodologies provided for age-specific game design, development, implementation and assessment, a significant portion of the book focuses on case studies where DGBLLL experiences were designed and implemented.

To guide the reader through the different chapters of the book, we introduce an expanded version of Winn's (2008) Game Design Play and Experience (GDPE) framework. We name this modification the Game Design for Lifelong Learning Playful Experience (GD-LLL-PE) and include three new considerations that are not included in Winn's original framework. Firstly, the educational context and a lifelong learners' needs analysis (Leone 2013) is proposed. The purpose of this analysis is to identify contextual and learner-specific learning needs to adapt the game design. Secondly, we include the pedagogical integration of digital games as an important step between game design and the effective implementation of game and learning experience (Romero and Barma 2015). Thirdly, we consider the evaluation of the learning experience and its outcomes. These three main changes are motivated by a specific need for a learning-based perspective in Digital Game-Based Lifelong Learning (DGBLLL). This approach requires us to analyze the learning context, the learners' need, and the pedagogical integration and the evaluation of the game and learning experience with care. The Game Design for Lifelong Learning Playful Experience (GD-LLL-PE) framework responds to the research complexity arising from game design, play and learning activity analysis, and the evaluation of the game and learning experience in DGBLLL. Before introducing GD-LLL-PE framework, we discuss the lifelong learning challenges at the base of the GD-LLL-PE framework.

Lifelong Learning as a Twenty-First Century Challenge for All

From childhood to older adulthood, twenty-first century citizens are invited—and at times can feel pressured—to engage in lifelong learning in an attempt to adapt to the rapid changes of in the circulation of information and proliferation of digital technologies (Romero 2015a, b). Lifelong learning may be perceived as an imposition of digital information and the processes of mediatization on younger and older adults, especially for those who have had negative learning experiences in their past (Hanson et al. 2007; Sawchuk 2013). Game-Based Learning (GBL) aims at engaging the learner in active and playful learning experiences to address the traditional dichotomy between learning and playing. This book examines the potential of GBL to enhance learning across the lifespan. Core to this approach is play, which is

widely accepted within educational studies as a "natural" way for children to learn (Edwards 2002). However, play in adulthood is often perceived as a mere hobby, a pastime or a waste of productive time (Okojie 2011). Given these pejorative associations, what then, are the potentials and the implications for playing games across the lifespan? A more profound examination of the perceptions of games and play across the lifespan is required in order to give an articulate answer to this core question. The proliferation of digital games within the current mediascape and the diversity and multitude of games found in game universes, narratives, mechanics, and devices make digital games potentially appealing to adults of all ages. Digital games are generally designed around a ludic intention that aims at offering a positive game and learning experience (Padrós et al. 2011). Game playing can be a compelling activity that may provide a series of self-administered, level-based challenges that are self-regulated by players. Through a game interface, players may take a break from their current realities and exert a level of control in an environment of relative, risk-free failure (Boyle et al. 2016; Hainey et al. 2014). The authors who have contributed to this volume argue that game design can be repurposed as a means to implement lifelong learning challenges unique to this moment in our media history. This book, which comprises a collection of case studies, highlights the opportunities and challenges for an engagement with digital games across the lifespan. Its focus is oriented towards the question of whether there are age-related needs, interests, or desires that can and should be considered for game design, development, and implementation. To guide the reader through the different chapters of the book, we introduce the Game Design for Lifelong Learning Playful Experience (GD-LLL-PE) framework in the next section.

Game Design for Lifelong Learning Playful Experience (GD-LLL-PE) Framework

Digital game-based lifelong learning (DGBLLL) engages the lifelong learner in interactions with digital artifacts, such as games, to support play activity. This artifact may be a digital "serious" game, an entertainment game repurposed for educational usage or even a gamification platform. What is common in the different digital, game-based learning activities is the joint purpose of providing a playful learning environment for the learner using digital media technologies, including an assemblage of software, devices, and networking capabilities. The complexity and diversity of DGBLLL requires an interdisciplinary analysis from the field of game studies, computer sciences, and human–computer interaction (HCI) but also from a diversity of social sciences including psychology, sociology, education, and media studies (Stenros et al. 2009). The complexity and diversity also requires us to consider the different phases of game designs and play experiences and their different perspectives in terms of learning, narratives, and gameplay. We consider Winn's Game Design Play and Experience framework (2008) as a valuable tool for

Fig. 1 Game Design for Lifelong Learning Playful Experience (GD-LLL-PE) phases and perspectives

differentiating three interrelated phases: game design, gameplay, and game experience. We also take into account Winn's four different perspectives: learning, storytelling, gameplay, and user experience. These four perspectives are combined to five phases of the game design, play, and experience. Combining these four perspective and five phases have led us to create a matrix for understanding and analyzing different components of digital games.

While Winn's original explanatory framework offers an initial starting point for our own reflections, the model has two main shortcomings. It tends to overlook the learner and does not analyze the context or the integration of the game in a particular learning situation or context. The GD-LLL-PE takes into consideration two more elements that are absent from Winn's discussion: first, an analysis of the content and learner explores the designing of serious games; second, a consideration of pedagogical integration that is oriented towards understanding how a game is used in specific pedagogical contexts. We also recommend a change to one of the terms used in Winns' fourfold explanatory framework that includes learning, storytelling, gameplay, and user experience, as mentioned. We recommend changing the term "storytelling" to the broader concept of "game universe," which includes storytelling and other aesthetic components of the game. The table below introduces the combination of the gameplay phases and perspectives that will be considered in this book.

Figure 1 shows the expanded release of the Game Design Play and Experience framework (Winn 2008) named Game Design for Lifelong Learning Playful Experience (GD-LLL-PE) framework. In Fig. 1, the concepts in italics aim to stress the structural differences between the original model and the GD-LLL-PE including two new phases and a broader level consideration of the game universe.

Throughout the book, the GD-LLL-PE framework introduced in Fig. 2 provides a roadmap to navigate the different chapters of the different authors.

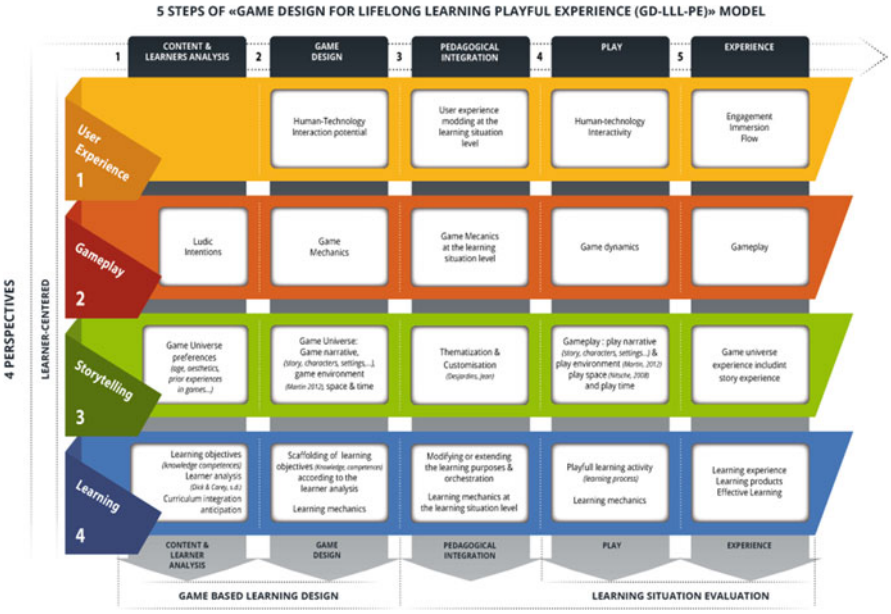

Fig. 2 Game Design for Lifelong Learning Playful Experience (GD-LLL-PE, Romero 2016)

Introducing the Five Phases of the GD-LLL-PE Framework

In the next sections, we describe each of the five phases of the GD-LLL-PE framework and introduce the chapters that are related to each of the phases or to some of the components of these phases.

Phase 1. Context and Learner Analysis

When integrating a digital game or creating a new one for educational purposes, we should take into account the lifelong learner needs. Conducting or engaging in learner analysis is an essential component of the approach that we are proposing. A learner analysis is a "systematic effort to identify learner characteristics and individual differences that may impact learning such as prior knowledge, personality variables, aptitude variables, and cognitive styles" (Dabbagh 2003, p. 39). Such an analysis assists in ensuring that the situation and the game-based learning activity are adapted to the learner characteristics, needs, and preferences. The learner analysis should be undertaken before deciding the type of game that will be integrated for educational purposes. This analysis should be taken into account by game designers (in case of a new game creation), educational professionals, or leisure staff who are

in charge of deciding the lifelong learning activities to be proposed to the learners. Before engaging in the creation or integration of games, we could benefit from an analysis of the lifelong learners needs to better respond to the learning context and the learners' needs and preferences.

The decision-making related to the integration of games in education should be done with the learner in mind. Following Dick and colleagues (2001) and Morrison et al. (2010), we identify several characteristics of the learner that should be considered for each of the four perspectives of the GD-LLL-PE framework.

Learning perspective. Lifelong learners' prior knowledge and experience, the level of their skills and competences before starting the learning activity.

Game universe perspective. Lifelong learners' game universe preferences may be influenced by their prior experience in games, their age, values, aesthetics, or their technological preferences. Game universe preferences may be related to different play modalities (individual as opposed to collective modalities; cooperative, competitive) and to preferences for different forms of interactive engagement, such as a lecture, discussion, the use of case studies, examples, learning by doing or other pedagogical strategies. Quickly analyzing and taking into consideration learner preferences may help the process of decision-making and make the model fit, at a certain level, with the expectations and preferences of play and learning of lifelong learners.

Gameplay perspective. Here, we consider the lifelong learners' known technological competencies and preferences. What is important here is to be attentive to the ways that digital ageism may operate in a learning context. Most important here is battle immediate perceptions that equate older adults with lower levels of interest and competencies in relation to technologies (see Ouellet, Romero, and Sawchuk chapter). The diversity among the lifelong learners' preferences and competences that we have encountered in our own experiences teaching digital game design or programming workshops is important. As such, we consider both younger users and older adult users are not homogeneous entities. There is a great deal of diversity within. From a value-based perspective, allowing for a degree of technological choice respects the technological preferences of individual users across the lifespan and helps to mitigate the social or psychological pressures that positions technological "adoption" as an external requirement to fit into digital society. Technology innovation as an external requirement has been described by Thierer (2014) as a "permissionless innovation." This external innovation is considered as an imposition which does not always fit the interest and needs of lifelong learners. Choosing to live and play without technologies is a choice that should be respected, valued, and understood. The views and perspectives of digital experts and enthusiasts should not be taken as an eternal or gospel truth, nor is there a need to become a digital missionary. We do not advocate turning individuals who prefer analog interactions or non-digital games into digital aficionados, be they young or old age.

User experience perspective. Here, we draw attention to lifelong learner attitudes and preferences towards the content related to the learning objectives, their intrinsic and extrinsic motivations, and their age and cultural diversity. Diversity should be respected both in terms of intra-psychological factors and the social and cultural dimensions that shape the experience perspective and thus influence the use of games

Phase 2. Game Design

Game design is the second part of the Game Design for Lifelong Learning Playful Experience (GD-LLL-PE) framework. Several characteristics should be considered to show what is taken into account when this stage is reached. As Winn (2008) outlines, many intricacies must be taken into account when designing a DGBLLL game. Different game design factors for each of the four perspectives of the GD-LLL-PE framework that we have identified include:

Learning perspective. Scaffolding of learning objectives according to the learning analysis.

Game universe perspective. Game universe (including game narrative elements like the story, characters, and settings), environment (Inal and Cagiltay 2007), game space, and game temporalities (Romero and Usart 2013).

Gameplay perspective. Learning mechanics are "building blocks of learner interactivity, which may be a single action or a set of interrelated actions that form the essential learning activity that is repeated throughout a game" (Salen and Zimmerman 2004, p. 316). Game mechanics should be considered both with a ludic intention and in coherence with the learning objectives and learning mechanics in order to be synergetic.

User experience perspective. Human–technology interaction potential of the different technologies should be chosen based on the analysis of the context and the lifelong learners' preferences.

Phase 3. Pedagogical Integration

Pedagogical integration is the junction point where the game is mediated by the teacher through a pedagogical activity and where learners are given access to the game. We identify different pedagogical integration factors that should be considered for each of the four perspectives of the GD-LLL-PE framework.

Learning perspective. Modification and extension of the learning objectives or mechanics through the pedagogical integration in a particular learning situation.

Game universe perspective. Customization through the use of a theme during the learning activity (Desjardins 2015). Some elements of the game universe including play environment and narrative (story, characters, settings, …) could be defined at the learning situation level as a way to extend, restrict, or modify the existing game environment and narrative.

Gameplay perspective. Game mechanics at the learning situation level. *User experience perspective*. User experience "modding" at the learning situation level. The term "modding" is often used within the computer game community to refer the act of creating new or altered content. In educational settings, El-Nasr and Smith (2006) considers game modding as a learning activity.

Phase 4. Play

The play phase is the moment where the learner is interacting with the game. Through the play phase, they are confronted to the intricacies of the mechanics and design of the (serious) game. It is the first part of the learning situation and evaluation of the game. Returning to our fourfold schema, we identify the factors influencing play that can be considered as a part of the GD-LLL-PE framework as it unfolds in this phase.

Learning perspective. The learning dynamics is the actual interactions developed by the learner within the learning mechanics constraints that have been introduced in the game design phase.

Game universe perspective. Gameplay including play narrative (story, characters, settings …), play environment, play space (Nitsche 2008), and play time.

Gameplay perspective. Game dynamics is the actual play activity within the constraints and possibilities defined by the game dynamics. For example, a learner can decide to avoid the point collection despite the game mechanics of point collection implemented in the phase 2 (game design).

User experience perspective. Actual human–technology interactivity between the lifelong learner (player) and the game.

Phase 5. Experience

The last phase describes the player's immediate experience of the serious game that has been developed or played. It constitutes the last part of the learning situation and evaluation of the game. Returning to our schema, the four perspectives of the GD-LLL-PE framework, here are the different game experience and learning experience and outcome factors to be considered.

Learning perspective. In the experience phase, we evaluate the actual experience of the lifelong learner (player) within the play activity-event. The learning experience should also consider the effective learning. In this sense, the game experience and outcomes could be analyzed through the learning analytics included in the game or through learning assessments included at the learning situation level (outside the game).

Game universe perspective. Game universe experience refers to the subjective experience of the lifelong learner player within the game and what are the effects of the game universe perspective.

Gameplay perspective. We should analyze at which point the game experience of the lifelong learner player has been pleasant and ludic. Player enjoyment in games could be evaluated through different instruments, such the GameFlow by Sweetser and Wyeth (2005).

User experience perspective. In this perspective, we should analyze the user experience perception in terms of flow (Chen 2007; Csikszentmihalyi 1990), immersion (Jennett et al. 2008), and engagement (Brockmyer et al. 2009; Romero 2012).

The GD-LLL-PE Framework: A Roadmap for the Book Reader

The expanded game play model that we have articulated above is used as a heuristic device to organize the book chapters and to stimulate a discussion thread. As the field of game studies is rife with approaches and opportunities, each author who is presented within this collection will illuminate different aspects of game-based learning across the life course in a unique way.

The chapters published within this book are centered on a multitude of themes including game design for lifelong learners, creating games in intergenerational context, and the evaluation of games as cultural artifacts that convey age and gender stereotypes. Serious games are an emerging, vastly complex topic of research and the authors approach the topic using different epistemologies, sensibilities, and sites for the investigation of different research topics. Taken together, the collection should not be considered as a monolith but as a multifaceted ensemble of interconnected works-in-process. The editing team has organized the contributions submitted by the authors around the five steps explicated in the GD-LLL-PE. de Schutter, Restorick Roberts, and Franks take into account game content in combination with a learner analysis and thus contribute to the four perspectives of the GD-LLL-PE that we have outlined, including: learning, game universe, gameplay, and the user experience (Chap. 2). Sauvé (Chap. 3) provides critical information about adaptive game design for seniors and older adults through gameplay and learning. Hausknecht, Neustaedter, and Kaufman (Chap. 4) reflect upon game design and creating serious games for intergenerational collaborative learning. Barma, Romero, and Deslandes (Chap. 5) interrogate maker spaces and their potential for intergenerational learning through game design and play. Ouellet, Romero, and Sawchuk (Chap. 6) highlight the opportunities and hurdles involved in the creation of intergenerational workshops to create playful situations and experiences. Barma and Daniel (Chap. 7) examine the pedagogical integration and possibilities offered by an innovative learning and teaching tool through the four perspectives. Ferreira, Sayago, and Blat (Chap. 8) inform us about the need for playful and effective learning activities that take into account experiences that are oriented towards older adults. Schuch theorizes and describes the user's experience and the engagement and the flow of the game (Schuch, Chap. 9).

The categories, topics, and themes introduced are by no means mutually exclusive. As you will discover by reading this collection, the chapters are intertwined with one another. This plurality of methods, research topics, and sites for intensive investigative inquiries constitutes the multifaceted character of the (serious) game studies community in its present form. It also allows us to consider GBLLL as a powerful terrain of collaborative and collective experimentation to enhance, prolong, and invest in the learning process across the lifespan. With serious games as its interface and learning at its core, the book presents a portrait of research that integrates different age groups across the different phases of game design, play, and experience process to make it more diverse and inclusive.

The expansion of Winn's framework (2008) also nuances the categorization of the different realities of games (and game design), highlighting the dynamics and complex interactions present when we examine game development and game play within the serious game field. As a representation, it visualizes some of the phases of the learning process as well as the scope and range of activities being undertaken by those who are invested in the subject of serious games and lifelong learning and play: from the idea, through the design process and its experience by the player, its potential as both a tool for teaching an analysis is far-reaching. As such, the GD-LLL-PE acts as a roadmap to navigate the work of the authors who have participated in the making of this book and as a tool to categorize or situate the different types of research in the DGBLLL field. In this way, we hope that the collection and the schema we have described will contribute to ongoing advancements in the development of common research tools in the interdisciplinary field of Digital Game-Based Lifelong Learning.

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Miami Six-O: Lessons Learned From an Intergenerational Game Design Workshop

Bob De Schutter, Amy Restorick Roberts, and Kelley Franks

Abstract This chapter reports on the Miami Six-O project, a creative intergenerational workshop aimed at developing a meaningful play experience for and with older adults. During the project, 5 older adults and 4 undergraduate game design students participated in a 4-step creative process, which resulted in 6 playable paper prototypes. Their collaboration was observed by a team of 2 professors and 3 graduate assistants. The resulting notes and audio recordings were analyzed through open, selective and theoretical coding. The project found that it is possible to successfully co-create game designs that are meaningful for both the older adults and the students, though how these teams worked together influenced the outcomes. Furthermore, we discovered that shared popular culture references and design themes such as competition, creativity, diversion, and social connectedness were helpful in moving the creative process forward and overcoming generational differences.

Keywords Game design • Intergenerational • Older adults • College students • Creative methods

Digital games have become a popular pastime for many older adults (Entertainment Software Association [ESA] 2015), and this popularity will arguably increase when the first generation that played digital games during their formative years heads towards their retirement. Furthermore, digital game technology has been demonstrated to hold a wide range of benefits for older adults. For example, they have been used for cognitive training (Anguera et al. 2013), to facilitate intergenerational

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interaction (Khoo et al. 2008), and to support social engagement among Alzheimer's patients (Alm et al. 2009).

While the academic study of digital games in later life has been around since the 1980s (Weisman 1983), it has recently taken a significant growth spurt. For example, through a quick online search for articles on games, using Medline/PubMed, Web of Science, Google Scholar, and article reference lists in November 2014, De Schutter found that 3.6 times more papers were published after 2009 than during all the years before (De Schutter, in press). While many advances have been made over the past 35 years with regard to the study of the accessibility constraints and health outcomes of digital games for older adults, a number of key questions still remain.

One question is perhaps the extent to which the efforts into studying and designing games for older audiences have been successful. For example, Mosberg Iversen (2014) suggests that the underlying discourse in the field of games and aging is one that regularly identifies older adults as a problem to society. With the increasing longevity of older adults globally, this view of older adults as an inconvenience to society is troubling. Nevertheless, this perspective of remediating the problems associated with aging through the potential benefits of digital games does embody an inherently positive cause (i.e., to improve the cognitive, physical, or social health, as well as general well-being of older adults). Yet, it also carries the potential to drive the field into less than optimal waters. More specifically, it is reminiscent of a debate that has been held before, as the field of serious gaming and digital game-based learning (DGBL) has a history of tension regarding the balance between the inherent non-purposeful nature of digital games and the pressure to demonstrate extrinsic outcomes.

One commonly cited example of work that considers this research question is the research of Malone and Lepper (1987) that differentiates between endogenous and exogenous fantasies. The former term is used to denote games whose stories and themes are closely intertwined with their educational outcomes, while the latter term refers to games whose thematic aspects are disconnected to the learning goals of the game. Habgood (2007) and Habgood et al. (2005) provided an extension to and reframing of the work of Malone and Lepper, by balancing intrinsic and extrinsic elements across all aspects of the game, from its fantasy to its game mechanics, flow, and representations.

As the digital game-based learning and serious gaming community seem to prefer an equally weighted distribution of both the learning outcomes and entertainment goals, it could be argued that the same approach could be transferable to the games and aging community. For example, in their analysis of the motivational pull of digital games through a cost–benefit model, McLaughlin et al. (2012) conclude that it does not suffice to only reduce the cognitive and financial barriers that older adults have to overcome to play games. In addition to addressing these barriers, game designers should also increase the perceived benefits that older adults experience as a result of their gameplay experiences. Even a game that has perfect accessibility, usability, and playability will not appeal to older adults unless it offers a fun, valued, or meaningful experience.

In light of these recommendations, De Schutter and Vanden Abeele (2015) recently expanded on the work of McLaughlin et al. (2012) and provided a manifesto for game design aimed at older players. Because later life is a time of personal growth as well as decline, games for older adults should incorporate good gameplay qualities as well as appropriate usability. However, the authors also support the idea that designers and researchers should provide recommendations to effectively create a clear division between the two purposes of game play in later life (the inherent meaningfulness of play versus play for the purpose of a predetermined outcome), with the potential benefits of digital games for older adults. Furthermore, the manifesto argues that game design for older adults should always prioritize the inherent playfulness of a game first, so that it will not lose its inherent qualities and motivational pull.

> "While serious games … might be useful for certain afflictions that are associated with older age, we argue that an exclusive emphasis on the external purpose … is detrimental to the very nature of play." —De Schutter and Vanden Abeele (2015, p. 115).

In the spirit of bringing renewed attention to the interests and motivational pull of digital games to older adults, this chapter will share on the process and findings of "Miami Six-O," a game design research project that was unencumbered by the restrictions of external funding or intended health outcomes for older adult gamers. Instead, it challenged a group of older adults to design a "meaningful play" experience for people between 50 and 70 years of age.

Design of the Workshop and Research Project

Meaningful play is a term that was coined by Salen and Zimmerman (2003) to describe the manifestation of successful game design, based on the relationship between the player and the game, and their actions and outcomes. While meaningful play is an appropriate concept to incorporate the inherent value of play into a design exercise, it also provided Miami Six-O with an additional goal as achieving meaningful play requires that a game reaches a perfect balance with the characteristics and intentions of its player:

> "Players bring in a great deal of the outside world, their expectations, their likes and dislikes, social relationships and so on… In this sense, it is impossible to ignore the fact that games are open, a reflection of who play them" (Salen and Zimmerman 2003, p. 171).

For the Miami Six-O project, this meant that the project would start with the recruitment of a group of older adults who were interested in designing their own digital games and who would serve as the reflection of "the older player." While it would be difficult to find local game developers for the project—industry reports indicate that only 1 % of game developers is over the age of 50 (Edwards et al. 2014)—we decided to recruit for older adults who had an interest in digital games. The resulting group was then augmented with a team of undergraduate game design students (who had a demonstrable experience in creating digital games).

Correspondingly, the project set out to explore digital games as a creative medium for intergenerational collaboration and to address the following four research questions:

- What differences and commonalities exist between the older adult and college participants with regards to digital games?
- How do the college students and older adults collaborate and learn from each other during the creative process of the workshop?
- What kind of meaningful themes and game designs emerge from the workshop, and how do they appeal to both age groups?
- What kind of games would an intergenerational design team with no constraints design?

The project was arranged as a creative workshop in collaboration with the Institute for Learning in Retirement (ILR) at Miami University. The ILR's mission is to promote "opportunities for individuals 50 and older to enrich their lives as they explore areas within science, the arts, society, technology, literature, languages, business, economics, and other subjects of interest." This digital game workshop was advertised to members of the ILR through their newsletter that described a diverse array of brief 5-week, continuing education courses. The goal of the workshop, as communicated to the older adult participants, was to work together with college students to create a meaningful digital game design for older adults. The promotional text read:

> **Digital Game Design**—Explore the world of digital games! In this hands-on course, you will learn about digital technology and collaborate with game design students from Miami to conceptualize and design a new game.

The five older adults who participated in this project were Caucasian men who lived in a small college town in a Midwestern state in the United States. Beyond these basic descriptors, the older adults were retired, highly educated, valued lifelong learning, and had previously enjoyed successful professional careers. Four college-age digital game design students were invited to participate in this workshop to learn about the interests of older adults. The college students anticipated that older adults will become a large consumer market for digital games in the near future, and they agreed in advance to prioritize the wishes and creative ideas of the older adults during the game design process.

While similar player-centered design projects for older adults (e.g., Romero et al. 2010; Vanden Abeele and De Schutter 2010) typically have certain educational or health-oriented deliverables and intended outcomes, Miami Six-O had none of the constraints. As a result, our participants were able to come up with any design they liked, without any practical or creative limitations. While the participants were asked to create an experience that would be meaningful to 50+-year-old players, they were free to define for themselves what this would actually mean.

The workshop used a 4-step creative process that was spread across five sessions of 90 min (see Fig. 1). The process was a custom design for the workshop. However, it followed a setup that was similar to preexisting models. For example, its four stages are similar to the analysis, generation, evaluation, and implementation phases

Fig. 1 The creative process of the workshop

that are described in Howard, Culley, and Dekoninck's (2008, p. 165) literature review of creative design processes. Throughout the five sessions, the intergenerational teams were guided through a structured process to generate ideas (weeks 1 and 2), develop concepts (week 3 and 4), translate these into game designs (weeks 3 and 4), and finally, create a playable prototype (week 5).

Phase 1: Ideas

The first phase was designed to analyze the problem statement and to come up with some initial game ideas. It was spread across the first two sessions. During the first session, the instructor introduced the research team and explained the setup and overall vision of the workshop to the participants. The participants had a discussion about the state of the art of digital games, and what digital games for older adults they already knew about. They were given the opportunity to discuss the role that games played in their lives, and what their goals for the workshops were. The participants were also given the opportunity to play a few indie games, and they were introduced to web sites that curate contemporary digital games (such as Gamejolt.com and Kill Screen).

At the start of the second session, the participants were reintroduced to the challenge of the workshop, i.e., "*to become the author of a game*." The term "author" was used to introduce the idea that games are a creative medium that can be used for meaningful self-expression. Next, the participants were given a brief primer on how creativity works (i.e., there are no "bad" ideas, adopt a playful attitude, fail fast and fail often, take breaks when you need them). The primer also provided them with a social contract as it emphasized that the session should be a positive and pleasant experience for everyone involved. Next, the participants performed a free associa-

tion exercise aimed at priming their minds for a creative assignment. After going through a number of free associations, the participants were asked to come up with a number of meaningful topics, and to write them on blank playing cards. This assignment was done individually, and after each participant had created some "idea cards," the entire group was shown a slide that contained a list of inspirational words, such as passions, people, places, events, stories, careers, accomplishments, change, love, perspectives, views, and family. They were also reminded that games are often characterized by procedures, resources, rules, conflicts, skills, and objectives, and that it would be easier to make games that would relate to these concepts. Once every participant was satisfied with the amount of idea cards that they had made, they were collected and shuffled.

Phase 2: Concepts

The next phase aimed to use ideas to come up with a number of game concepts. In this context, a concept is defined as a brief description for a game. For example, a concept could be as short as the following: "*A trivia game in which grandparents and grandchildren learn about each other's culture by asking each other questions*."

During the third session, intergenerational groups consisting of at least one college student and one older adult received an array of random idea cards per group. Each intergenerational team was asked to order the cards in clusters that made sense and to make personal notes about the ideas that they liked. The participants then summarized each cluster onto a blank playing card and were asked to reflect on whether or not there was a game in the ideas in front of them. Next, they moved around the table to the clusters that were organized by a different group. The participants were allowed to make a copy of a "summary card" and take it with them to the next table if they wanted to do so. Next, they were invited to rearrange the concepts (that originally came from a different team) and/or to combine them with their summary cards to further expand upon their own digital game design concepts.

Phase 3: Designs

In this phase, the goal was to provide more depth to the concepts by coming up with a more detailed overview for a game. For the trivia game example above, this could mean that a participant would start to think about high-level details such as the presentation of the trivia game, its structure and fantasy, the kind of questions or challenges it would present to the player, etc.

During the third and fourth session, the teams were tasked with creating an illustrative poster that outlined their favorite game concepts using large flipchart post-it

sheets. Every team had the flexibility to either determine which ideas or concepts would be carried forward from earlier sessions, or to run with a new idea. Once the posters were done, the teams finalized and presented their game designs to the group.

Phase 4: Prototype

The final phase asks the participants to create a paper prototype for their game design. In other words, they have to try to create a playful experience that delivers the gameplay that their digital game aims to facilitate, without actually programming it.

During the fourth and final session, the participants moved to this part of the exercise and created a paper prototype of their concept. Before working on the prototypes, they were provided a brief primer on how to create a paper prototype for a digital game, and shown paper prototypes of well-known commercial digital games including as Tony Hawk's Pro Skater 2 (2000), Asteroids (1979), and Spore (2008). Finally, the prototypes were shown and discussed, after which a focus group session was held.

The project was analyzed by a research team consisting of 2 professors and 3 graduate assistants. Data was collected by means of participatory observation (Delamont 2004) and was subsequently analyzed using open, selective, and finally theoretical coding (Charmaz 2006). The workshop was led by a moderator (i.e., one of the professors) who had previous experience with organizing similar workshops. While the moderator introduced the assignments, answered questions and provided game design guidelines, he did not engage into any discussions between the members of each intergenerational design team.

Findings

In this section, we will share our observations and interpretations regarding the 5-week workshop focused on designing digital games. First, we will discuss some of the differences and commonalities in gaming experience and expectations for the workshop between these two age groups. Next, we will consider the interpersonal aspects of our design workshop and describe the diversity between intergenerational game design teams as they sought to work together through the process to eventually create a prototype. While strong collaborations were observed, some groups struggled to manage creative decision-making authority and function as a team. Lastly, we will present the promising design concepts that emerged from the workshop.

Commonalities and Differences Between Older Adults and College Students

During the first session, we recognized that the older adults and the college students shared a strong interest in playing games in a variety of forms and expressed joy in the creative process. The idea of engaging in the process of creating new games or modifying the rules of existing games added more excitement and entertainment value to the project. All of the college students expressed that they enjoyed designing and developing digital games. At the beginning of the first session, they were briefly given the opportunity to share the kind of games that they had made in the past and what kind of games they liked to make. More specifically, one student specialized in interactive novels (using the Ren'Py engine), one specialized in critical games (using the Game Maker Studio engine) and the final two students were most experienced with making 3D exploration games (using Unity3D).

It is also important to note that two of the older adults had already designed their own digital games, as well, for themselves and their young grandchildren. In the large group, particularly among those who did not have the experience of designing digital games, many of the older adults reminisced about games from their childhood and the fun they had as a kid playing a game with a friend or sibling. One of the older adults shared:

> I've never been a big gamer, but for some reason it, it reminded me of an incident as a kid. I was probably 8 or 10 and my brother's 3 years older than me…. We used to play Clue, but got bored with the game so we made a second story to it. And we'd build out our own room, actually a lowered floor, because we had a dungeon and new murder weapons from robots, and stuff like that. So, it was kind of fun to create a game. I really loved that.

Despite the shared interest that brought older adults and college students together to participate in this workshop, we also found differences in the level of experience with digital games and beliefs about computers and gaming. The different generations had varied interests, and different options about the purpose of digital games (for entertainment, learning something new about yourself, social interactions, or improving health). Older adults explained that digital games were fun, but viewed them (at least partially) as a waste of time. Their enjoyment of digital games stemmed from gaming as a form of competition that may keep your brain young. However, they occasionally seemed to struggle with the complexity of the software or equipment. In contrast, the college students saw games as a creative medium for self-expression and strived for complex story lines and character development. Over the course of the workshop, more of the older adults embraced the story-driven, experiential concepts. In fact, some of the final designs were intricately tied to their former professional careers.

Finally, the older adults and college students came to the workshop with different expectations. College students were accustomed to creating digital games in a short period of time. From their previous experience and familiarity with coding, they were confident that the workshop should be able to produce a digital game within the 5-week timeframe. On the other hand, the older adults were concerned that the

workshop was making too many demands on college students that may interfere with their classes and other commitments. Still, at least one of the college students insisted that he would create a digital game within the timeframe. The college students approached this co-design process with curiosity, openness, and a desire to share digital games with others. At the same time, some of the older adults were concerned about protecting their "intellectual property" if a multi-million dollar digital game was produced within the workshop. Nonetheless, the older adults were very eager to participate and brought a lot of questions about games to the workshop. In particular, they asked for more information about game addiction, programming languages, costs of buying and creating games, and what it actually means for something to be a game.

Building Collaborative Intergenerational Teams

Among our intergenerational teams comprise at least one older adult and at least one college student, group dynamics differed. In each team, we analyzed communication patterns to gain more information about the process of intergenerational game design. The core category of analysis was how the balance of power was negotiated in every group to eventually arrive at the final game prototype. We analyzed the interactions qualitatively and noted when an older adult or student either dominated the group's creative process, followed the group, disconnected from the group, or remained actively engaged in collaboration. We considered collaboration as the ideal scenario, when both the older adult and the student created a high functioning team, mutually supporting one another to achieve the group's outcome of a digital game.

In approximately half of our groups, the conversations were dominated by either the older adult or the college student. The other half of our groups displayed a collaborative approach in which there was no dominant participant. One of the teams struggled to collaborate (due to creative differences and an uneven understanding of the medium), and eventually they agreed to pursue each individual's design independently. Over the course of the workshop, there were times when both generations were involved in dominating the creative process, as well as following the others in the group. While some of older adults would disconnect if the student's input became too large, none of our college students ever disconnected from the game design process. It is possible that college students were less likely to disconnect because they were motivated to participate in the workshop to learn more about the perspective and interests of older adults. Surprisingly, the college students at times showed more respect to an older adult they disagreed with creatively than the older adult showed to the college student.

During the course of the workshop, a creative strategy that seemed to work for both parties was to "explore the familiar." By discussing references from well-known popular culture, both generations seemed to be able to understand each other better. For example, the participants used Rube Goldberg machines (art installation), Avalon games (board games), Angry Birds (video game), War Games (movie), Avatar (movie),

I Am Legend (book), Groundhog Day (movie), MacGuyver (television show), and Life (board game) to describe and illustrate their ideas to each other. The students also used YouTube gameplay clips from Limbo, Don't Shit Your Pants, McPixel, and Passage to help illustrate their ideas when the older adults were unfamiliar with them.

Meaningful Digital Game Themes

A number of meaningful themes emerged from the workshop. In the transcripts of the first and second session, we found seven common themes: competition, personal growth, diversion, nostalgia, creativity, and social connectedness. Among these themes, nostalgia and creativity were the most consistent. The digital game prototypes that were created encompassed problem-solving, social interaction, and learning as core mechanics. In many cases, the meaningfulness of these games for older adults was closely tied to their family relationships and professional skills and accomplishments. After reviewing the final prototypes, it is clear that the initial view of digital games for competitive purposes only changed significantly over the workshop to tie digital games to more personal experiences and storylines.

In general, the themes that resulted from the workshop appealed to both audiences. Competition, creativity, diversion, and social connectedness have been common aesthetic outcomes for digital games, regardless of the age of the player. The nostalgic stories of the older adults seemed to provide a rich source of inspiration to the college students. Personal growth was typically framed within the context of money management and career planning, a theme that the older adults were experienced about and the college students were interested in.

The Games

At the end of the workshop, the ideas and concepts were turned into playable but non-digital paper prototypes. Three categories could be identified among the prototypes, (i.e., problem-solving games, relationship games, and learning games).

Two of the groups placed the player in the position of decision-making in complex situations. The first game, "Escape the Room," challenged the player to find different paths to escape a room filled with booby traps and dangerous contraptions. Winning the game requires multiple attempts to use different strategies to evacuate and survive (Fig. 2). In the second game, "Facing Fears," players enter a world of fantasy where they are placed in high stress situations. Eventually, the player has to learn how to trust him or herself in order to adapt and survive.

Two games drew their ideas from social relationships within families or romantic relationships. As the only prototype developed specifically with an older adult role, "Dreamtime" is a two-player game that involves a grandparent and a young grandchild being transported into a fantasy world to play games together while they are asleep (Fig. 3). In this intergenerational game, the grandparent and the grandchild

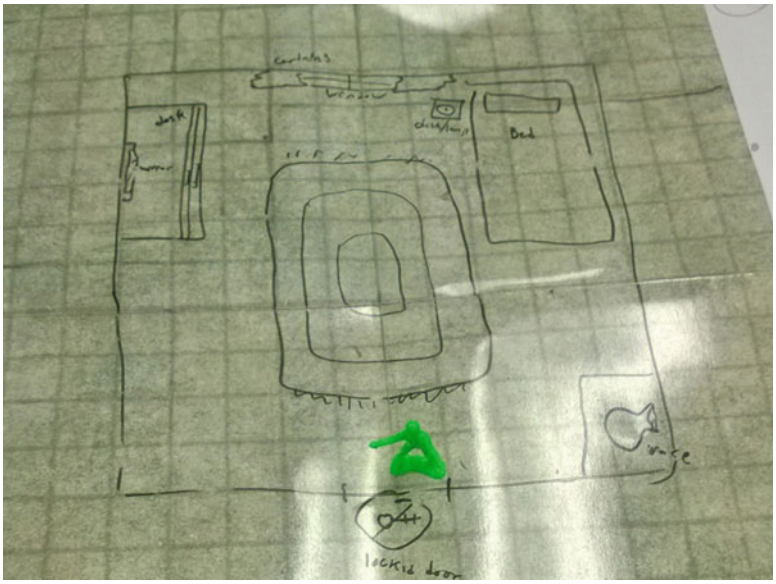

Fig. 2 Prototype for "Escape the Room"

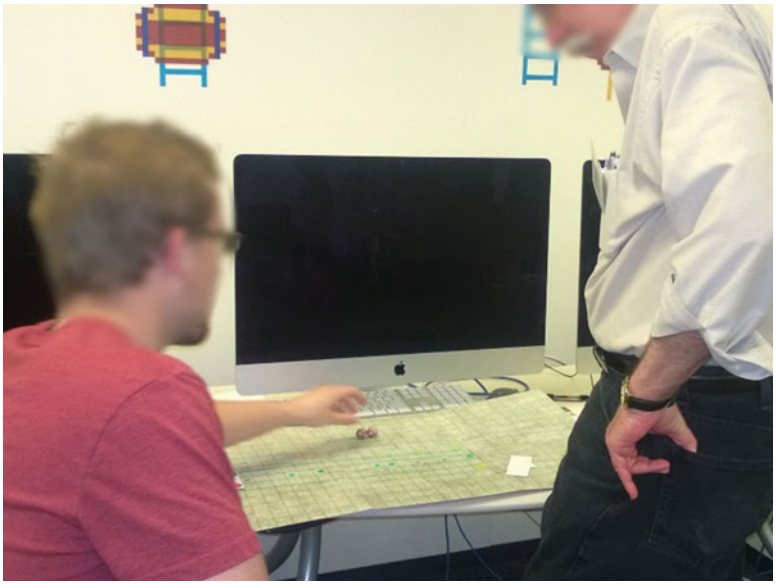

Fig. 3 Working on the Dreamtime prototype

each have their own strengths and abilities but work collaboratively to complete tasks and advance through the game's challenges. Elements of dating were also included in a different group's prototype, "The Dating Assassin," where the critical issue is trust in a dating relationship. In this game, the player's goal is to attempt to date the unsuspecting victim and get close enough to him or her to complete the

assassination. “The Dating Assassin” was one of the two games in which the collaboration between the college student and older adult stopped at some point and each worked on their own game in a more independent manner. In the case of this game, it was the college student’s idea and the older adult disconnected.

The last two game prototypes were intended to teach players about the rewards of strategic choices and apply historical knowledge to solve problems. In “The Game of Life,” players can make different life decisions (e.g., go to college, select a major, get married) and the players learn about the consequences of those decisions to try out different options. This game, in particular, has a strong connection with the older adult’s former profession. While the game is not overtly intergenerational, it does communicate the process of imparting wisdom to younger generations. The group saw the game as a teaching tool to help younger people better shape their destiny by making better choices early in life that lead to a desirable outcome. In the last game, “Battlefield Simulator,” the group re-creates historical battles in wars to teach players what happened and rewards players as they figure out new and creative approaches to winning battles. “Battlefield Simulator” was the second game in which the collaboration between the college student and older adults was not ideal. In this case, the older adult dominated the creative process. The game idea, derived from the older adult’s interest in military games, clashed with the college students’ interest. Although the college student was hoping for a more complex, innovative approach, he did not fully disengage from the process (Fig. 4).

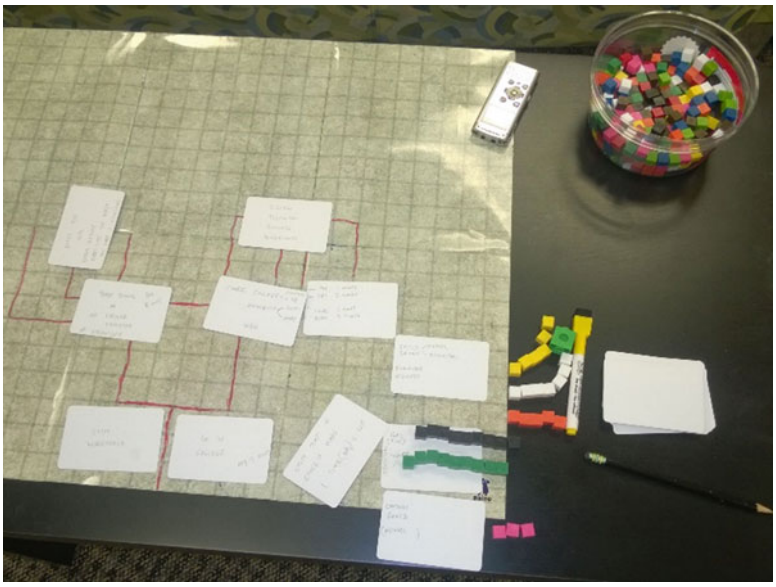

Fig. 4 Prototype for the Game of Life

Discussion

In our intergenerational game design workshop, participants embarked on a creative journey of game design that would ultimately lead to a meaningful play (Salen and Zimmerman 2003) experience for older adults. However, the largest constraint for the project was fitting everything within the limited timeframe of five sessions of 90 min each. While we managed to finish everything that we prepared for, it should be noted that the prototypes were in a very early state.

Going forward, we recommend this game design workshop for a diverse array of participants to gain a better understanding of the range of meaningfulness in game design concepts to the individual gamer. The findings reported here are limited by our voluntary sample of older adults who were exclusively well-educated men and younger male college students. We speculate that when women participate in this workshop (either older adults or college students), additional game design ideas will emerge. While the ILR and the games program at Miami University have an equal mix of genders, female participants were not motivated to sign up for it, and this has more than likely added bias to the team dynamics. Future work should attempt to evaluate to what extent a workshop such as this leads to different outcomes when the design teams demonstrate greater diversity.

Considering the concepts, it should be noted that only "Dreamtime" was a truly intergenerational game, in the sense that it included a strong intergenerational collaboration. Furthermore, this concept included meaningful roles for players belonging to an older and a younger generation. This is consistent with the findings of McLaughlin and colleagues (2012), which found that video games provide a mechanism for social interaction between older and young players, by allowing players of varying abilities to play together through different levels of play and by testing each player according to their skill level. While "Escape the Room," "Facing Fears," and "The Game of Life" were not intergenerational in the same sense that Dreamtime was, they could be defined as semi-intergenerational in the sense that their themes and mechanics appealed to both the older adults and college student. Finally, the "Dating Assassin" and "Battlefield Simulator" games were created primarily by one team member while the other sat by and observed or even chatted with other groups while their own partner continued working alone. In this regard, some of the game designs did not emerge through the intended highly collaborative group effort, and certain games appealed more to certain age groups, with the dating game specifically being more relevant to college students.

This project lead to a number of games that were meaningful to their authors. Correspondingly, the results of the workshop fit well within the current emergence of "personal" games. As the costs to develop games have decreased, highly personal games such as the ones on display at the Different Games Conference, Gamejolt.com, or IndieCade have become more and more prevalent. Thus, we believe that the games designed in this workshop have more in common with independently published games than with mainstream games.

Finally, it is interesting to note that we found the games from this workshop to be very different from the typical outcomes of design research projects that aim to market games for older adults for the goal of improving physique or cognitive health. Even though the older adults initially indicated that they are interested in games that would provide certain benefits, the resulting concepts have no ties to brain training or fitness games. In fact, the only game that would come close to having demonstrable benefits (i.e., "The Game of Life") deals with smart life choices, wisdom, and crystallized skills, as opposed to training fluid skills or improving physical health.

Correspondingly, we would argue that results fit some of the theoretical points that were made at the beginning of this chapter. All four concepts that were developed in intergenerational unison could potentially lead to positive intellectual and health outcomes. For example, "Dreamtime" could foster social interaction, "Escape the Room" and "The Game of Life" could train crystallized intelligence and problem-solving skills, and "Facing Fears" could become a form of anxiety training or stress management. Nonetheless, they all demonstrate a sense of integrated game design (Habgood 2007), and their content has no direct connections to age-related stereotypes. In this regard, the project outcomes seem to fit within the design manifesto by De Schutter and Vanden Abeele (2015) that argues that digital games for older adults should emphasize personal growth over usefulness or age-related decline.

While this chapter does not attempt to provide empirical evidence for such claims, as both the challenge to create a meaningful game and the input of the college students certainly had some influence on the outcomes of the project, it does demonstrate that older adults can have great fun in designing meaningful games when provided with a creative setting to do so.

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Online Educational Games: Guidelines for Intergenerational Use

Louise Sauvé

Abstract Creating effective online educational games for seniors in an intergenerational context requires that these games be adapted to the players and educational goals being pursued. To improve the quality of life for seniors through the use of digital game, we must develop these games so they are able to be adapted to players' cognitive and physical demands. Using a user-centered design process that relies on an ergonomic approach, we took into account the ergonomic criteria of utility and usability to build an online educational game. In an intergenerational context, these criteria must be able to satisfy two types of users: seniors (those aged 55 and over) and secondary (young people 12 to 18 years old). In this chapter, we describe the ergonomic requirements that were used to adapt an existing game, Bingo, for these two types of players and we illustrate these through the online educational game *Live Well, Live Healthy!*.

Keywords ergonomic criteria • educational games • online • intergenerational • seniors • young people

Introduction

What do we know about ergonomic requirements for creating an effective online educational game for seniors to play with younger generations? Researchers have pointed out that the effectiveness of educational games depends on players' needs and individual characteristics and that we need to develop systems that can adapt to their demands (De Schutter 2011; Diaz-Orueta et al. 2012; Marston 2013). Although digital games can provide physical, cognitive, and social benefits to enhance seniors' health and quality of life (Whitlock et al. 2011), an ineffective design can discourage seniors from playing. But can adapting educational games to seniors' ergonomic requirements in turn create barriers for young people who play with their elders in an intergenerational context?

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We consider that an online educational game is effective when it meets two quality criteria: it must be *useful*, or adapted to the learning objectives and the prior knowledge of users, and *usable*, i.e., easy to learn and to play (Adams and Rollings 2003; Nielsen 2000). Mainstream games are often difficult for seniors to use because they do not accommodate older adults' cognitive and physical needs (Connolly 2013; Hwang et al. 2011). To construct an effective educational game interface for seniors, game developers must take into account ergonomic requirements that ensure that the game is adapted to the cognitive and physical characteristics of seniors. Similarly, for the game to be appealing to younger players, it must contain features that challenge and engage them. This chapter describes an approach to designing an online educational game, based on a board game model that takes into account design guidelines for both seniors and younger players.

Although some recent literature addresses ergonomics and ergonomic standards for video games (Game Accessibility Guidelines 2012-2015; Nogier 2008), it has little application for online board games for seniors and even less for board games with explicit learning objectives. We address this gap here by first describing the methodology we relied on to identify usefulness and usability criteria for an online board game (hereafter referred to as the "game"). We then discuss the ergonomic requirements used in adapting the game of Bingo for seniors in an intergenerational context. Finally, we illustrate how we applied these requirements to the design of the Bingo-based game *Live Well, Live Healthy!*.

Ergonomics for Online Educational Games

Ergonomics is a body of science related to humans and their interactions with systems. It is necessary for designing tools, machines, and devices for use with maximum comfort, security, and effectiveness (Wisner 1972). For gaming environments, the ergonomist develops and implements solutions to inform and guide the player while minimizing cognitive load (effectiveness) and ensuring that the game is easy to play (comfort), safe (security), and enjoyable. This applies to all external and internal components of the game. For us, "external" refers to interface elements such as menus, mechanisms for interacting with the game (menus, choosing a game, choosing an avatar, viewing scores, viewing game scores, and learning outcomes, responding to an evaluation questionnaire, etc.) and "internal" refers to all the components needed to play the game, including the board, pieces, the dice/abacus/roulette, instructions, tutorial, rules, visual and textual player identification, and the score.

Our game development approach is rooted in a user-centered design methodology. This design approach is derived from computer ergonomics, in which the needs, expectations, and characteristics of users are taken into account at every stage of the development process (Nielsen 2000). This differs from other approaches in seeking to adapt the product (in this case, an online educational game) to the

needs and preferences of the end user and, if appropriate, to those of a secondary user, rather than imposing characteristics imagined by the product's designers.

Ergonomically, this approach is based on utility and usability criteria. Utility expresses the ability of the game to meet learning objectives defined for a specific user in a specific context for use. Usability incorporates the ability of the game's external and internal environments to be intuitive to use and to adapt to the characteristics of the target players. Usability is high if (1) a game's navigation and display makes it easy to understand and to play, so that player–game interactions are simple and fluid; and (2) the game is stimulating in its design, maintaining a sufficient level of difficulty (challenge and competition) to provide a fun and enjoyable gaming experience (Schell 2010).

Our use of this methodology is iterative, allowing us to identify areas for improvement during the modeling phase (through testing a mockup of the game on paper), the prototype phase (testing a limited version of the programmed game), and during implementation of the final version of the game (online testing of the full game). In our experience over the past 20 years, our online educational games have normally required two or three iterations to finalize a game's design; this is consistent with the recommendations of Nogier (2008). In this chapter, we focus on the ergonomic requirements that achieved a high degree of player satisfaction with the Bingo-based game *Live Well, Live Healthy!* (Sauvé et al. 2016).

Usability of the Game

To provide for experimentation in an intergenerational context, the game *Live Well, Live Healthy!* targeted adults aged 55 years or more, together with young people aged 12 to 18. We began by conducting a literature review to synthesize ergonomic criteria for both of these groups. Concurrently, we surveyed 317 seniors aged 55 and over in Quebec. Two categories of seniors were identified: those who are currently 65, the threshold that delineates "seniors" according to Statistics Canada, and those who are considered the next generation of seniors, adults aged between 55 and 64. Respondents most frequently mentioned the games of Bingo (30.2%) and Solitaire (30.0%). We chose to adapt Bingo into an online educational game that could be used in an intergenerational context.

The documented criteria were tested in a game prototype with the help of 27 seniors (Sauvé and Veniere 2014). This was followed by an experiment in an authentic environment with 87 seniors (Sauvé et al. 2016) who were independent or semi-independent and lived at home or in a seniors' residence. In this experiment, the majority of participants (78.2%) considered themselves novices with online games, and none considered themselves expert players. The game was tested over 1 week with groups of three to six players who played two to four times. Using a Likert-scale questionnaire, we found a high degree of satisfaction among seniors with the game's design (from 3.05 to 4.25/5) and user-friendliness (4.09 to 4.37/5). This was

a first step toward ensuring that seniors felt comfortable with the game's external and internal environments and had enough fun playing the game that they would continue to play after the end of the testing.

The remainder of this chapter describes in detail the ergonomic requirements that we defined for an intergenerational online educational game and the ways in which we applied them to the Bingo adaptation *Live Well, Live Healthy!*

Game Design

The design of a game first refers to its essential attributes: competition/challenge, number of players, rules, and the predetermined goal (Sauvé et al. 2010). It also encompasses the game's educational aspects, including how the learning content and feedback are integrated into the game. We will now examine the ergonomic requirements for these aspects of the game design.

Competition

Various mechanisms are found in the literature to ensure challenging and healthy competition in online educational games (Sauvé et al. 2016). To support intergenerational competition, the game should include levels of difficulty or challenge appropriate to the knowledge, age, and physical abilities of the targeted players (Diaz-Orueta et al. 2012). Concerning knowledge, the learning content must be graduated from the simple to the complex (De Schutter 2011). We have suggested that a game should offer at least three levels of difficulty (Sauvé 2010a). It is equally important that the game mechanics allow players to select increasingly difficult questions from one game to another in order to maintain a sense of challenge, especially for youth. In terms of age, the use of short games (5 to 15 min) is recommended for seniors, as is the use of a function to vary the duration of the game (Ogomori et al. 2011). This condition does not seem to influence the young in their game preferences (Sauvé 2010a). In terms of physicality, it is necessary to provide options that allow seniors to adapt the game to their reaction speed, degree of autonomy, and physical ability (Sauvé et al. 2016).

To maintain a degree of uncertainty (challenge) throughout the game (De Schutter 2011; Marston and Smith 2012; Sauvé 2010a), we suggest that random events be added. For example, unforeseen situations or bonus cards can be generated by the system in order to reduce the gap between opponents who are sometimes too strong or too weak. In another example, chance may be nonexistent in one level of a game while, in a subsequent level, chance intervenes more to make the player's task more difficult and maintain their motivation. Chance can thus be a contributing factor to increasing the level of difficulty within a game.

Number of Players

To ensure older adults' active participation in gameplay, we must take into account their physical and cognitive limitations (Mubin et al. 2008). One possibility is to include in the game design the option to play as a team. Various strategies can be implemented, for example (1) playing on the same computer with a family member (such as a child) who can help to navigate within the game, or (2) participating passively in a multiplayer game as a spectator or as a teammate of an active player (Al Mahmud et al. 2012). Because chat requires high concentration from seniors (Wiemeyer and Kliem 2012), such play scenarios must be facilitated by a real-time audio communication tool to enable team play and mutual assistance.

It is also necessary to sustain in players a sense of immersion (flow) throughout the game (Dinet and Bastien 2011). Mechanisms for earning points maintain players' motivation, whether they are young or old. The game's sights and sounds should meet the expectations of the intended players. For the young, it seems important to include relevant contextual elements (e.g., advertising Formula 1 races in a motor sports game). Finally, we must pay special attention to visual elements (balanced male and female), sounds (both male and female voices), and the values conveyed by the game so that it is encourages the participation of the elderly of both sexes (Al Mahmud et al. 2012; Mubin et al. 2008).

Rules

The rules are instructions, simple or complex, which describe the relationship between the players and the game environment (Sauvé 2010b). Understanding the rules of the game and mastering them gives players a sense of control in the game interface (joysticks, buttons, movement in the game, etc.) (Dinet and Bastien 2011). We must therefore make sure that seniors as well as young players master these quickly and easily.

A recommended way to engage seniors is to use known games with few and well-understood rules, since confusion about the rules can discourage seniors from playing (Gamberini et al. 2006). Al Mahmud et al. (2012) and Mubin et al. (2008) suggest adding new rules to known games to maintain challenge and manage the integration of learning content. Finally, we must make the rules accessible at any time through a single click from any page of the game's internal environment (Sauvé 2010a).

Predetermined Goal

The predetermined goal of a game refers to how a game ends and to its notions of reward and victory. A game must have a goal and winners (Marin et al. 2011; Whitlock et al. 2011). The rules that determine winners and losers can be formulated to engage players' abilities and knowledge; for example, by giving points to

young people based on their reaction speed in the game when answering, manipulating, drawing, or writing (Sauvé 2010a) and giving points to seniors for correct answers and actions (Kickmeier-Rust et al. 2012).

For educational games, it is important to link points gained to positive learning outcomes and their loss to negative results (Kickmeier-Rust et al. 2012; Ogomori et al. 2011). However, fewer points must be lost than gained in order to maintain seniors' interest, particularly for those who have little knowledge of the game's subject matter (Wu et al. 2012). Acquiring points in connection with performance increases seniors' self-confidence, while displaying players' scores and highlighting the winner motivates seniors to replay the game.

Learning Content

Studies show that a balance between play time and learning time is needed to maintain players' motivation, whether they are young or old. To maintain this balance, the learning content in the game must be properly measured so that there is a place for chance and for actions that are only related to the pleasure of playing (Sauvé 2010a; Sauvé et al. 2016).

To integrate learning content into the game without creating cognitive overload for seniors, information should be broken up into small units (one or two lines) or simple questions. It seems best to use closed questions (true/false or multiple choice with one or more answers), sentence completion, or objects to be matched, therefore facilitating older adults' participation without highlighting their memory difficulties (Diaz-Orueta et al. 2012; Sauvé et al. 2016).

For seniors, we recommend repeating questions or information units within a game. We found useful to limit the number of questions and learning activities, reusing them several times during the game. Repeating content elements allows seniors to recognize them and consider them useful for their progress in the game (Diaz-Orueta et al. 2012). However, repetition of the same content or questions demotivates young people, especially boys. We suggest gradually reducing repetition as the degree of difficulty increases in order to maintain competition and young people's interest (Sauvé 2010a).

Feedback

In an online educational game, feedback is generally related to navigation and learning (Sauvé et al. 2016). For learners who perform actions in the game to achieve learning, on-the-spot feedback is recommended (Callari et al. 2012). The result of each learning activity (success or failure) should be highlighted by visual or audible feedback, such as a smiling or sad face, a positive or negative sound tone, or points added to the player's score (Lopez-Martinez et al. 2011). For an incorrect response, the game should provide textual, visual, or auditory feedback about the content together with additional information about a correct response, in order to

sustain the player's interest (Marston and Smith 2012). At the end of a game, it is important to display the learning outcomes with a general view of players' results for the learning activities, and to provide access to learning materials for reviewing subject matter that was not learned (Sauvé 2010a).

For older adult players, immediate feedback about their actions is also recommended. This feedback often takes the form of a tutorial, guiding each player throughout the game to enable them to see the results of their actions (Senger et al. 2012; Wu et al. 2012). The tutorial facilitates understanding of the game without forcing seniors to learn the rules quickly, thus reducing their cognitive load (Marston and Smith 2012). In an intergenerational context, the tutorial should be available when needed and accessible at any time by a simple click. The instructions should be simple and contextualized to facilitate comprehension of the game, helping seniors to avoid demotivating mistakes (Lopez-Martinez et al. 2011). The tutorial should give explicit instructions using the imperative forms of verbs and/or offer reinforcements for the execution of tasks. It should also use visual and auditory elements to guide seniors in their actions; examples and metaphors from everyday life facilitate this process. It should be noted that the error messages should be clear and always displayed in the same place on the screen. Finally, message boxes should be available when needed and accessible at any time by a simple click.

A demonstration of the game in the form of a short video (2–3 min) can help both young and older players to understand the game (Callari et al. 2012; Lopez-Martinez et al. 2011).

User-Friendliness in the game

User-friendliness refers to the qualities of a digital game that make it easy and pleasant to use and understand, even for someone with little computer knowledge. The role of the game's external and internal environments is to help the player focus on what is important.

A visual interface that does not sufficiently highlight the essential elements to be looked at is problematic (Kellner 2008). Problems in the use of technologies reported by seniors are predominantly associated with user-friendliness (navigation and display) and could be resolved by an appropriate design. A simple interface with short texts, color, large fonts, and icons can greatly reduce confusion and increase ease of use. For seniors, the game's user-friendliness also depends on using appropriate physical equipment to accommodate eyesight and dexterity problems.

Navigation in the Game's External Environment

To make the game intuitive, the external environment (game interface) should not require that seniors think hard about what they have to do (Caprani et al. 2012). First, we must standardize the different pages of the game's external environment,

using screen layouts, navigation, and terms that are consistent, simple, and easily understood (Lopez-Martinez et al. 2011; Sauvé 2010b). Position important information on the left and bottom of the screen and/or the middle and bottom of the screen. Choose the top right of the display to present graphics, texts, or quantifications. Simplify navigation menus to minimize the amount of information that must be memorized (Lee and Park 2013). Avoid complex visual displays by using known visual clues to reduce searching; seniors often forget command names and waste a lot of time searching for basic information. Reduce the number of steps and controls needed to accomplish a task (Gamberini et al. 2006; Lee and Park 2013). Older people prefer a more direct way to access information without deep hierarchies although this constraint has not been found in younger players. Avoid replacing a page with another without using a visual alert or sound (Muskens et al. 2014).

Navigation in the Game's Internal Environment

To make the internal environment of the game intuitive, designers should be careful to make sure that seniors always have access to all components (board, pawns/tiles/tokens, navigation buttons, instructions/tutorials, rules, and score) needed for the game to run smoothly (Barnard et al. 2013; Hwang et al. 2011; Nielsen 2000; Ogomori et al. 2011; Sauvé et al. 2016; Wu et al. 2012). Providing useful information during the course of a game gives players more control over their gameplay. In an intergenerational context, pay particular attention to elements such as blinking, animations, new windows, and cascading menus that are not useful for the game but are intended to maintain interest (Caprani et al. 2012; Muskens et al. 2014). Young people appreciate graphic cues such as blinking and short animations to highlight important information (Sauvé 2010b), but age-related attention span deficits might make these distracting for older players.

We also advise caution in positioning scores and game rules at the bottom of the page as they might be outside the field of view for users with small screens (Adams and Rollings 2003; Nielsen 2000). Minimize the use of superimposed windows during the course of a game. Because some older users are less likely to notice page changes and can become confused, a clear notification of a change of screens should be displayed (e.g., when the player goes from the "game" page to a "Questions/Information" page) (Shneiderman and Plaisant 2004). Finally, excessive mouse clicks (more than three) to access game components should be avoided, since this slows down the pace of the game and undermines players' motivation (Lopez-Martinez et al. 2011; Nogier 2008; Whitlock et al. 2011).

Displaying the Game's Internal Environment

To facilitate players' movement in the game, it is very important to make sure that the game and its components display without overflowing the screen and without blocking some game elements (Lopez-Martinez et al. 2011; Sauvé 2010b). For a

comfortable gameplay experience, use a predetermined frame or a responsive web design to maintain a standard display layout across screens. Make sure that the game board and accessories for playing cover most of the screen, and especially avoid scroll bars in page displays, since these especially frustrate young people.

To facilitate in-game learning, activity and question content should be limited to one screen page. This avoids long and tedious scrolling on the screen, which particularly demotivates youth and seniors with short attention spans (Barnard et al. 2013; Ogomori et al. 2011; Sauvé 2010b; Wu et al. 2012). Similarly, if content is integrated into questions, all relevant information (e.g., points to win, degree of difficulty, question, answer, feedback, and access to the material for a review) must be available to the player through single clicks.

Equipment for Playing

Game equipment, such as a laptop, tablet, keyboard, or joystick, must be used with some constraints to make them comfortable for seniors (Sauvé et al. 2016). Complicated physical actions, such as those that require a double-click of the mouse or that force the player to precisely control a pointer on the screen while having to correctly press a button, should be avoided (Sauvé 2010b; Lopez-Martinez et al. 2011). Mouse handling should be reduced to essential actions, since it requires hand-eye coordination and increases cognitive load (Al Mahmud et al. 2012; Marin et al. 2011). Instead, use the arrow keys of a standard keyboard or a keyboard adapted to handle the game. For seniors, avoid newer technologies that require high skills for effective use (Lopez-Martinez et al. 2011). These constraints do not typically apply to younger players.

If a game controller is used, we recommend using devices that are one-handed, such as the computer mouse or the Wii Remote. Tablets or smart phones must have screen sizes that are large enough to clearly display needed information (Al Mahmud et al. 2012; Marin et al. 2011).

Adapting an Educational Game to the Ergonomic Requirements

As mentioned above, we chose to create an online educational game for seniors and youth based on Bingo, which was the most popular game played by the seniors in our survey.

We will now outline how the structure and content of this popular game was adapted to create an online educational game for seniors in an intergenerational context.

Fig. 1 Welcome screen for the game

Game Design

Competition: In our Bingo adaptation, it takes at least two participants to establish competition between seniors and up to a maximum of 12 (Fig. 1C) for intergenerational teams. Players can vary the length of the game by choosing how the game ends and therefore deciding the game time: completing a vertical row of boxes requires less time than a full card or the contour of a card (Fig. 1B). Similarly, players can choose their level of difficulty before the start of the game (Fig. 1A). These levels (easy, medium, or difficult) are based on the players' knowledge of the game's learning content.

Number of players: In the game, players have access to audio and textual communication tools. A microphone is associated with the avatar of each player (Fig. 2G) to promote exchanges in real time, and a chat space (Fig. 2H) is provided for seniors who do not have a sound card available.

Rules of the game: During game development, the rules were validated with seniors in terms of their understanding (Fig. 2I). Some rules were added in connection with the learning content and game challenges. Bonus points were incorporated to reduce the imbalance of a game when some players have significant knowledge of the material and others have little or none.

Predetermined goal: The different ways in which the game ends were maintained (Fig. 2E): a horizontal or vertical line, crossed diagonal lines, card edges, and the full card. The rules were amended to determine the winners and losers in the context of an online game without a game master. The first player to click the "Bingo" button (Fig. 2D) after having correctly placed their tokens on the Bingo

Fig. 2 Point system

card wins 50 points. Players who have "Bingo" at the same time but were not fast enough to click first on the "Bingo" button, receive 25 points instead of 50. Should a player click the "Bingo" button without having properly placed their tokens, the game continues and the player loses 25 points. The score for each player is displayed at all times in the game's internal environment (Fig. 2F). Points that reward or penalize players as they answer the questions correctly or not allow the players to place a token in one of the boxes on the card. The penalty is 50% less than a gain in order to maintain the interest of players, especially for those who have little knowledge about the content being learned.

Game's learning content: The learning content was divided and allocated to question cards that appear whenever a number of a randomly drawn ball is on the card of one or more players. If the player answers the question correctly, a token appears in the box and gains points (20 points for an easy question, 30 points for a medium question, and 50 points for a difficult question). If the player fails to correctly answer the question, no token appears in the box and the player loses half the points allocated to the question. We prepared 100 questions instead of 75 (number of balls) distributed across three levels of complexity with regard to learning: easy (75% easy questions and 25% medium questions); medium (75% medium questions and 25% difficult questions); and difficult (100% difficult questions). To ensure balance in an intergenerational context, players are invited to choose the Easy level if they wish for questions to be repeated at least twice. The Difficult level uses repetition only if players opt for the full card as the endgame.

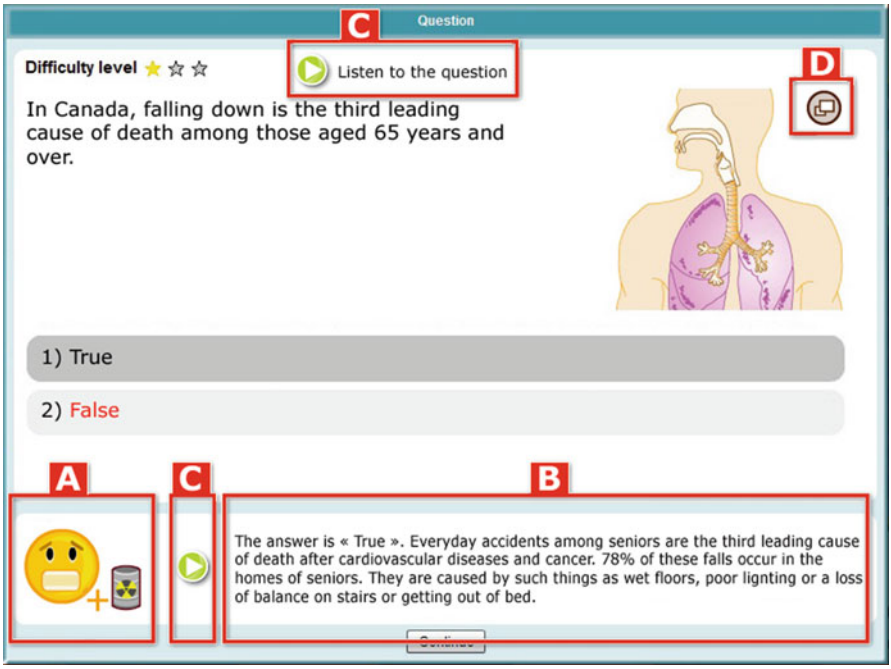

Fig. 3 Question card

Feedback: When a player answers a question card, there is immediate feedback on the result (success or failure) in the form of a smiling or sad face (Fig. 3A) with a positive or negative sound as well as textual and auditory feedback to explain the correct answer (Fig. 3B and C).

When the game is over, each player can see his/her learning process in the game's external environment. Fig. 4 displays questions that were not correctly answered and the proposed content for reviewing the subject matter.

A tutorial, accessible if needed, was included in the internal environment of the game to guide players throughout the game (Fig. 5A). They can at any time open and close it with a single click. We have also made available in the external environment a short video that explains the flow of the game.

At the end of the game, the score of each player is displayed, the winner is identified by a Bingo button, and the order of the players is given based on their performance in answering the learning questions (Fig. 6). On this page, players are encouraged to review the results of their learning activities by clicking on "My learning" or to play again by clicking on "Continue."

Fig. 4 Example of learning feedback

Fig. 5 Example of a tutorial

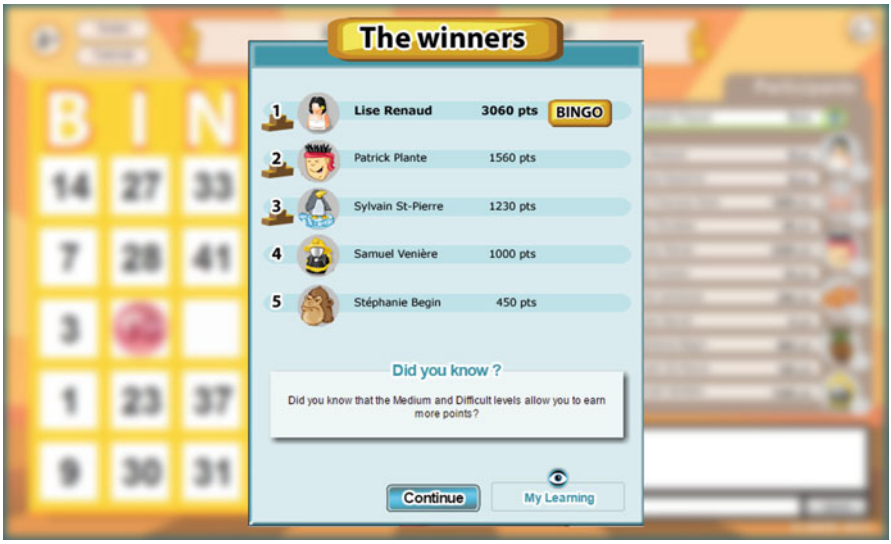

Fig. 6 Ending a bingo game

User-Friendliness

Onscreen display of the components of the internal environment: The game board display format was programmed to respond to the smallest resolution used by our target clientele (1024 × 768) as well as for display on tablets. For screens with larger dimensions, we inserted a background of the same color as the background of the board and programmed the display so that the board is positioned in the center of the screen. This window is always visible regardless of the other superimposed windows that appear. A second window may appear superimposed on the game board. It contains questions, answers and feedback, the tutorial, or the rules of the game. The size of this window is variable but always smaller than that of the board. Finally, the onscreen display of the game components requires no waiting time and no use of scroll bars in the web page.

Navigation in the game: The internal environment of the game was divided into three zones (Fig. 2): (A) information about the game: Bingo card, rules, and tutorial; (B) information on the flow of the game: game type, ball drawn at random, the Bingo button to end the game, and the number of players who have not completed an action that is in progress; and (C) the information related to player actions: player names and their scores and controls for the microphone and chat. Each of the player's actions is chosen by a single click. Finally, we have limited the number of superimposed windows to two. When the second window appears at the center of the screen, the game board becomes greyed out and inactive, as shown in Fig. 5.

Game controls: Double clicking was not used to perform actions, whether to answer questions, to place a token in a box, or to interact with other players using

real-time verbal communication tools. As for the recommended physical equipment for the game, we opted for lightweight tactile screens that are touch sensitive; these allow seniors to adjust text size and images and allow the moving of game elements with a finger. To play on the computer, a player must move or click the mouse to perform a game action.

Conclusions

Establishing the usability of an online educational game is not to provide help or to excessively simplify the game, but to allow all targeted players, whether beginners or experts, to enjoy the game. In an intergenerational context, while adapting the educational game to the requirements of seniors, some aspects should be taken into account to maintain young people's game motivation.

Finally, other ergonomic requirements, related to the use of tablets and the handling of touch screens, must be added to those presented in this chapter; these requirements will be tested in future studies. Further research will be also conducted with seniors to consider whether our guidelines for the design of online educational games are consistent with those for more general online learning and web design although our research to date suggests that these are similar (e.g., see Arch and Abou-Zahra 2010). Our immediate next step is to test this educational game in an intergenerational context to ensure that grandchildren (aged 12 to 18) will have the same playing pleasure as their grandparents.

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Blurring the Lines of Age: Intergenerational Collaboration in Alternate Reality Games

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Abstract Intergenerational play and collaboration can be valuable for various age cohorts. However, there has been limited research that explores such intergenerational play especially in the context of intergenerational games. In this chapter, we explore the idea of using alternate reality games (ARGs) for intergenerational collaborative learning. ARGs provide an opportunity for pervasive, immersive, gameplay where cooperation and collaboration are often required. First, we describe the role of serious games for older adults and intergenerational learning. Second, we describe ARGs as a new genre of game for collaborative learning and articulate a series of design considerations for creating ARGs for intergenerational learning for youth and older adults. These focus on ways to promote collaboration, blurring the boundaries between real life and the game, utilizing collaborative storytelling, and using demographic-specific mixed media as part of ARGs.

Keywords Alternate reality games • Intergenerational learning • Digital games • Older adults

Introduction

Intergenerational contact is becoming increasingly limited due to age segregation through institutions, culture, change in housing situations, and other factors (Hagestad and Uhlenberg 2005). Such contact is important for the well-being of all generations. For example, previous studies have found benefits in intergenerational

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relationships such as a higher sense of emotional well-being (Weintraub and Killian 2007) and life satisfaction (Meshel and Mcglynn 2004) in older adults, and a reduction of ageism and lower depression rates in younger generations (Ruiz and Silverstein 2007). Relationships between youth and their grandparents have been found to provide a mutual beneficial exchange of social support (Moffatt et al. 2012). On the other hand, limited intergenerational contact may contribute to ageism (prejudice against age) (Hagestad and Uhlenberg 2005). Ageist views are often more acceptable than other forms of prejudice and this can be seen through societal facets such as media representation, workplace, and institutions (Nelson 2005). Increasing intergenerational relationships may help to ease some of these perceptions (Hagestad and Uhlenberg 2005; Nelson 2005). One possibility of this is by having intergenerational groups engage meaningfully in an interactive environment where collaboration and cooperation occur. Beyond the benefit of simply interacting, they may be able to form new understandings through the coming together of differing perspectives. Furthermore, this could contribute to personal growth and a sense of lifelong learning.

Technology may help to enhance intergenerational interaction and create an environment of reciprocal learning (Kenner et al. 2007). Digital games, for example, are increasingly being studied as mediums to help establish and maintain intergenerational contact (Aarsand 2007; Chua et al. 2013) where they can act as learning environments (Siyahhan et al. 2010). This is the focus of the current chapter where we explore multiplayer games that allow players to collaborate and problem-solve in a situated or contextual environment. *Alternate reality games* (ARG) represent one genre of game that has this type of environment and potential for increasing intergenerational interaction and learning, but has had limited research conducted around such topics. An alternate reality game is a transmedia experience spanning various types and forms of media that combines collaborative storytelling with game elements and uses real life as a medium (Bonsignore et al. 2012). It is argued that ARGs may have the potential to promote intergenerational learning, where players can collaborate and try to solve real-world issues (Hausknecht 2015).

The remainder of this chapter explores this topic. First, we describe the ways in which researchers have studied games for older adults and intergenerational learning. This provides a backdrop for our specific research explorations. Second, we provide the reader with a definition and background understanding of alternate reality games and their potential for supporting learning. Here we describe several ARGs in detail as illustrative examples. Third, we step back and assess ARGs as intergenerational learning tools by articulating a series of design considerations that should be thought about when creating ARGs to connect two distinct demographic groups, youth and older adults. Our overarching goal is to provide the reader with a deeper sense of how ARGs may be valuable in the context of intergenerational learning and what factors will be critical for their successful design.

Serious Games and Older Adults

Over the last 10 years, there has been an increase in research on older adults and serious games. The Entertainment Software Association (2015) report found that 27% of gamers are 50 years or older. However, this has been a largely ignored demographic group by the game industry and researchers until recently. This is not overly surprising as games are often seen as the territory of youth, but are believed to fade in importance as we age (De Schutter and Abeele 2015). In contrast, play as a valuable human experience in the later years has been downplayed. Much of the research on older adults has focused on examining the benefits to quality of life. Researchers have examined social (Schell et al. 2016), cognitive (Basak et al. 2008), and physiological aspects (Wiemeyer and Kliem 2012), or they have focused on accessibility issues (Sauvé et al. 2013). Although this research has value and has added to our understanding, it tends to emphasize concepts of aging as a declining state instead of exploring what benefits age might bring (De Schutter and Abeele 2015). When considering age-related changes, it is important to look beyond perceptions of a negative decline and decreased performance, as there are also many individuals that gain knowledge, wisdom, and an in-depth understanding from life experiences (Hummert et al. 1994).

De Schutter and Abeele (2015) suggest a *gerontoludic manifesto* in designing and researching games for older adults where they put forth a number of adages. First, they suggest focusing on "playfulness over usefulness." Here play is seen as a valuable activity. Older adults should not need an excuse to play, but instead researchers should honor play as an expression and valuable activity. The next adage they suggest is "growth over decline." Aging is a process of both growth and decline; however, in our society the decline is often focused on more than growth when it comes to the older population. Personal growth and challenge are important to older adults and, thus, games for older adults could utilize this instead of focusing on how to stop decline (De Schutter and Abeele 2015). Finally, they articulate that games research and design should concentrate on "heterogeneity over stereotyping." Older adults who are gamers have a diversity of preferences, experiences, and physiological health. As such, there still needs to be consideration for accommodations when needed. Lynch and Vitols (2015) add to the manifesto by suggesting that gaming for self-expression and creativity should also be included while a final addition is the opportunity for community, such as in massively multiplayer online role-playing games (MMORPGs). Multiplayer games contain players who range in age where they can form valuable communities. Other social gaming experiences can also contribute to a sense of community as seen in research on a Wii Bowling tournament (Schell, et al. 2016), which found that game play created increased social connections. A follow-up study of this experience showed that many of these connections continued to be valuable additions to people's lives, and some groups maintained their cohesiveness long after the tournament was over (Hausknecht et al. 2015).

When it comes to game-based learning for older adults there is often a focus on cognitive stimulation, or brain training. However, this is aligned more with the reductionist view versus the adages suggested by De Schutter and Abeele (2015).

Instead, we are suggesting an approach to game design that, first, integrates the knowledge and experience of older adults and what they can share with youth and vice versa. Second, we are considering learning as collaborative. Some serious games, and those we are interested in, fall under the category of computer-supported collaborative learning (CSCL). Collaboration is where two or more individuals are in the act of knowledge construction together (Lipponen 2002). Furthermore, it can sometimes be discussed as knowledge construction that an individual would not have been able to create on their own (Stahl 2004). Thus, in designing games for these types of interactions, the focus is on experiences and challenges that can be overcome with group efforts.

We suggest that to address the principles of the gerontoludic manifesto proposed by De Schutter and Abeele (2015) and contribute to this discussion when conducting research and design on intergenerational learning, it is imperative not to focus on what the young person can do for the older person, but instead to frame the interaction as finding the best approach to create an environment where reciprocal learning and collaboration can occur (Koschmann 1996). Thus, how can the positive aspects of age, such as the possible knowledge gained through time, be used in ways that can benefit younger learners' knowledge construction? Mutually, in what ways can younger learners' experiences and understandings contribute to the knowledge construction of older adults? The rich variety of perspectives of multiple age groups could provide a fertile ground for learning. We argue that a style of game, alternate reality games, may be utilized for these purposes and suggests possible design approaches to enhance the intergenerational collaborative experience.

Serious Games and Intergenerational Learning and Interaction

Intergenerational learning can be considered learning that occurs between one or more generations (e.g., parent/child, grandparent/grandchild, and youth/older adult). Traditionally, research and theory on intergenerational learning has focused on unidirectional knowledge acquisition, usually from the older person to the young; however, these ideas have evolved to view intergenerational learning as a mutual sharing of the learning experience (Kenner et al. 2007). For example, the European Network For Intergenerational Learning (2015) describes it as "a learning partnership based on reciprocity and mutuality involving people of different ages where the generations work together to gain skills, values and knowledge." Thus, the emphasis is on the reciprocal relationship of learning. Furthermore, if perceived through a social constructivist lens, it is the knowledge construction that occurs between two different age cohorts. The emphasis is on a collaborative exchange, and not a top-down system. Consequently, intergenerational learning designs should consider the collaborative space and interactive affordances of the game. Various benefits of intergenerational learning have been reported specifically from psychologists where it has been found to have beneficial effects on well-being; however, it has also been

shown to be useful in creating a reflective environment through the exchange of differing experiences and perspectives (DeMichelis et al. 2015).

Digital games can serve as interactive environments that facilitate these types of intergenerational interactions. Several studies (Aarsand 2007; Siyahhan et al. 2010; Chua et al. 2013) have examined the possibility of increasing and developing intergenerational relationships using digital games with mixed success in regard to collaboration. Aarsand (2007) conducted an ethnographic study of families with children aged 8 to 10 years old and found that the digital divide was used in various ways to support intergenerational interaction during gameplay. The children often dominated the game control when playing with parents and grandparents since they had increased experience with the technology. However, this did not appear to affect the relationships negatively, but, instead, resulted in a positive exchange where the child was the knowledgeable teacher. As pointed out by Aarsand (2007), although the learning seems mainly asymmetrical, it also allows grandparents and parents to engage in a shared activity space.

Chua et al. (2013) conducted a longitudinal study on the perceptions of older adults and youth on playing a digital game. Older adults were recruited from two seniors' centers in Singapore where the study took place and were paired with a youth partner. Participants were randomly assigned to either the videogame group or a nonvideogame group. The experimental group met once a week for 2 months and played various Nintendo Wii games for sessions lasting around 30 min. The control group met for the same amount of time but were asked to simply interact with each other. The video game experiment group had higher positive increases in intergroup anxiety and attitudes compared to the control group. Intergroup anxiety was examined and they found that game group members became more comfortable around each other compared to the control group. Both groups increased the same in positive perceptions of the other participant, but the game group was found to have a spillover effect, so that they had a better attitude toward older adults/youth in general. The authors suggest that it may be due to the play being a context that requires a common goal and cooperation. They point out that the games were not selected for any specific reason and suggest games designed for intergenerational play may create a further synergistic ability to increase intergenerational relationships. This study showed positive results of reducing ageism through intergenerational play versus simply interacting, since participants who played games together had an increase in positive attitudes toward their partner's age cohort and not just the individual. If this effect remains, it could reduce ageism through a continued change in perceptions of different age groups.

Digital games focused on intergenerational collaboration have also been studied in educational settings. Siyahhan et al. (2010) conducted a study on an afterschool program called Family Quest that used a 3D immersive educational game (Quest Atlantis) played by 9–13 year olds and their parents. Positive results were found for parent–child relations in general but the dynamics varied between each pair. One challenge they encountered was that some dyads had different directions and desires based on traditional societal roles. For example, a father felt he needed to be the leader in the game and did not allow the son to negotiate the game's direction. This created tension between the players and the game due to family and community

norms. Siyahhan et al. (2010) propose that intergenerational games need to be designed to push back on societal norms. One particularly successful pair had similar intentions within the game and were able to exchange the role of expert at different times. Thus, each was contributing and collaborating to achieve a similar goal. They also found that when content was meaningful to both members, an example was a bullying scenario, it allowed for meaningful discussions to occur. Siyahhan et al. (2010) provide design principles for future game developments based on their results; in particular, they suggest designing games that are meaningful to participants, creating a space where both players will be motivated by similar intentions, and promoting a game narrative that challenges traditional norms. These suggestions may also relate to reducing ageist views. Similarly to the suggestions by Chua et al. (2013), having a common goal allows for collaboration and working together, as players interact with a dynamic environment that is influenced by player actions (Siyahhan et al. 2010). As players work together they may require mixed skill sets that allow for joint contribution. The addition of meaningful topics can create a space to communicate about subjects that are valued by both players and may also allow for consideration of varying perspectives. Furthermore, challenging traditional roles may require players to look past prejudice that is tied to age.

The above studies outline the possibility of using digital games to bridge generations and provide opportunities for intergenerational interaction. However, there are still a limited number of studies aimed at designing for intergenerational collaboration. In the above papers, one important area that emerged was the varying roles and negotiations of these roles against traditional norms. To enhance collaboration and allow for a more reciprocal learning experience, specific games designed for intergenerational collaboration may be valuable. One style of game that has the potential for being designed as a collaborative space for fostering learning and "pushing back" on traditional roles is alternate reality games. We describe these next.

Alternate Reality Games

Alternate reality games (ARGs) are a form of game that combines narrative, collaborative storytelling, mixed media, and puzzle solving. ARGs are an immersive form of game in which the narrative and a series of puzzle pieces make up the core components (Connolly et al. 2011). The game takes place over a mixed media environment, which could include websites, phone calls, real-life environments, newspapers, etc. Additionally, ARGs use media and narrative to blend the player's real life and game life creating a pervasive environment. Thus, ARGs attempt to blur the lines between reality and fiction (Benford et al. 2006).

ARGs start with some form of a "rabbit hole." This is the first point of contact between a player and the game and it guides the player to the game. Typical rabbit holes include a random link on a website, a QR code on a poster, or any clue that is deliberately left for players to discover the game. The puzzle pieces within the game are often designed to be solved through group efforts and collaboration between the

players, for example, clues may be left in various cities or require different skill sets. A "puppet master" is the person who orchestrates the events and guides players through the unfolding narrative. The storyline itself has a certain flexibility as players discover fragments of the narrative throughout their gameplay and share their interpretations with others in the group, creating a collaborative story (Bonsignore et al. 2012).

The narrative of ARGs have two layers, the macro or *canonical trajectory* that the designer creates, and the micro or *participant trajectory* that the player creates (Benford et al. 2006). It is the designers' decision on how much influence the players have over the narrative by creating gaps and points of convergence between the canonical and participant trajectories (Bonsignore et al. 2014). To explore the affordances of ARGs for collaboration and interaction, a more thorough examination is presented below using several exemplar games to illustrate the key design features that ARGs include; in particular, these include an immersive environment, collaborative storytelling, puzzle pieces, pervasive gameplay by blurring reality and game play, and counterfactual thinking.

Immersive Environment, Collaborative Storytelling, and Puzzle Pieces

Arguably, one of the first ARG was *The Beast*, which was launched in 2001 and ran for 3 months (Sebastian and Kinzie 2006). The Beast was a viral marketing campaign designed to promote Steven Spielberg's film, AI. The rabbit hole was found at the end of a trailer for the movie amidst one of the credit lines. Later, this same line was found on a poster. It read: Jeanine Salla "Sentient Machine Therapist." This was not a typical movie credit and if someone was curious—and there were people who were—they could do an online search for the person's name. This search revealed an entire biography of the person, including facts such as a fake university, family, and phone number. If a person phoned the number, they discovered that Jeanine's best friend, Evan Chan, had died on an AI boat. This lead to a series of clues that slowly revealed that the friend was murdered and the players needed to figure out who did it, while other narratives also arose as the story progressed. The game immersed people in the mystery by involving them in the unfolding story. In addition, people who called the phone number started receiving strange messages (via prerecorded phone calls and fax) as part of the game plot (Sebastian and Kinzie 2006). Near the end of the game's lifespan, Anti-Robot Militia rallies in New York, Chicago, and Los Angeles saw game players and actors interacting in real life with the actors passing on clues to those attending the rallies (Sebastian and Kinzie 2006).

During the game, players self-organized themselves into online forums in an attempt to solve the puzzles. The developers of *The Beast* left the game fairly open, allowing the players' storylines to be included in the unfolding plot. The story was being adjusted based on the players' experiences and pieces of the storyline were

written in as the game progressed. Thus, in this example, there was collaborative storytelling between the players and the puppet master. During the 3 months, players formed their own collaborative groups to solve complex problems within the ARG. Arguably, the most notable group was called Cloudmaker, which boasted approximately 7000 group members (Sebastian and Kinzie 2006). Sebastian and Kinzie (2006) used a combination of analysis from interviews of members of Cloudmaker and the pivotal points in the archives to explore why the game was engaging for players. First, the game was seen as being novel because it broke traditional game rules, particularly by having no clearly defined line between reality and fiction, which helped create an immersive environment. Second, the narrative itself was emerging throughout the game. This caused players to feel as if they had some control over the game's end. This engaging narrative was essential to continued gameplay, like reading a good book that the reader cannot put down.

These communities of learners, or possibly better worded, communities of problem solvers, came together with a set purpose of solving the mystery. Although the game was an advertising ploy, the possible educational value in regard to collaboration can be noted by the self-formation of groups to solve the puzzle pieces, collect clues, and contribute to the game together. Sebastian and Kinzie (2006) proposed that ARGs offer "potential for collaborative, socially-constructed learning during gameplay (p. 2354)." Puzzle pieces are the main problem artifacts in ARGs and help to provide an engaging problem-solving environment. Although there are more active players that may help keep the pace, the puzzle pieces require various types of knowledge (Sebastian and Kinzie 2006). This illustrates the potential for ARGs to act as intergenerational learning tools that can foster collaboration between multiple "topic experts" from varying age groups.

Pervasive Gameplay: Blurring the Lines

Part of the immersive capacity of ARGs is their pervasive nature. Pervasive games are games that allow play to cross over into the real world (Benford et al. 2005). Traditional video games often create a "magic circle" where the player knows they are in the game space and it is clear where the game ends and real life begins (Adams 2013). Yet ARGs sometimes deliberately manipulate this aspect, creating a pervasive environment. Part of the immersive ability of ARGs involves this blurring of the lines between reality and fantasy by interweaving the narrative with the real world (Whitton et al. 2014). In *The Beast*, this was seen from the initial rabbit hole on a movie trailer, to including a live rally in New York. An extreme example of pervasiveness is seen in the ARG called *Uncle Roy All Around You (URAY)*. URAY played with the boundaries of reality and fantasy in many ways. Gameplay started with players having to give up their personal items (including phones, wallets, etc.), briefing them on the game, and being given a PDA which they could use to guide themselves through the streets to find a mysterious figure called Uncle Roy (Benford et al. 2006). Collaboration occurred with an online player who tracked their

progress using an online map of the city. Players could communicate with each other and the online players could choose to help or hinder the efforts of the street player. Here, the lines were blurred by using live actors and the city as a game environment. Players did not always know whether people in the streets were actors or members of the general public and this could be used by the designers to increase the game's pervasiveness (Benford et al. 2006).

Benford et al. (2006) studied gameplay in *URAY* in three different cities. They gathered feedback from participants, and used ethnographic techniques such as observations of players, actors, and staff. They found that the game succeeded in blurring the lines between the real world and the fantasy world and this brought an exciting and different experience to the game for players (Benford et al. 2006). The advantage of blurring the lines was in creating a pervasive interactive experience. However, this same aspect also crossed the comfort levels of some players. A balance of allowing players to feel safe and yet still immersed may need to be carefully considered in future ARG designs, particularly for youth and older adults where safety is sometimes of increased concern.

Collaboration and Counterfactual Thinking

Counterfactual thinking and collaborative problem-solving are two aspects that have created a growing interest for using ARGs in education. ARGs can support counterfactual thinking which involve players examining the "what ifs" and weighing of different options (Bonsignore et al. 2012). The counterfactual opportunities and required collaboration of ARGs leave room for player input and the imagining of different scenarios (Bonsignore et al. 2012). One exemplar ARG that did this was *World Without Oil (WWO). WWO* took place over the first 32 weeks of a fictitious global oil crisis. Each day of gameplay represented a week in the narrative. Players participated in the scenario by posting blogs, videos, etc. where they attempted to solve the problems that occurred. Thus, differing perspectives came together in this "what if" scenario to solve problems that might occur if the world had an oil crisis (JafariNaimi and Meyers 2015). According to Connolly et al. (2011), the value of *WWO* was in playing out scenarios in a serious way to resolve real-world problems.

JafariNaimi and Meyers (2015) conducted a critical analysis of *World Without Oil*, asking questions such as whether it actually promoted problem solving and what kind of collaboration occurred. The game had 1900 people signed up, 1500 stories, and 60,000 observers. To better understand participation at a granular level, JafariNaimi and Meyers (2015) created a database of contributions. They captured 86 audio files, 1165 blog entries, 117 images, 114 emails, and 75 videos. They used quantitative data analysis to identify participation type and conducted a qualitative analysis on 232 randomly selected entries (15 % of total).

The quantitative analysis found similar results to other online forums: there were often a core set of contributors and, although many people signed up, not all were

active players (JafariNaimi and Meyers 2015). They described the players as toe dippers, lurkers, drop-outs, late-comers, and regulars. They found that the top 10 % of active players contributed half of the posts, suggesting an uneven distribution. However, people may have very different ways of being involved with these types of games. For example, they describe lurkers as people who posted only once at the end of the game. Yet their posts showed content that suggested they were active peripheral participants even if they were not actively involved within the unfolding narrative until the end. This suggests they were doing what has been termed "e-listening" which is differentiated from lurking as it can serve a valuable learning approach (Wise et al. 2014). Thus, they are still active players who engaged in other ways. Based on their combined analysis, JafariNaimi and Meyers (2015) concluded that *World Without Oil* allowed for a creative, interactive space for people to discuss a real social issue even though its design fell short of producing a deeper collaborative learning environment.

Alternate Reality Games for Learning

Several ARGs have been designed for educational purposes. One example is the *Arcane Gallery of Gadgetry* (*AGOG*), an ARG designed for a youth demographic in an educational setting (Bonsignore et al. 2012). This ARG focuses on the US Patent Office, which was a hub of innovation between 1836 and 1932. The game required students to use inquiry-based learning to examine history. The story starts with cryptic messages and a questioning of history, since history is tainted by the perspectives of the people who write about it (Bonsignore et al. 2012). From here students play the role of being part of a secret society in which they must examine historical texts that were recently discovered to see if they are accurate. Bonsignore et al. (2012) used a variety of design strategies including a pervasive transmedia interface, integrative participatory narrative, a blended hybrid story world, player participation and authenticity. Bonsignore and her design team attempted to create designed experiences, versus using the game to deliver content. Thus, it attempted to get the students to question history and make their own interpretations by providing gaps and inaccuracies.

The first iteration included sixty 13–15-year-old students, with 55 playing consistently. It took place over 2 weeks during a history class. Bonsignore et al. (2012) used a multimethod case study approach to study game play. Study results suggest that the game was an engaging collaborative experience where students needed to negotiate meaning. Some students reported enjoying feeling like spies, whereas others felt that they were constantly thinking about the different puzzle pieces and how to solve them, although a couple of students expressed frustration at having to think beyond "memorizing history." Even though more studies are needed, the researchers came away with a sense that the design allowed history to "come alive" through the fun interactive environment (Bonsignore et al. 2012). This is one of the few ARG designs for youth.

Although *WWO* may have only touched the surface of the potential for ARGs to be learning environments, it opened up many ideas and possibilities for using ARGs in education. Bonsignore et al. (2012) begin to show the true potential of using these games for a specific learning purpose and demographic. Through the series of challenges and unfolding narrative of ARGS, they may help create puzzlement and mystery, which in turn stimulate engagement as seen in *The Beast*. The above cases show the power of ARGs in terms of being pervasive, collaborative environments. The rich narrative and immersive quality of the games provide a possible situation where intergenerational collaboration could occur through an exchange of perspectives and negotiation with the game. Furthermore, the flexibility and adaptability of designs can provide a unique opportunity to address the heterogeneity while maintaining accessibility concerns. As with MMORPGs, these games have the ability to create rich communities that are engaging as seen in games such as *The Beast* and *WWO*. The focus on narrative in the games often allows for deep problem-solving techniques and the imaginative power of counterfactual thinking (Bonsignore et al. 2012). Such environments could create opportunities for different age groups to be immersed together. However, to harness the potential of these forms of games for intergenerational collaboration, an exploration of design considerations is a worthwhile approach.

Design Considerations

There have only been a few alternate reality game designs that have considered these game spaces for intergenerational collaboration and learning (e.g., Hausknecht 2015; Costa and Veloso 2014). This section examines and discusses possible design approaches for intergenerational collaboration within the game genre of ARGs. Our approach also attempts to address the concerns of the *gerontoludic manifesto* (De Schutter and Abeele 2015) by focusing on creating a reciprocal learning experience within play. Thus, the design approach utilizes the perspectives of both age cohorts—youth and older adults—to challenge their understanding of the world. This exchange of learning is situated within the rich environment of the game narrative and play mechanisms.

Crossing Game Trajectories for Collaboration

In this chapter, we showed that digital games can create an opportunity to bring intergenerational players together (Aarsand 2007; Siyahhan et al. 2010; Chua et al. 2013); however, many games are designed such that only one player can take on an expert role or one player may dominate due to traditional norms (Aarsand 2007; Siyahhan et al. 2010). This leaves limited room for collaborative gameplay or perceptions of reciprocal learning (Aarsand 2007; Siyahhan et al. 2010). One way to

design ARGs to overcome this is by creating specific game trajectories that require collaboration to move the game forward.

Benford et al. (2009) suggest that pervasive games, such as ARGs, can use a framework of trajectories as a design and research approach. The trajectories in a game involve the canonical trajectory and participant trajectory. The canonical trajectory is the experience and points in time that the designer intends the player to go through (Benford et al. 2006). However, within a game the players are able to also create their own participant trajectory that strays from and adds to the canonical trajectory depending on how open the game structure and narrative is. For example, as players figure out what elements are part of the game and which are not, they will move along their own path or trajectory and intersect with the canonical trajectory at points when their actions map to the actual game elements. Part of the success of an ARG is in the management of the tension between canonical and participant trajectories (Benford et al. 2009). Allowing players to stray too far from the canonical trajectory may cause play to be confusing, while forcing players to always stay on the canonical trajectory may make a game boring. The flexibility to move throughout the game environment and "come and go" from the canonical trajectory may create excitement for players as they discover the game's plotline and lead their own explorations.

We suggest that these ideas can be expanded upon when creating ARGs to support intergenerational collaboration. For example, when creating an ARG for both youth and older adults, one design strategy might be to create a single canonical trajectory through the game, thereby forcing both generations to participate in the same elements of game play. Yet this could be challenging since the same game elements may be too difficult or boring to one of the two demographics, or one player may become the expert throughout. An alternative strategy may, instead, involve designing multiple canonical paths though the game. There could be, for example one canonical trajectory for each generation. This path could be designed to be of specific interest to one of the two demographics, thus increasing interest in the game. To encourage collaboration and interactions between the generations, canonical paths through the game could then be designed to converge at various points. Interaction between players from each demographic could be necessary for further progression in the game. For example, players may need to come together to move the game forward, similar to finding different pieces of a puzzle and bringing them together and figuring out how they fit. Although there is hope that both players will collaborate when they are along the same trajectories, this divergence and convergence specifically requires both parties to be actively engaged in gameplay. Another approach may involve designing two different trajectories where players need the help of another at various points in order to progress along their own trajectory; one person may be considered an expert that can help out the other player at a certain point. For example, youth players may have to solve puzzles about World War II where older adults who are potentially subject-matter experts (by experiencing the war period firsthand) can help them progress on their path. Then the role of expert could change in the next set of puzzles.

Crossing Game Trajectories with Real-Life Trajectories

Previous intergenerational game studies have suggested the inclusion of "meaningful topics" within games (Siyahhan et al. 2010). Rich learning and discourse can occur when learners share multiple and varying perspectives (Stahl 2004). One way to create these experiences is through the incorporation of cohorts' real-life trajectories and history into the game.

In gerontology, *life course theory* considers many aspects that affect a person's life and how the interplay of different trajectories influence and create the individual's life course (Elder 1994), something not that dissimilar from game trajectories. Life course theory comprises of a number of factors including a sociohistorical perspective, life timing, linked lives, and human agency (Elder 1994). A sociohistorical perspective focuses on the importance of the birth year and what is happening historically for a person at different times of their life due to specific events. There is a certain cohort effect due to events occurring for these groups at the same time (Elder 1994). Historical points can affect a person's life course. For example, if a person was alive in World War II, their experience and understanding of the event will be very different depending on the age they were when it occurred. If they grew up as a child during World War II, it might have meant rationing food and possibly parents who were very busy or away; whereas, if they were adult men, it may have meant being a soldier in the war.

With this in mind, puzzle pieces and clues within ARGs could be used to leverage differences based on diverse cohort understanding. We are not suggesting stereotyping all people of a cohorts' experience. To the contrary, a person's memory and perspective of historical events could be used to generate meaningful discussions across generations. For example, designing a game narrative that takes players back to 9/11 and the terrorist attacks on the World Trade Center in the United States may provide a point in players' real-life timeline where they have specific experiences and knowledge to share. Thus, in using 9/11 as a narrative focal point, those born in the 1980s or earlier may remember the difference in security and governmental security measures. However, for those born after this point in time, their experience is a world that has always been this way. Both generations may be able to share their differing perspectives as part of the ARG.

Games designed with narrative that incorporate issues relevant to the players' lives allow for meaningful discussions to occur (Siyahhan et al. 2010). Incorporating meaningful experiences could be achieved by finding narrative that intertwines with topics of importance that cross both cohorts' timelines as suggested above, which leaves opportunity for sharing perspectives and reconstructing understanding. These may be very broad such as perspectives on fundamental human rights or issues that expand across time, such as woman's rights. They could also be very specific such as one's reactions to the Boston Marathon bombing on April 15, 2013. Furthermore, incorporating aspects of current topics or "what if" possible futures as seen in *WWO* allows for the pervasive feeling and blurring of the lines as it crosses with the person's real time in a person's life trajectory (Bonsignore et al. 2014).

Another possibility for utilizing the cohort effect is through the types of clues and codes used in an ARG. A person of a certain generation may be able to recognize Morse code (not necessarily read it), whereas a younger cohort may understand how Snapchat works and may see a clue embedded there more easily. Thus, a combination of leaving clues in recognizable forms and media for the two generations may help to keep the momentum of two players requiring each other's assistance to complete the game. This aligns two separate canonical trajectories where hopefully a variety of prior knowledge is required, increasing the likelihood of multiple experts throughout.

A final point on cohort effects is the differences in understanding of what play is (Brown and De Schutter 2016). The authors noted that cohort experience with play and digital games may be different and designs could consider such differences. For example, different age cohorts may have had certain games that were popular in their childhood/youth that were enjoyed and easily recognized (Brown and De Schutter 2016). These may shape their perceptions of play. Each player will be bringing their own experience of play to the ARG which will require negotiation during their collaborative interaction. Thus, there may be a reciprocal learning of what play means. For example, if a player is used to ludic style puzzle games such as Tetris while another has been involved with immersive Multiplayer narrative style games, the two may bring different skills and understanding to the game experience. Within the game, one player's understanding of play as fitting together of puzzle pieces and the other's understanding of an unfolding narrative may leave opportunity for showing each other the excitement of the different styles. Brown and De Schutter (2016) suggest that designers could also incorporate these effects by finding out which games were popular at different points in time.

Collaborative Storytelling

Alternate reality games provide the opportunity for knowledge construction through collaborative storytelling. As players attempt to make sense of the narrative pieces, they will also be adding to the narrative with their own understanding of the events (Bonsignore et al. 2014). ARGs provide the possibility for players to contribute to the game narrative, or at least feel like they do. Some games may use a thickly plotted narrative where the players neither veer too far off of the designed canonical trajectory, nor do they actually have much control over the plot. In these designs, there is often a strong guiding force as players are directed through certain narrative points (Bonsignore et al. 2014). On the other hand, some ARGs are loosely designed leaving a lot of room for player input, such as in *World Without Oil* (Bonsignore et al. 2014). This allows for counterfactual thinking, but may create a less guided gameplay (Bonsignore et al. 2014). This balance could be particularly important within a game designed for players who may not have experience with these styles of gaming environments. Scaffolding may need to be carefully structured. Hausknecht (2015) suggested progressing in phases, easing players into the pervasive mixed media environment.

Furthermore, in learning environments there is often a need for player guidance from the start (Romero et al. 2012). Leaving the game too open may not work for all players, especially those with varying levels of experience and understanding that could easily occur with intergenerational games. However, guidance should not influence the narrative, the immersive nature, or the pervasiveness of the game negatively. Opportunities are available for just-in-time guidance from characters that push the narrative forward. Including guidelines within plot structure or even within clues may be a useful way to create continuity.

The narrative is a large feature in ARGs and it can guide characters in positive or negative directions. As noted by JafariNaimi and Meyers (2015) in examining *WWO*, the design of the interface and focus on oil prices guided players to continually focus on transport issues, rather than a broader set of concerns. This may have limited the possibility of further in-depth discussions amongst players. Thus, when considering this for a combined interaction of youth and older adults, the guiding structure of the narrative needs to be targeted to the desired collaboration and knowledge construction.

Mixed Media

Alternate reality games are mixed media experiences that span different types of online and offline media. Depending on the media and the skill level of the players, this may pose difficulties. The experience may require a certain level of scaffolding and guidance to move the players between media types. Content may also need to be designed for different types of media, given the differing skill levels (e.g., text messaging for older adults as it may be a new technology to them, but Vine for young adults to reflect their interests). Or, one could design for the same media and suggest that the two demographics collaborate to help guide each other. At times, the younger person may utilize their skills and teach the older adults how to understand and use the new technology. As mentioned, one would not want this to be the game's entire focus as it would create a one directional approach to learning, yet this could still be a valuable learning and teaching approach at certain points in the game.

Another important aspect is the design of the rabbit hole and an ARG's main web site, if it has one. Intergenerational ARGs would need to be designed cautiously such that all players would be able to find the rabbit hole and main site and recognize them as such. An example of where the rabbit hole could pose a problem is given with the ARGs for Orientation, Socialisation and Induction (ARGOSI) project that took place in Europe. This included a game called ViolaQuest that provided students at Manchester Metropolitan University with an alternative process for induction, getting to know others, and providing information literacy (Whitton et al. 2014). One difficulty they encountered was advertising through a rabbit hole. While the researchers had a specific rabbit hole that students were meant to engage with, the students did not realize what it was. Many students said they did not understand

the purpose, yet when it was explained to them they said they would have been really interested in the game (Whitton et al. 2014). Thus, this project points to an important design flaw for educational settings. Although traditional ARGs use rabbit holes for initial discovery, and then word of mouth starts to take hold, with a specific target audience, this may not be viable. Having an obscure entry point into the game would likely also not work for a range of diverse players. Thus, a design with a targeted audience will likely need an overt rabbit hole that explicitly guides players to the game. For example, after players agree to play, they could receive an email link that is clearly related to the game and denoted as the starting point. This may come back to understandings of play. If players have not experienced an ARG before, they may not immediately understand that "anything" could be part of the game.

While working with youth, Bonsignore et al. (2012) found that having one main web site for sharing information (with multiple subpages) was easier in a learning environment with the cohort they were working with. Initial ARG designs may need to include plans for increased guidance where needed. For example, Hausknecht (2015) suggested incorporating characters who play as players and provide extra guidance where needed, while not ruining the flow of gameplay.

Conclusion

Alternate reality games could provide an opportunity for intergenerational collaboration and learning that can use varying skills and world views to contribute to game play. Their pervasive nature allows for engagement and a crossing of real-life trajectories with game trajectories. This may allow for points where meaningful discussions can occur.

We believe that we have addressed some of the current concerns of game-based learning across the lifespan, particularly where older adults are concerned, by exploring games as a means for contributing to intergenerational learning that is reciprocal, playful, and meaningful to players. Such games may ease some of the tensions between experts and novices as seen in previous research on intergenerational play. It is hoped that the interaction within such games will also help to reduce ageism through playful interaction, shared experience, and negotiating different perspectives.

We have presented background research that describes ARGs as intergenerational learning environments, along with a series of design considerations that suggest the ways in which ARGs may fulfill this role. While grounded in the related literature, as well as our expertise in game study and design, these design considerations are certainly preliminary. We suggest that designers of educational systems and games consider them as a starting point for design explorations such that they can be verified, critiqued, and built upon as a part of future research.

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Implementing Maker Spaces to Promote Cross-Generational Sharing and Learning

Sylvie Barma, Margarida Romero, and Rollande Deslandes

Abstract In this chapter, we seek to contribute to a reflection on cross-generational sharing and learning by presenting a position paper on the potential that the implementation of maker spaces presents in formal and informal educational settings. We first discuss the main characteristics of the maker movement and illustrate some concrete activities that are taking place in Montreal and Quebec City. We then explore to which extent students build knowledge within maker spaces, acquiring knowledge, and competencies through a participatory approach with the extended members of the school community. Our conclusions highlight the great potential that maker spaces hold for the improvement of cross-generational relationships and for the foundation of learning across the lifespan.

Keywords Cross-generational learning • Boundary crossing • Communities • Maker spaces • Families

Introduction

In this chapter, we seek to contribute to a reflection on cross-generational sharing and learning by presenting a position paper on the potential that the implementation of maker spaces presents in formal and informal educational settings. We first discuss the main characteristics of the maker movement and illustrate some concrete activities that are taking place in Montreal and Quebec City. We then explore to which extent students build knowledge within maker spaces, acquiring knowledge, and competencies through a participatory approach with the extended members of the school community. Our conclusions highlight the great potential that maker spaces hold for the improvement of cross-generational relationships and for the foundation of learning across the lifespan.

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The maker movement aims to interconnect people who want to engage in constructing and tinkering with objects, new technologies, and digital tools (Dougherty 2012). According to Dougherty, the community and the maker interconnectedness are at the basis of the maker movement and an essential trait of the maker spaces reuniting makers of different ages for learning and creating artifacts together. While the term "maker space" is widely used in North America, the term "FabLab" (Fabrication Lab) is sometimes used to describe it. In both cases, the spaces unite people interested in technological tinkering and in the co-construction of artifacts (Suire 2016). For Capdevila (2013, p. 2), "Hacker spaces, Maker spaces, Living Labs, FabLabs or co-working spaces are common denominations of localized spaces of collaborative innovation (LSCI) where knowledge communities meet to collectively innovate spaces of collaborative innovation." For this author, common features of these spaces include openness to the public and shared norms related to the way they share information, tools, and knowledge among the different participants sharing these collaborative spaces of innovation.

From an educational perspective, maker spaces have a great potential for the fostering of learning in science and technology and other fields. They provide opportunities for cross-generational projects too. Maker spaces are defined by Scalfani and Sahib (2013) as "informal learning environments where users are physically brought together in a highly collaborative setting to create and explore research as a team" (p. 11). They are also starting to be integrated in formal education for age-specific groups. For instance, maker spaces in elementary schools are considered a children-oriented space where teams explore techno-physical solutions. At the high school level, teenagers find new spaces to connect with each other and also with their teachers and many parents also get involved in the support of such initiatives. The allotted time for learning and making is redefined as new spaces and schedules emerge. Let us now dive into this emerging culture, namely the maker movement.

Maker Movement: General Considerations

Occidental societies have been organized in increasingly specialized group activities which tend to concentrate citizens according to their main role in society: toddlers are placed in kindergartens, children in schools and children-oriented extracurricular or leisure activities, teenagers in high schools, adults in professional organizations or leisure activities, and older adults in foster care and older adults' leisure activities. The age segregation in current societies has led to a high level of isolation, especially among older adults (Hagestad and Uhlenberg 2006; Vanderbeck 2007). Families including grandparents, parents, and children are becoming minorities and there is an increase in average physical distance between different family members (Hallman and Joseph 1999). Community centers, which are one of the structures having greater facility for the creation of intergenerational activities, have also embraced the age-specific leisure orientation, making short time slots of

age-based group activities where there is very little time for activities that could help to create a sense of cross-generational community. The opportunities and spaces for intergeneration activities within community centers are still innovative programs that are not generalized globally (Kaplan 1997). Considering that different family generations live in different households separated geographically, there is a reduction of informal learning opportunities inside the family because of limited and, often computer-based, interactions. Outside families, intergenerational learning opportunities are very limited (Fielding 2011) despite the obvious value of older adults' experience-based knowledge and younger generations' technological strategies that could be transferred to older generations. Creating maker spaces for joint projects requiring both experience-based and technological know-how could be an opportunity not only for different types of intergenerational learning but also for achieving the goal of inclusive design (Clarkson et al. 2013) when creating new technological artifacts. Maker spaces are "open to do-it-yourselfers of varied backgrounds and ages" (Savage 2013, p. 20) which can contribute to the development of scientific career interest among younger participants and a better relationship to science and technology in older adults. Diving into the maker culture has inevitable impact in the formal educational setting. We see why and how it has an impact on traditional pedagogical practices in the classroom.

Maker Spaces to Challenge Traditional Models of Teaching and Learning Across Generations

According to the OECD (2001), the knowledge public space is in constant motion (OECD 2001). The second half of the twentieth century was marked by the production and distribution of a large amount of knowledge and the development of communication technologies (ICT). These changes have transformed the social, industrial, and technological environments in which we live. We are witnessing the transformation of family structures and the labor market as well as a change in the learning and school public spaces (Maroy and Cattonar 2002; Tardif 2012). Individuals are asked to take on new challenges in a world marked by a significant amount of new information, such as the development and mobilization of new skills allowing the individual to live and emancipate (Aikenhead 2006; Barma et al. 2015; Jones and Graham 2015). The most significant consequences of these changes include trades multiplication and job diversification (Savickas, et al. 2010). According to some American statistics, young people today will have an average of 11 different jobs between 18 and 42 years (US Bureau of Labor Statistics, 2008). Prospects for employment are less predictable and the transitions are becoming more frequent and more difficult (Savickas et al 2010). These changes encourage the worker to develop skills and competencies related to sophisticated technologies, thus meeting challenges related to expectations of flexibility rather than stability, and making it possible to maintain their employability and the creation of their own job opportunities.

Countering the Documented Decline of Interest in Science and Technology

Younger generations in Canada are putting aside science studies accentuating the deterioration of scientific culture, resulting in irreparable loss of know-how essential to the functioning of enterprises, economy, and society in general (Robitaille 2010). According to the World Economic Forum (WEF 2014), the competitiveness of economies is a key issue in the economic growth of a country, but for the past 3 years, the quality of mathematics and science and technology teaching is declining, positioning Canada in 18th place behind Finland, Switzerland, and France. It is also declining with respect to the use of the newest technologies (31st place). This situation is worrying and it justifies the importance of equipping individuals in order to better understand a social reality increasingly marked by science and technology (Aikenhead 2006). Science education has been taught in a traditional form in Quebec universities, with very little innovation in the latest years. The recent integration of educational robotics and coding has introduced new constructionist approaches (Papert and Harel 1991) where learners learn by modeling, constructing, and evaluating techno-physical artifacts. This enriches socio-constructionist approaches and the increasing use of game-based learning both in formal and informal contexts (Kaszap and Rail 2010). The maker activities engaging learners in modeling techno-physical artifacts through electronic and robotics components could help to develop interest in science, technology, and art for learners engaged in a tangible constructionist process. Younger generations need to have relevant situations presented to them that could lead to a personal commitment on their part over a longer period of time and the development of a positive feeling regarding a scientific concept (Barma 2011, Lacasse and Barma 2012). Many researchers suggest that implementing innovations in and outside of the classroom allows the development of a positive feeling about scientific concepts (Eick and Reed 2002).

Originally, most typical "interests enjoyed by the maker culture included engineering-oriented pursuits such as electronics, robotics, 3D printing, and the use of digital control tools, as well as more traditional activities such as metalworking, woodworking, and traditional arts and crafts" (retrieved from https://en.wikipedia.org/wiki/Maker_culture). Maker spaces have the potential to be participatory activity systems that engage students, their teachers, and the community in a modeling approach and construction of artifacts both digital (programming and visualization) and tangible (objects and technological systems). Building prototypes using computer supported software or engaging in analytical retroengineering is also a collaborative activity. To this end, research sheds light on the importance of using educational activities that guide students toward a design approach or a testing of technical objects (Crismond 2001a, b; Edelson 2001; Lacasse and Barma 2012). It promotes better critical analysis of technical objects and their integration with scientific concepts. This recalls Vygotsky (1978) who argues that learning is based on

Fig. 1 A wooden windmill capable of producing up to 40 V

the activity, context, and culture in which it is done (Greeno 1998; Lave and Wenger 1991) and the learning-by-making approach (Papert and Harel 1991). Koballa and Glynn (2007), as well as Eick and Reed (2002), who report that a majority of students want a greater proportion of practical work. Hodson (2006) highlights the relevance of science teaching in light of practical work. According to these researchers, teachers must not only focus on *minds on* approaches, but also on *hands on* approaches.

A concrete example of this trend has been implemented in Quebec high schools where an applied science curriculum is mainly oriented toward a pedagogical approach rooted in technical objects, technological systems, and products more or less familiar to the students, but still part of their environment. In Quebec City, since 2010, Barma has brought together 84 teachers and lab technicians to accompany more than 500 10th and 11th graders to design and produce technical objects such as wooden windmills or wooden microscopes they can bring home and use in their backyards. Figures 1 and 2 provide a concrete representation of the technical objects produced by students.

The preliminary results of the 6-year study are very encouraging and highlight the importance of contextual active learning to enhance student's self esteem and interest in science, technology, and craft (Lacasse and Barma 2012). One of the most promising openings for researchers is a shift of perception of the world of technical production by students: they become makers, not only consumers.

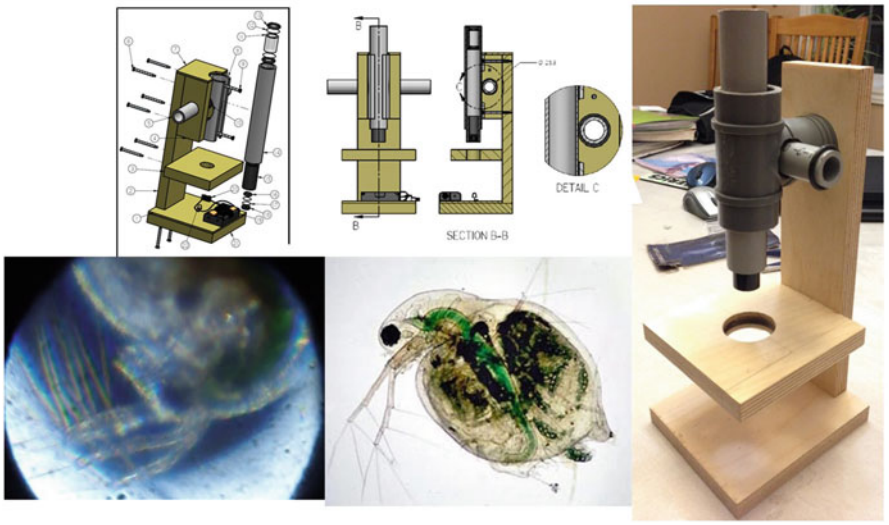

Fig. 2 A wooden microscope in progress. Possible magnification to look at a daphnia around 100× (depending on students' precision)

Building on the Maker Culture to Promote Cross-Generational Dialog

Maker spaces seek the long-term cultural transformation of material consumption to a culture of knowledge creation (Katterfeldt 2014). There are nine key ideas underlying the maker culture: making, sharing, giving, learning, equipping, playing, participating, supporting, and promoting change. The importance attributed to the construction of physical objects (physical artifacts), in addition to promoting the creation of digital spaces (digital artifacts) is a feature of the maker device that distinguishes it from previous information technology revolutions. In 2012, Chris Anderson, then chief editor of Wired magazine, compared the maker to a new industrial revolution. Maker spaces promote (1) the creation of new digital applications by programming learning and (2) their intersection with areas traditionally separated as manual work on machine tools and other working methods in workshops. It also encourages the reconciliation of education in formal and informal environments. For decades, some researchers have seen expertise as an essential part of learning (Martinez and Stager 2013). The development of skills in action encourages learners to be aware of the consequences of their actions and of the influences and positive changes they can create in their school or in their community (Gee 2007; Gouvernement du Québec 2011). Playing, experimenting, investigating, and solving problems are actions that progressive educators have put forward in their classes (Halverson and Sheridan 2014). Concrete examples of creative maker spaces in schools appear as open public places where machine tools or 3D

printers are computer driven for the design and construction of objects by and for the students. Many see it as a major effort of democratization of teaching and learning science and technology (Gershenfeld 2008). Coffield (2000) argues that "informal learning is not an inferior form of learning": it is very important and valuable too.

For the past 5 years, the maker movement has been growing in North America not only within communities but also in the field of education in science, technology, engineering, and mathematics (STEM) (Halverson and Sheridan 2014). Based on the data from hackerspaces.org, Capdevila (2013) observes the apparition of the first Hacker spaces in 1982, but he observes the change from a marginal expression of the hacker culture to the popularization of these collaborative learning innovation spaces since 2007. In Quebec, we are witnessing the emergence of different initiatives in the form of FabLabs or digital manufacturing citizen workshops. In Montreal, Communautique is a "non-profit organization dedicated to promoting information literacy and promoting civic participation via communication technologies. They aim for a democratic cyberculture that is available for everyone, to combat socioeconomic exclusion and promote resourcefulness and self-reliance" (communautique.qc.ca). Communautique hosts not only different initiatives of collaborative spaces of innovation but also training services. The SAT Urban Hub aims to provide facilities and support facilities for Montreal and Quebec artists, researchers, and business developers. In Quebec, the Espace Lab of Quebec is organized as a part of the MIT FabLab networks and is hosted in the Bibliothèque Monique Corriveau in order to facilitate access for a large public. In addition to this public and non-profit initiatives some private schools are also developing their maker spaces as a way to transform the traditional library into a co-creation space for innovation and learning through construction (Papert and Harel 1991).

Inspiring Initiatives to Promote Interaction Between Parent–Adolescent and School–Family–Community

Maker spaces are also a way to promote interaction between parent–adolescent and school–family–community. In line with Epstein's (2011) and Hoover–Dempsey's works (Walker et al. 2010), and the "out-of-school learning opportunities" highlighted by the Harvard Research Project, we suggest providing informal science and technology events. By partnering with community organizations, businesses, and local universities, it becomes possible to have access to resources that are essential for the success of such an event, that is, space, vendors, content experts, volunteers, and money. These activities bring together parents and youngsters and even the whole family to play together, to understand science and technology education, to learn from each other, and to share new knowledge. As Henderson et al. (2007) point out some parents are hungry for knowledge. Frequently, children will pair up with parents or other community members when it comes to more high-tech areas. These experiences raise awareness among students and their parents that what they

learn in school matters in their life outside the classroom. By experiencing such activities, parents and members of the community can encourage youngsters to develop their creativity, their autonomy, and their critical-thinking skills (McCubbins et al. 2014). As members of a community of learning, they themselves become more informed of youth's experience in traditional schooling.

Moreover, in light of extensive work over the last decades regarding school–family–community collaboration and interaction between parents and adolescents (Deslandes 1996, 2006, 2009, 2015; Castelli et al. 2003a, b; Epstein 2011; Henderson et al 2007), this sharing is a means that is likely to foster family and community involvement with their youth. Indeed, studies have shown that school practices influence parental involvement in schooling (Dauber and Epstein 1993). The interactions between parents and adolescents characterized by warmth and acceptance and through which parents express an interest in the youngsters and promote their autonomy contribute to the development of their identity, their sense of responsibility, and their full potential (Deslandes 2005, 2007; Deslandes et al. 2008). The role of the student, participating with his/her parent(s), is also an important element of effective family–school collaboration (Deslandes and Bertrand 2005). For its part, the community–school partnership refers to links between schools, community members, organizations, and mid-community affairs that directly or indirectly support and encourage growth and social, emotional, physical, and intellectual youth (Little et al. 2008). This may be neighborhoods, community organizations, businesses, cultural groups, municipalities, universities, sharing norms, values, and attitudes that can be targeted to promote learning, success, and student retention (Deslandes 2011; Epstein 2011; Sanders 2010). In a formal education setting such as the school, a system put forward in maker spaces, that seems to be working with our southern neighbors, might suggest avenues to promote the appropriation of knowledge by high school students and change their relationship to the larger community fostering cross-generational interest and dialog.

Maker Spaces and Cultural Activity Theory: Hybrid Spaces to Promote Cross-Generational Learning

Cultural historical activity theory (CHAT) is now guiding our reflections to foster collaborative relationships between student's diverse age groups or between other members of the community. CHAT focuses on how new forms of learning can be addressed and how they may enable social innovation (Engeström 1987; Engeström 2015). This theory holds that the learning activities are socially situated human activities (Parks 2000). Reading social innovation in the form of cross-generational interrelations makes us consider school education a form of human activity that cannot be reduced to content or pedagogical methods for fostering learning (Engeström 1987). In sociocultural theories, activities undertaken by an individual are closely related to a conscious goal, a motivation that is linked to the actual

context in which the activity is occurring. Regarding personal motivators, some teachers believe that working with parents is part and parcel of their professional responsibilities: that they are expected to do so from both the school and the district leaders as well as making a difference in actively supporting parental involvement in students' learning (Deslandes et al. 2015).

In line with other sociocultural and cultural-historical scholars (Hedegaard 2005; Monk 2011; Rogoff 2003), we believe that we must move away from unidirectional and top-down transmission models in investigating intergenerational learning. It is no more a question of exclusive straightforward linear view. CHAT opens up an alternative lens to study the processes involved in intergenerational learning with its concepts of participation, mediation, and motives along with artifacts (e.g., technological devices) and tools (e.g., communication). It is thus possible to study reciprocal influences and transformations that are happening between parents and adolescents and other members of the community. Maker space situations provide social opportunities for participation that acts as a mediator of transformation of knowledge and practice learning within and between generations. Maker spaces can provide the openness for creativity to take root as well as more content-oriented subject topics. The educational activities developed in maker spaces are in support of collaborative product development. The process of problem solving and co-creativity is part of the constructivist process (learning-by-making) (Papert and Harel 1991) related to computational thinking (Wing 2006) that mobilizes computer programming as knowledge modeling. In terms of the activity system, it is now possible to identify several activity systems that will be involved in the process of putting into place maker spaces or of sharing events in different settings: classroom, school, family, or the larger community. This wealth of diverse backgrounds refers to the concept of hybrid space development. It requires that several activity systems come into relationship with each other for the establishment of a zone of proximal development. This new shared space called hybrid assumes that at each of the boundaries of the students', teachers', or community members' activity systems, individuals will take action to pursue the goal of sharing maker experiences across generations (Fig. 3).

To understand the creative object under construction and expansion (the maker spaces for maker activities), the border is a key concept. Kerosuo (2006) defines the boundaries as "established distinctions and differences between and within activity systems that are created and approved by groups and individual actors during a long period of time while they are involved in these activities" (p. 4). Gutiérrez et al. (1999) show how a classroom in itself is a polycontextual environment and is constitutive of multiple connected systems and informal spaces of learning contexts. Transforming school activities in their expansion through the construction of hybrid spaces is an idea from the third generation of activity theory (Engeström 1987). We find the metaphor of expansion fruitful in the context of our positioning on the maker movement because it puts primacy on communities whose members learn "something that is not yet there" (Engeström 2001). Applying Gutiérrez and Calabrese Barton's (2015) notion of building a Third Space or a hybrid space, maker

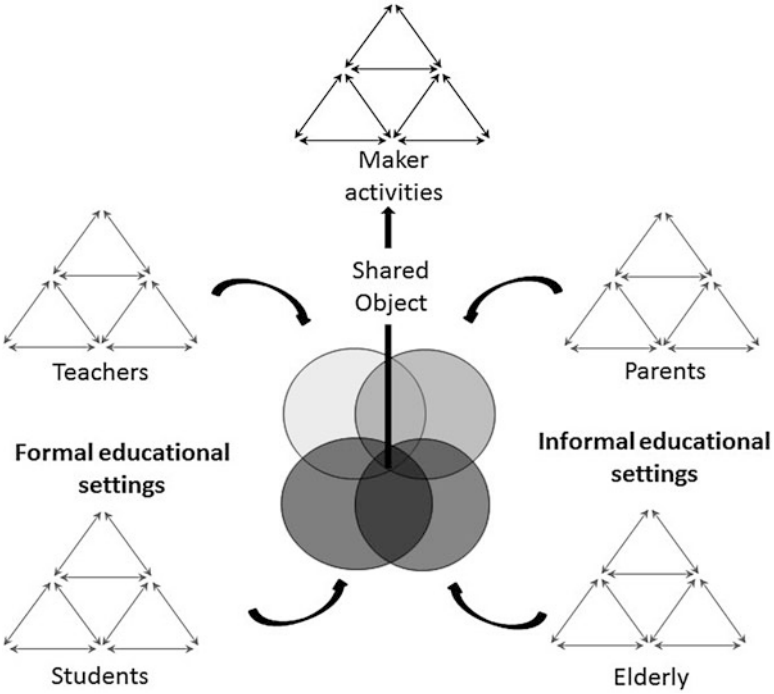

Fig. 3 Sharing an object and providing conditions to put in place maker activities

spaces can reveal organizational, pedagogical, and social imaginaries. Yamazumi (2008) pointed out that the projects in schools should teach the content in reference to their social development and outside the school context. This is in fact what pedagogical practices linked to maker spaces are likely to facilitate and put into place.

Opening Up Toward the Future

Maker spaces will enhance both the "old way" of working in classrooms such as experimentation, work on machine tools, and the essential digital skills to develop in the twenty-first century. We strongly believe that encouraging individuals to participate in maker activities can be an important advance in terms of knowledge creation. Little empirical research has been done to document the impact on students as well as the influence maker spaces can have on cross-generational dialog. The sharing of experiences and maker expertise may contribute to the dissemination and the demystification of knowledge creation among students, parents, and the general public.

On the occasion of a conference organized by the BBC recently, the British astrophysicist Stephen Hawking said that one of the greatest threats to humanity is

currently linked to the progress of science and technology. In our opinion, this statement is a strong incentive to put forward learning experiences and provide maker spaces for the benefit of cross-generational dialog and the empowerment of all citizens to develop twenty-first century skills. These new hybrid spaces may be revealed as fruitful to address future cutting-edge technological challenges and shared knowledge built with members of their community. In the United States and in some Canadian provinces, makers appear as passionate individuals who come together in associations, schools, institutions, and enterprises. It is imperative that the policy makers and stakeholders get involved in this process. The impacts go beyond the school setting and meet the identity dimension so important across life. Sharing fairs put forward the importance of school–family–community relations. It bridges intergenerational differences. Canada has entered a period when there are more baby boomers than teens under 16 years. The maker movement can be an effective means of combating intergenerational tensions because maker fairs are meant to be public and participatory. Dialog between adolescents and adults around issues like industrial robotics, drones, 3D printing, repair, or welding of electronic circuits may contribute to a demystification of all technological progress. From the perspective of teaching practices, co-modeling of educational activities between researchers and practitioners is a unique way to motivate the extended educational community. In response to a decrease in the interest of scientific careers, in the long-term, knowledge creation in maker spaces may restore confidence to young people in their capacity to produce, play, and no longer act only as mere passive consumers but as creative, critical, and active citizens.

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Promoting Intergenerational Participation Through Game Creation Activities

Hubert Ouellet, Margarida Romero, and Kimberly Sawchuk

Abstract This chapter analyzes game creation as a way to promote intergenerational participation, develop new learning opportunities, and help reduce generational segregation through the use of ICT. We start discussing the current societal challenges including digital ageism, digital access, and interaction (Sawchuk and Lafontaine 2015) among elders and the generation segregation (Thang 2011). We then introduce the activities developed within the Silver Gaming group in the *Ageing + Communication + Technologies* partnership project (http://www.actproject.ca) to advance our understanding of how applied research activities can contribute to the development of participatory game creation and different types of digital games (Romero and Loos 2015). Within the context of the ACT Silver Gaming activities, this chapter explores four instances that used game creation as an intergenerational participation activity. The first activity, held in a secondary school of the Québec City metropolitan area used making a game to bring together the life narrative of an older adult who had immigrated to Québec with secondary level students. The second and third occurrences were held during the *Silver Gaming International Summer School* (SGISS) in August, 2015, reuniting participants starting from secondary level students and adults from different ages groups. The fourth instance was a workshop held in September, 2015, at an intergenerational activity day at *La Maison Léon-Provancher*, a Québec city-based organization that is promoting biology, science, and technology to grade-school children and the community, including their parents and grandparents. We end the paper by discussing the limits and opportunities of the game creation as a way to promote, through creative uses of ICTs, intergenerational participation, and learning.

Keywords Intergenerational • Game design • Digital ageism • Participatory game creation • Game creation • Serious games

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Introduction

In many ways, game creation can be seen as a cross-generational Trojan horse: its alluring exterior sparks curiosity and is expected to announce unlimited fun to children and teens—are not games *supposed* to be fun? (Bourgonjon et al. 2013). Children see game creation as a way to tinker with computers and express themselves (Brennan and Williams 1995; Caperton 2012). As Livingstone and Bovill has contended, children are generally curious about technologies (2013) and engage in trial and error, copying and demonstration strategies to develop their understanding of technologies (Plowman et al. 2008). In contrast, research has indicated that there are more reflexive uses of technologies amongst older adults (Hyvönen et al. 2013), who often analyze the potential of technologies before deciding to use them. This way of thinking technological usage by older adults tends to be less impulsive than the trial-and-error discoveries of the younger users of technologies (Boyd 2014). Because of the higher degree of critical thinking toward the use of technologies among older adults observed within the CoCreat Lifelong Learning project (Hyvönen et al. 2013; Romero et al. 2012), we cannot assume that older adults who do not show "unconditional techno enthusiasm" are ICT illiterates or have difficulties in using "new" technologies; their reflexive appreciation of technological artifacts leads to different engagements with technologies, which may be less intensive in terms of ICT frequency and time-on-task and more oriented toward the accomplishment of predefined communicational goals, creative activities, or information searching. While this suggests different intergenerational learning styles, it is difficult to predict or define levels of ICT literacy or the degree of interest in technologies by younger or older generations that consider age as the only significant factor. Despite the discussion of the existence and advantages of the so-called digital natives in terms of ICT skills (Bennett et al. 2008) and the myth of the homogeneity of older adults in their relation to technologies (Mitzner et al. 2010), there is a growing corpus of evidence that point to a high level of diversity within age cohorts and much variability regardless of the age of the subject (De Schutter 2015; De Schutter and Malliet 2014). In our experiences with intergenerational game development, we have observed both highly connected, gizmo-oriented older adults and technophobes and techno-agnostics among children and teens (Plowman and McPake 2013). The main argument for the existence of digital natives is that technology creates a gulf between generations and that these differences become innate because users are born into different generational cohorts. By staging learning experiences that allow end-users from different age groups to show their digital diversity and creativity, these arguments can be addressed and redressed. This chapter contributes to our understanding of these critiques through a reflexive self-examination of game creation as an opportunity for learning-by-doing at different stages of the lifespan and as an opportunity for intergenerational learning (Romero 2015).

Stereotyping Digital literacy

A persistent argument in the current literature is that older adults should acquire a certain digital literacy before engaging in the digital society (De George-Walker and Tyler 2014) because of their status of "digital immigrants" (Loos 2012). Children, by contrast, are assumed to be "digital natives" and are supposed to have a certain degree of digital literacy because they started using technologies younger (Bennett et al. 2008); age is used as the determining factor in identifying who are digital literates. But is it really the case? As Boyd (2014) argues:

> Teens may make their own media or share content online, but this does not mean that they inherently have the knowledge or perspective to critically examine what they consume. Being exposed to information or imagery through the internet and engaging with social media do not make someone a savvy interpreter of the meaning behind these artifacts. Technology is constantly reworking social and information systems, but teens will not become critical contributors to this ecosystem simply because they were born in an age when these technologies were pervasive. (Boyd 2014, p. 177).

Let us go back to the etymology of the word *literate*. Linked closely to the Latin *literatus*, it means "educated, learned". It is not specified *how* we learn or are educated. We argue that digital literacy is neither linked to age nor is it innate. As with any skill or competence, "it requires hard work, regardless of age" (Boyd 2014, p. 177). We also argue that digital literacy is not necessarily acquired in a linear manner. Digital literacy can be acquired in a variety of ways and in a variety of contexts or settings across the life course. Our research hypothesis depends on the potential of game creation activities as an opportunity to foster intergenerational learning.

Game Creation as a Participatory Intergenerational Learning Activity

Game creation could be used as a participatory activity in the pursuit of strengthening—or even, in some cases, *establishing*—the link between generations (Kayali et al. 2015; Khaled et al. 2014). Each of the four activities developed within the Silver Gaming group will be described in the following section. The intergenerational game creation activities described in this chapter are based on a participatory design approach toward digital interactive narratives and knowledge-based games (Blat et al. 2012; Vanden Abeele and Van Rompaey 2006). Our aim is to engage both younger and older people in digital creation activities (Hyvönen et al. 2013; Uzor et al. 2012) that are oriented toward the development of the creative uses of technologies (Romero and Barberà 2015). The goal of this intergenerational learning activity is not toward affirming the life narrative as a *product*, with a defined teleological end goal that is the same for all, but as a digital life narrative where the conditions for participatory creation as an intergenerational learning process are set into motion.

Intergenerational Game Creation on Immigration

The first activity, created with secondary-level students was held in a school in the Québec City metropolitan area and centered on the life narrative of an older adult, who self-identified as an immigrant to Québec. The activity took place in the context of curricular demands that students should develop their critical thinking abilities within the social studies curriculum. Social studies curriculum in Québec follows "In-World" studies programs, and in this model the learning situation must enable the students to interpret and take a position on sociohistorical and geographical issues. This first intergenerational pilot project aimed to analyze the relevancy of an intergenerational learning activity for developing the students' critical thinking on the topic of immigration. The activity brought together high school students and an older adult (50+) entrepreneur who had immigrated to Quebec City in 1990. Together, they created an Open Educational Resource (OER), a digital game-based narrative based on the immigration narrative introduced by the older adult entrepreneur.

The workshop that was created as a digital learning experience lasted 3 h in Levis' Marcelle Mallet high school, a private secondary school in the Greater Québec area (Canada). The experience was facilitated by the school pedagogical advisor, who helped recruit eight volunteer–students and placed these students in three teams. During the focus group discussion held in the last minutes of the workshop, we analyzed the experience from the participants' point of view. We first describe the activity and the high school students' account of their subjective experience followed by a discussion of the perspective and reflections of our older participant whose story of immigration fuelled the workshop activity.

Participating high school students ($n = 8$) reported that they had a more engaging experience than in their traditional, lecture-based classes. They also spontaneously expressed their interest in combining a traditional macro-social information-based method of data-gathering with the life narrative technique, which is micro-social, to develop a richer vision of the migration thematic. The students were greatly interested in the entrepreneur's life narrative. They learned, for example, about historical events that previously were unknown to them were presented in a nuanced manner: in the communist regimes in Eastern Europe in the 1960s and 1970s instigated a discussion of the lack of individual freedom at the same time as they learned that these same regimes had a more progressive view of women's equality compared to what was going on in Quebec at the time. The cocreative activity allowed students to learn beyond the original thematic of immigration and prompted them to establish links with other social sciences concepts that were being studied throughout their high school years. Indeed, through this case study of the immigration process, students were introduced to other concepts included in the curriculum objectives for history outlined within the Programme de Formation de l'École Québecoise (PFÉQ, Gouvernement du Québec 2011), such as the functioning of political regimes, freedom, democracy, citizenship, equality, and delocalization.

The older adult who participated in the project also reported the experience as overwhelmingly positive. The sharing of her life narrative with high school students, including her experience of immigration, allowed her to articulate a more nuanced vision of communist regime to the students, for example. She also was proud to use her story as an example of a women entrepreneur becoming integrated in the host society contributing to Quebec's business life and social affairs. One interesting aspect of the reflections of our older participant included the importance of having a blueprint, or template, such as a digital game with a set of instructions to provide a structure to facilitate her story telling. Thanks to her participation, and her desire to include a testimonial on her first impressions when she arrived in Quebec, this template was improved.

The learning and human experience of this pilot intergenerational educational creation of an OER activity was evaluated very positively by all the actors of the activity (secondary level students, the older adult immigrant, and the school pedagogical staff). This initial intergenerational pilot project was successful far beyond the initial expectations of the researchers and the school pedagogical advisor. The group discussion between the school staff participating in the pilot and the research team (one professor and three PhD students) highlighted the importance of sharing real-life narratives from a first person perspective and the interest in reproducing this approach in further studies. The scaffolding approach, one where participants build slowly together, to game narrative creation was considered a key element for facilitating the intergenerational collaboration. Based on this initial experience, two workshops were organized within the Silver Gaming Intergenerational Summer School which are described in the next section.

Intergenerational Game Creation Within the Silver Game International Summer School (SGISS)

The second and third occurrences of the intergenerational game creation activities were held during the *Silver Gaming International Summer School* (SGISS) in August, 2015, reuniting participants from different groups of ages, starting from secondary level students ($n=2$) and adults ($n=32$) from different age groups (18 to 80 years old). One workshop was held in French and another in English. The main objective of these workshops was to explore a creative and collaborative approach of ICTs for learners to create their own digital pedagogical resources.

We first asked the participants to position themselves on an age and gender pyramid (Fig. 1). The purpose of this exercise was to help us put together teams with the higher intergenerational diversity possible; however, this playful first gesture also set the mood and tone for the workshop and created a way for participants to break the ice with each other. Each team then had to determine what topic they would work on. Because of time constraints, we gave simple instructions to initiate collaboration and play: the topic had to be related to the modernization of the province

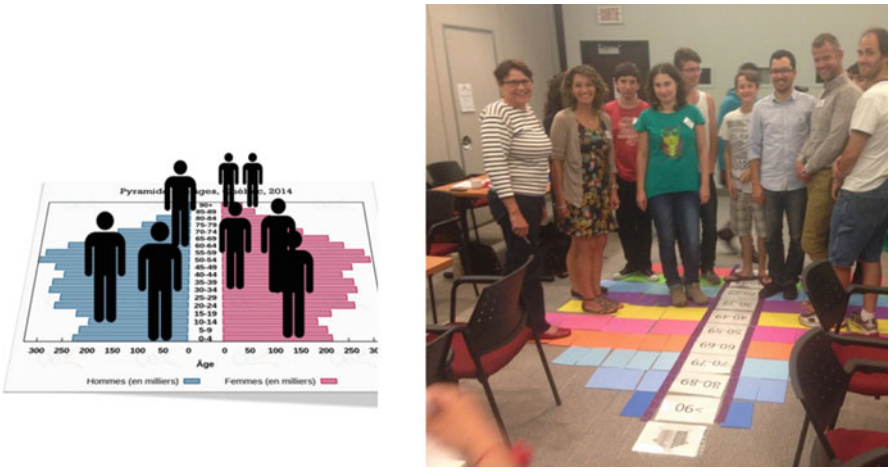

Fig. 1 Age pyramid distribution of the workshop participants

of Québec and the researchers gave a list of events that could be explored (i.e., the electrification of the province, women's right to vote, Expo 67, the Baby Boom, etc.). We noticed that the choice of topic often was strongly influenced by the older member of the teams who suggested topics that connected to the first-hand memories that were a part of their life narrative. The secondary-level students who participated supported these choices because they had touched on those subjects in their prior school year. They positioned themselves as "nonexperts." Secondary level students reported being engaged in the co-construction of knowledge during the game design process. They also reported they did not feel so engaged when they learnt the different subjects in their prior school year. The students openly challenged the limits of classroom learning, stating indicating that in having to engage in research for the game that it opened up a much more nuanced reading of historical events. We often heard I "did not know that." In the Silver Gaming sessions, the student participants remained fully focused, asking questions and commenting on the topic or the life experiences of the older adult(s).

As a way to put the teams into an active learning position, we chose to rule out the transmission approach to communicating information often used to teach history as a series of events from the past. Instead, we focused on an interactive process where the objective was to create a short narrative sequence centered on the decisions made by a significant historical figure whose actions helped to shape this particular event. It is this "character" that was used to communicate directly to the students by asking them questions on the chosen event. We used question-asking as a framework to structure the creation of the game. Each question constitutes a scene in the game, therefore deciding what to ask is an integral part of the writing and conceptualization process for the creation of new knowledge and new ways to engage with our knowledge of the past.

The first step in this process was to identify what questions could be asked. We suggested that each team write what they knew spontaneously about their topic of

choice. They then identified what could be rephrased as questions and assembled the information in a chronological order to determine a sequence plan. The second step was to formulate possible answers (or hypotheses) to the questions that were chosen, hence rendering explicit their prior knowledge. In some cases, their preconceptions were erroneous; for example, women have been always allowed to vote in Québec. These false conceptions were used to make explicit the erroneous ideas and develop a socioconstructivist process of knowledge deconstruction and its reconstruction.

The third step was to research information regarding the hypotheses formulated before and find the right answer about the topic. As the erroneous possible answers and knowledge that were formulated by the team could be shared by other learners, none of them were to be discarded; instead, they constituted possible wrong answers for the student to select. To further explain why they were not the desired answer, we asked the teams to write a short text hinting at the right answer.

Once all these steps were completed, teams were asked to assemble a storyboard to explain what would constitute their game. They could create it by using either analog (pen and paper, post-its, blackboards, etc.) or digital tools. Each scene had to contextualize a key question. Now in possession of a storyboard, teams started digitally recreating their ideas in Scratch. They had 30 min to code a functional, playable game. In line with the findings of existing research on ICTs, we observed that the programming part of the workshop was understood differently by the students and the older adults. The younger members of the teams tried to program through "trial and error," while the adults in the different groups used a more reflexive approach to implementing this rudimentary game design into the Scratch template. They understood the goal as the accomplishment of a definite task: some asked for tutorials and several tried to understand "why" and "how" it worked before starting the design process.

As we ended the session, we asked participants to demonstrate their work to the other teams. As a synthesis and a closing comments, participants gave their impressions of the workshop and of coding, its limits, and the opportunities for education.

Intergenerational Activity in a Community Center

The fourth activity was a workshop held in September, 2015, during an intergenerational activity day at *La Maison Léon-Provancher*, a Québec city-based organization that is promoting biology, science, and technology to grade-school children and the community, including their parents and grandparents. Of all the activities offered to the kids and their family, only the one we offered used the ICTs; the others consisted in discovering Quebec history through biology and the natural sciences as a way to kindle and foster curiosity about the sciences, Provancher and his legacy. Kids were placed in the role of "discoverers," who would learn to explain the natural world through their contact with living, breathing creatures, and natural phenomena. In stark contrast to many of the ways that science is taught, our workshop's aim was to immerse them in the topic and take on a role of responsibility as "creators" and digital makers, not only outside observers.

The children participants ($n = 10$), aged between 3 and 10 years old, were of mixed gender and origins. One of them came with his grandmother, the others with a parent (generally the mother). None of them had ever been introduced to coding. As most of the workshops were held with at least two children and their parents, the adults participated in the coding process by helping the youngsters and encouraging them. In only one instance did we see an adult refusing to take an active role in the workshop. It should be noted that the diversity of participants that came to the workshop at *La Maison Léon-Provancher* were not part of academia; they were neither the children of colleagues, nor had any links to ACT or any other research groups whatsoever.

The proposed activity was to customize and move a character in Scratch. To explain what was needed to accomplish this in the program, to make it real and embodied, we asked the participants to use cardboard on which actions were written (move, left, right, 90°, etc.) to order one of the researcher around the room. Specifically, they had to move the researcher (called a "human robot" during the exercise) around the room to make it walk in a square. This preamble had two aims: first, to make them "program" without touching the computer, hence demystifying the process; second, it enabled them to work in concert with the other participants to abate their initial shyness. Encouraged by their parents and the research team, the participants completed the task and then repeated the same movement sequence in Scratch. Researchers acted as guides to help them in the coding to make sure they did not get discouraged.

Researchers tailored their workshop depending on who was participating. For example, in one case it was made simple and was oriented around the idea of "coding as magic" because of the ages of the children (3 and 5 years old). With the older children, the idea proposed was "creating instead of consuming." They were encouraged to have fun while playing through problem-solving ("how do I get him to make a square figure?") and cooperating. At the end of the process, when asked if they first thought they could code using a computer, they all said "no." When asked if they had fun doing it and if they would like to do it again, we heard nothing but affirmative answers. As the interface of Scratch encourages exploration and trial and error, parents took great interest in the activity, and felt that they could also come to understand simple programming. As the software is free and multilingual, it allowed for those whose first language was other than French or English to engage in the activity.

Discussion

The intergenerational workshops described in this chapter point toward many similar findings on the use of games as a pedagogical tool, described in prior researches. As Livingstone and Bovill (2013) pointed out, most children who took part in their activities were curious about technology. Indeed, they were learning by doing, tinkering with the interface as soon as possible even if they were not familiar with the software used. These dynamics confirm the main arguments of Plowman et al. (2008), who assert that there are adults who are not necessarily more apprehensive of using technologies than children. Instead, as their research team argues these intergenerational

experiences in game making reveal that there are parallel way of thinking, neither better nor worse, that can actually complement each other in a collaborative learning environment. The workshops also indicated the danger of that making assumptions about the perceived digital literacy of a person based on age: in fact, many older adults who participated in the workshops were as comfortable with technology as the youngest members of their team. Instead of trying to define entire generations as ensembles of homogeneous like-minded individuals, we opt for a person-to-person approach that looks beyond the subject's age and is centered, instead, on the possibilities and potentials for intergenerational learning and dynamics (Romero 2015).

The research team involved within these four intergenerational game creation workshops have identified, in addition, some factors that may facilitate the future development of these kinds of intergenerational learning experiences through game making. First, the planning and prior work with the educational staff at the chosen location is a key element for success. This allows for a prior elaboration of the materials that will be used to scaffold the game creation process and for researchers and teachers to define, in advance, the steps and modalities of the intergenerational game creation experience that will be staged. These elements play a role in making such an experience worthwhile for participants and manifold. First, timing is key. By this we mean paying attention to the given day, duration, and timing of the event in the curriculum so that there is an integration of the topics for the game creation that works in tandem with the curriculum. This varied in our three workshops: it was predefined in the first experience with the pedagogical staff of the school, somewhat open in the second and third workshops where a historical period was suggested as a framework, and totally open in the last informal workshop in the community educational center. For workshops that span one or two days, allowing participants to have the time to talk and eat together so that they come to know each other, and build relations of trust "off scene" were notably important—along with food and drinks to keep the team nourished. Second, creating a climate that is open to the idea that learning is fun and key. This will be reflected in all aspects of the event, including how one constitutes intergenerational groups to work together. We tried several approaches to group constitution. In first experience, it was based on educational level. It can also have the aim of creating intergenerational diversity within the team. Even with the creation of spontaneous informal "teams" such as those the workshop of the fourth experience, were predicated on a playful way of ensuring diversity within groups. Third, there are different ways that one can create the opportunity for feedback at the end of this process. One can conduct focus groups at the end of the game creation intergenerational workshop, from the semi-structured focus groups we engaged in the first three experiences and to a more open discussion, which we engaged in, in the fourth workshop. Fourth, we found that using a guided approach to scaffold the intergenerational game creation workshop into a series of discrete tasks that build toward making a prototype, is a key element for the successful development. We used this approach in all of our workshops. Along these lines, making explicit all the tasks that were to accomplish was beneficial to the flow of the workshop and ensured to achieve the pedagogical and intergenerational learning objectives. Fifth, having a set of predetermined topics listed helped to get the teams to work together, quickly, in the second and third workshops

as it eliminated the time that would be spent on discussion of the theme, and instead allowed participants to focus on realizing the theme together in game form.

As for the difficulties and challenges that may occur, we noted that in one workshop held at the SGISS, one team had two computers to work on instead of one shared by the whole team. While the original intent was perhaps to divide the workload, the result was that this separated the team into two independent groups who each produced their own game. This split hindered both teamwork and fun for the participants. Other challenges, include considering the investment in time required to prepare the intergenerational game creation workshops in terms of participant recruitment, the ethical committee approval at the university and the preparation with the pedagogical staff in the different educational settings (high school and community center). These are not insignificant and researchers embarking on similar experiences need to be aware of how much preplanning is involved and be prepared for delays in processes. Finally, given the variability needed to make the experience successful in different locations, for different configurations between ages, there is no one recipe for success. Rather, this calls for an interactive approach to thinking through game creation design that emphasizes collaboration, and finessing at all stages of the process.

Despite the efforts required to deploy an intergenerational game creation workshop, the intergenerational learning and cross-age social bonding can be extraordinary for all of the actors engaged including the learners, teachers, pedagogical experts, game designers, and researchers. These four intergenerational game workshop experiences were appreciated enormously by all in terms of education, social participation, and fun and have encouraged us to continue staging these experiences in different venues, locations, and with different communities and schools. The intergenerational game creation activities will be continued over the next months and years of the ACT project. As this happens we will provide additional evaluations of the intergenerational learning to allow us to reflect on these experiences and to study further this fun and socially innovative way of learning together through intergenerational game creation.

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Designing Enhanced Learning Environments in Physics: An Interdisciplinary Collaborative Approach Producing an Instrument for School Success

Sylvie Barma and Sylvie Daniel

Abstract Parallel, an innovative teaching and learning tool, was designed by a multidisciplinary team gathering together university and college professors, post-graduate students, teachers, as well as young adults and college students. The creation of Parallel, made possible fruitful collaboration between students, teachers and researchers. The collaborative experience was part of an effort to understand how a serious game on a mobile platform using augmented reality could be exploited in a formal educational context to overcome the difficulties encountered by physic's college students. Up to now, 60 % of these students have been failing the course as they are being taught the laws of electromagnetism. As Lave, points out, "too often, school lessons are fraught with difficulty and failure more many students" (Lave, Anthropol Educ Q 16:171–176, 1985, p. 174). We will discuss how we arrive at the conclusion that Parallel can act as a potential instrument for student's mastery of their own relationships with society and allow them to reinvest their learning with youth and the elderly. Although the empirical study we are presenting pinpoints a specific aspect of physic's learning, it opens new horizons for cross-generational and age-oriented digital game-based learning from childhood to older adulthood.

Keywords Augmented reality • Mobile learning • Physics • Activity theory • Longlife learning.

Introduction

Parallel, an innovative teaching and learning tool, was designed by a multidisciplinary team gathering together university and college professors, post-graduate students, teachers, as well as young adults and college students. The creation of Parallel made possible fruitful collaboration between students, teachers, and researchers. The

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collaborative experience was part of an effort to understand how a serious game on a mobile platform using augmented reality could be exploited in a formal educational context to overcome the difficulties encountered by physic's college students. Up to now, 60 % of these students have been failing the course as they are being taught the laws of electromagnetism. As Lave, points out, "too often, school lessons are fraught with difficulty and failure more many students" (Lave 1985, p. 174). We discuss how we arrive at the conclusion that Parallel can act as a potential instrument for student's mastery of their own relationships with society and allow them to reinvest their learning with youth and the elderly. Although the empirical study we are presenting pinpoints a specific aspect of physic's learning, it opens new horizons for cross-generational and age-oriented digital game-based learning from childhood to older adulthood.

Augmented Reality and Ageing Population

Brief Introduction to Augmented Reality

Augmented reality (AR) overlays computer-mediated information on the real world in real time. This ability enriches environments for action and learning and offers the potential for new kinds of shared experiences. Unlike virtual reality (VR), where the user is completely immersed in a virtual environment, AR allows the user to interact with the virtual images using real objects in a seamless way (Zhou et al. 2008).

The first AR interface was developed by Sutherland in the 1960s (Sutherland 1965). This first system involved head-mounted display and movement sensor. The real development of AR started in the 1990s with Bajura et al. (1992) and State et al. (1996) work as new interaction and visualization capabilities in the field of medicine. AR applications usually relate to various research areas ranging from computer vision, computer graphics, and human–computer interaction that operate in conjunction with the aim of presenting an enhanced reality as well as allowing the user(s) to interact with it in a natural way (Liarokapis 2006).

One common paradigm for AR is the *magic lens* allowing the user to *see-through* to an image of the real world with added AR elements (Cawood 2008). Optical see-through augmentation is based on semitransparent head-mounted displays (HMD), superimposing the real environment using semitransparent mirrors while video see-through displays show a captured video image superimposed with the virtual content. Recently, handheld devices such as touch tablets and smart phones have become popular platforms for AR applications. These systems are less bulky than the head-mounted displays usually worn for see-through augmentation. Handheld devices are also more widely spread outside the research community today than the HMDs fostering a better integration of AR in various applications fields (e.g., tourism, automotive industry, and games) and their adoption by the user community. Similarly to video see-through HMD, visual extension with handheld devices is

typically done using a video camera. It provides the handheld display with a live video stream of the real world that can be augmented with synthetic graphics.

Augmented Reality Interface Benefits

Given the 3D visualization intrinsic to augmented reality, AR seems suitable for science and technology applications, either in industrial or in educational contexts. It allows for the illustration of intangible concepts, for instance the application of forces, such as gravity, on objects. The literature includes several studies demonstrating that augmented reality has actual advantages. Compared to conventional 2D interfaces, AR solutions support the understanding of complex phenomena by offering a unique visual and interactive experience. It provides a tangible presentation of what are often abstract phenomena and demonstrates spatial and temporal concepts more effectively. Augmented reality also has a positive impact on users and learners, their connection to the activity, their attention, and information retention.

On the other hand, mobile AR applications (i.e., augmented reality solutions using mobile platform) change the nature of how we interact with and understand spatial data and our environment. The advanced AR techniques render the interface in a far more intuitive way than usual computer-based solutions making it easier for users to match what they see in the display with their view in the real world. In addition, tangible interactions with the "real" world can be performed through multimodalities components. A connection is thus formed between the physical and the virtual worlds in which the users find themselves, and many layers of information are easily accessible at the same time.

Such possibilities offered by augmented reality interfaces are well adapted to the ageing population. They allow to escape the confines of typical information systems for which some technical expertise is required. Mobile AR can be used to add realistic visual cues into a user's surrounding providing natural and explicit interactions. The Nacodeal project (Saracchini et al. 2015) proposes a guidance and communication service dedicated to elderly people using such solution. Their new technology, relying on a wearable device with an embedded pico projector, exhibits content autonomously based on the user location and device orientation.

The use of immersive augmented reality solutions as a rehabilitation tool for Parkinson Disease (PD) has been investigated (Boucher 2013). AR is seen as an optimal tool for meeting the rehabilitative criteria for people living with PD. By making use of virtual features, the major areas of concern (motor, cognitive, and quality of life) in the PD population may be addressed simultaneously. Mobility associated with AR solution allows people to ambulate and practice movement strategies in realistic situations while virtual reality platforms are often constrained to treadmill. AR interface provides a strong sense of presence (i.e., a sense in being in the virtual representation provided by the interface) and realism. A system need to appear to be realistic to the user if any rehabilitative benefit is to be achieved from the program.

Museums are increasingly offering new methods of engaging and educating visitors through the use of AR systems associated to mobile guides, interactive exhibits, downloadable games, and 3D artifacts. A comparative study involving two populations of respectively young adults (18–21 years) and elderly (65 years and older) revealed that regardless of age, experiencing artifacts using AR on a tablet was enjoyable and encouraged emotional responses (Alelis et al. 2015). Seeing the physical artifacts after the digital ones did not lessen their enjoyment or emotions felt. These findings underline the effectiveness of augmented reality interfaces in cross-generational contexts of use.

We now focus our attention on the educational needs of younger generations and the potential of AR to modify the dynamics in classrooms and in collaboration between generations. Even if the results of the study we are presenting are drawn from a specialized area, we hope that the following section will resonate to the reader as the conclusions open up a fruitful dimension for cross-generational learning.

Challenging the Way Physics is Taught in the Classrooms

Addressing the Needs Related to the Younger Generations

Today's youth are the first generation to be immersed from childhood in the World Wide Web and it has to be taken into account when training tomorrow's citizens (Piette et al. 2007). Other authors, such as Prensky (2001), describe young people born in the 1980s as Digital Natives, and as the Game Generation. Prensky argues that they are able to assimilate information much more quickly than their parents because they have always lived in a world of ubiquitous technologies. Kaplan Akili (2007) also examined the characteristics of these young "digital natives" and argued that they are more skilled and able to quickly find answers to their questions by themselves.

However, younger generations in Canada are putting aside science studies and exacerbate the decline of scientific culture, resulting in irreparable loss of know-how essential to the functioning of enterprises, economy, and society in general (Robitaille 2010). Despite the evolving cultural context where adolescents evolve, most educators have remained sceptical about the relevance of using mobile platforms (PDA and tablet) to facilitate learning (Pachler et al. 2010). At the present time, the pervasive use of digital technologies as tools of mediation in cultural practices, both in the West and elsewhere in the world, can no longer be ignored. As the Canadian Council on Learning's report on virtual learning stated (2009):

> Canada's younger generation is primed to exploit the potential of learning technologies. Computers, multimedia programs, chat rooms and other manifestations of the digital age are now common throughout children's developmental years—as almost any parent or educator will attest.

The current challenge for educators is thus to integrate digital technologies into their teaching practices (Barma et al. 2010). We believe it is a manifestation of a generation gap that needs to be addressed. Twenty-first century students are better off developing competencies in preparation for their future involvement in a society marked by the rapid production of scientific and technological knowledge and the proliferation of their applications (Government of Quebec 2006). How it can be done and what promising new technologies can be exploited for the benefit of science students?

The Added Value of Mobile Learning

With increasingly powerful networks, mobile learning is becoming an inescapable reality. There are multiple advantages in the use of portable computers or tablets in education. It allows the enhancement of student motivation, their sense of responsibility, their development of organizational skills, individual and group learning, and improvement monitoring of students' progress (Savill-Smith and Kent 2003). These mobile technologies are said to facilitate social interactions and increase the learning motivation by allowing children to move freely (Zurita and Nussbaum 2007).

A review of the scientific literature provides different definitions of mobile learning (Pachler et al. 2010). According to Wali et al. (2008), some authors emphasize the mobility of devices and propose technocentric definitions (Kukulska-Hulme et al. 2005). Others define mobile learning as a continuation of e-learning (Quinn 2000) or emphasize the importance of the social practices in which learning activities take place (O'Malley et al. 2003). To illustrate their conceptualization of mobile learning, Wali et al. (2008) conducted three studies with the goal of determining how students use portable devices (e.g., laptop computers and cell phones) comparing the use of more conventional media (e.g., classroom note-taking) for the facilitation of learning in formal and informal settings. To these authors, current definitions of mobile learning are not representative of what actually happens in the learning context. Their studies demonstrate that students do not only use mobile technologies, they also employ conventional tools, such as books and other documents, to facilitate learning. Consequently, more traditional learning should be considered mobile, since students use conventional tools in the same way as they do mobile technologies during learning activities, in different contexts. Additionally, certain uses of portable devices are rather static, meaning the mobility component is not always the most important.

Wali et al. (2008) come to the conclusion that the definition of mobile learning should be enriched to take into account several contextual elements, considered as a combination of the physical location, the environment constraints, the rules, and the division of duties within the community of learners. For these reasons, they offer the following definition: "learning that occurs as a result of pursuing learning activities

Table 1 Convergence between technology and learning (Yin 2010, p. 10)

Mobile technologies	Learning methods
Personal	Customizes
User-centered	Learner-centered
Mobile	Located (contextual)
Network connection	Collaborative
Ubiquitous	Ubiquitous
Durable	Lifelong

that are directed toward achieving the same objective across multiple contexts (both physical and social)" (Wali et al. 2008)

In physics teaching, two concepts remain promising in a classroom: learning and mobility when students are apprehending difficult concepts like electromagnetic fields, electrically charged particles, and the interrelation between forces and charges (Barma et al. 2015). It requires the students' capability to abstract their representation in a three-dimensional way (3D). As presented in the introduction, the technology used in mobile devices allows for the integration of additional functions (geolocation, Wi-Fi, email, video, discussion blogs, etc.). These rapid changes motivated our team to create a digital-based teaching tool, test it with a small group of students to reflect on how giving them a certain degree of freedom of movement around a virtual 3D interface could allow them to test knowledge transmitted in a lecture-based class. The problem was complex since it asked students to predict the movement of electrically charged particles under the effect of magnetic and electrical forces. The relationships between technology and learning proposed by Sharples et al. (2005) seem to be very interesting in the context of this study, because they allow for the conceptualization of how the learner's experience is reflected in the form of new knowledge.

> "The role of technology in these explorations and conversations is to form a distributed system of meaning making. At a first level of analysis we shall make no distinction between people and interactive technology, instead examining how the human-technology system enables knowledge to be created and shared in a continual process of coming to know through the construction and distribution of shared external representations of knowledge." (Sharples et al. 2005, Chap. 14, p. 4).

Several studies on the use of mobile technologies for learning have been carried out. Among them, that of Waycott et al. (2005) concluded that:

> "like other mobile devices, PDAs (Personal Digital Assistants) have not been designed with learners in mind, yet they offer great potential to support lifelong learning and indeed are being extensively used by learners. Therefore it is important to investigate how learners make use of such devices: what benefits the devices enable and what learners encounter problems." (pp. 126–127).

The reflexions above open the door to possible convergence between technology and learning with a vision of durable cross-generational lifelong learning (Table 1).

According to Waycott et al. (2005), the use of mobile devices can support lifelong learning, and devices bring constraints as well as benefits, which may be

important in certain areas of learning, such as sciences. Hennessy (2000) demonstrated in his research that "where learners have devices for extended periods, they develop a strong sense of ownership over both devices and the tasks for which they use them" (p. 127).

If we now focus on two other aspects of new technologies, that is, the contribution of serious games and augmented reality to students' learning, many educators believe that the use of games confers many benefits in the educational context (Barma et al. 2010). Serious game is the term used for games whose primary purpose is something other than mere entertainment. They *"invite the user to interact with a computer application designed to combine elements of teaching, learning, training, communication and information with playful aspects provided by the video game. Such an association is designed to supplement utilitarian content (serious content) with a videoludic approach (a game)"* [translation added] (Michaud and Alvarez 2008, p. 11).

Augmented reality (AR) is one of the technological tools recently associated with serious games. An interesting potential use of serious games, according to some studies, arises from the fact that they have the ability to make us rediscover "memory" (Alvarez 2012). In our opinion, this aspect is important. It implies that, in addition to learning, the game permits the reuse of already acquired knowledge, which resurfaces during play. When combined with AR, it allows for a fluid, real-time connection between the digital world and the real world.

Augmented Reality: Enhancing the Learner's Experience

The literature includes several studies on the use of augmented reality to teach mathematics (Kaufmann 2003), mechanical physics (Bergig 2009), electromagnetism (Billinghurst and Dünser 2012), engineering (Liarokapis et al. 2004) and biomolecular sciences (Nickels et al. 2012). Such studies have helped demonstrate that augmented reality has actual advantages. Compared to conventional 2D interfaces, AR solutions seem to help students learn more effectively and increase knowledge retention. Augmented reality supports the understanding of complex phenomena by offering a unique visual and interactive experience. It also has a positive impact on learners, their connection to the activity, their attention, and information retention. It seems to improve understanding in kinesthetic learners. However, while several studies have demonstrated such key benefits (Dunleavy et al. 2009), they did not clearly evaluate and quantify the actual gain derived from the use of these technologies in terms of learning.

It seems relevant to reflect on how students form concepts in learning environments that use increasingly powerful technological tools. The relationships between technology and learning proposed by Sharples et al. (2005) seem to be very interesting, because they allow for the conceptualization of how the learner's experience is reflected in the form of new knowledge while engaging in a serious game to better understand electromagnetism. Furthermore, according to Sanchez and Jouneau-Sion

(2010), games constitute complex and nondeterministic learning situations encouraging involvement, decision making, autonomy, and collaboration. They provide environments characterized by reflexivity, generally virtual, within which learners can develop their own strategies and test their ways of thinking and acting. These practices are well integrated into the practices of today's adolescents. Consequently, they have become a beneficial teaching approach that can be used when students have access to technological tools. However, in a teaching/learning context using serious games, it is important to go beyond the technological tool and aim for learning by the user. The tool alone is insufficient and learning depends on the ways it is used.

Overcoming a Basic Contradiction in Physics Teaching by Introducing an Instrument of Success

The research team focused on augmented reality imbedded on a mobile platform (Apple iPad Tablet) as a technological innovation to foster autonomous and durable lifelong learning. The application setting was a college-level electromagnetic physics class. Research has revealed the conceptual difficulties students face with concepts taught in physics class (Cepni et al. 2000; Hestenes et al. 1992). Electromagnetic forces act on charged particles. These electromagnetic phenomena are introduced in the preuniversity course,[1] Electricity and Magnetism. They pose significant difficulty for students when the time comes to represent them in space. The behavior of charged particles in space may result in counter-intuitive trajectories. Then how could we provide a realistic, concrete visualization of the interrelations between these forces on the particles? In order for a particle to be subjected to an electric or magnetic force, several conditions must be respected. For the electric force, the particle must first have a positive (+q) or negative (−q) charge, and must be located near another source of electricity. Every electrically charged object generates an electric field. An electric force is created when a charged object is found in the electric field of another charged object. If the charge of the object has the same sign as the source of the electric field, repulsion will occur. Otherwise, there will be attraction. The situation becomes more complex when magnets, which generate magnetic fields, come into play! To generate a magnetic field, a particle must always be charged, and must also possess a speed and be traveling near a magnetic field source. The mathematical equations developed from the laws of physics to describe the trajectories of charged particles rapidly become complex when they include more than one electromagnetic field component. Most physics students cannot visualize the 3D dimension related to the interrelations between, charges, electric, and magnetic fields. They just memorize equations and are not able to predict the

[1] The *Electricity and Magnetism* course is offered in Cégep. In the Quebec educational system, students attend cégep between high school and university. The system includes 5 years in high school, then 2 years in cégep prior to attending university. Cégep is considered part of higher education.

trajectories of particles in 3D. Engeström's qualifies such memorizing actions as "conscious memorizing" which is a form of transmission of knowledge and experience that brings about conscious learning actions (2015, p. 75).

Even if some recent analysis highlights the fact that "none of the reports offered concrete proof that personalized learning technology delivers a more complete, robust and nuanced understanding of students than those held by experienced teachers" (Roberts-Mahoney et al. 2016), the research we conducted lead us to believe that a combination of formal teaching and the use of a digital-based tool improves students' comprehension of electromagnetism. It is a challenge to teach difficult and not apprehensible concepts in physics or in chemistry. A promising avenue is presented by Kim et al. (2012) as they suggest that teaching methods based on the discovery (inquiry-based pedagogy) combined with portable digital tools are transforming the children from single passengers into active role-playing scientists who share their knowledge and solve problems collectively.

In addition, the abilities of children to incorporate technologies into their learning are often better than those of their teachers, and the speed of such adaptation may surprise many adults. Nevertheless, most of the time, physics teachers provide students with experimental step-by-step laboratory protocols that are designed to test the adequacy of a mathematical formula presented during a lecture-based class (Larochelle and Désautels 2003). Engeström (2015) argues that the outcome of school going activity is, for example, the reproduction of algorithms to solve well-structured, "closed" problems (p. 80). This form of learning encourages the reproduction of texts by students for good grades (Miettienen and Peisa 2002). More specifically, in education, science teachers can be expected to have a basic contradiction between teaching for tests and grades versus teaching for supporting students' mastering their own relationship to a sociotechnical society and become autonomous thinkers during their life time. The challenge of our interdisciplinary team was to create a tool not so that it would just to be reproduced (like a closed mathematical problem to be resolved with a precise algorithm) but that would allow students to negotiate their own way while integrating many possible electromagnetic parameters by immersing themselves in a 3D environment to solve an enigma that would be different every time and being given some degree of liberty when choosing parameters to play with (Barma 2009).

Redefining the Object of School Going Activity to Promote Lifelong Learning

Cultural activity theory considers the activity system the key unit of analysis, as the result of goal-oriented individual and social interactions (Engeström 1987; Engeström and Sannino 2011). In his systemic triangular model, Engeström (2001, 2015) illustrates human collective activity with six interacting poles or components of practice (see Fig. 1). The subject is the viewpoint from which the activity is analyzed

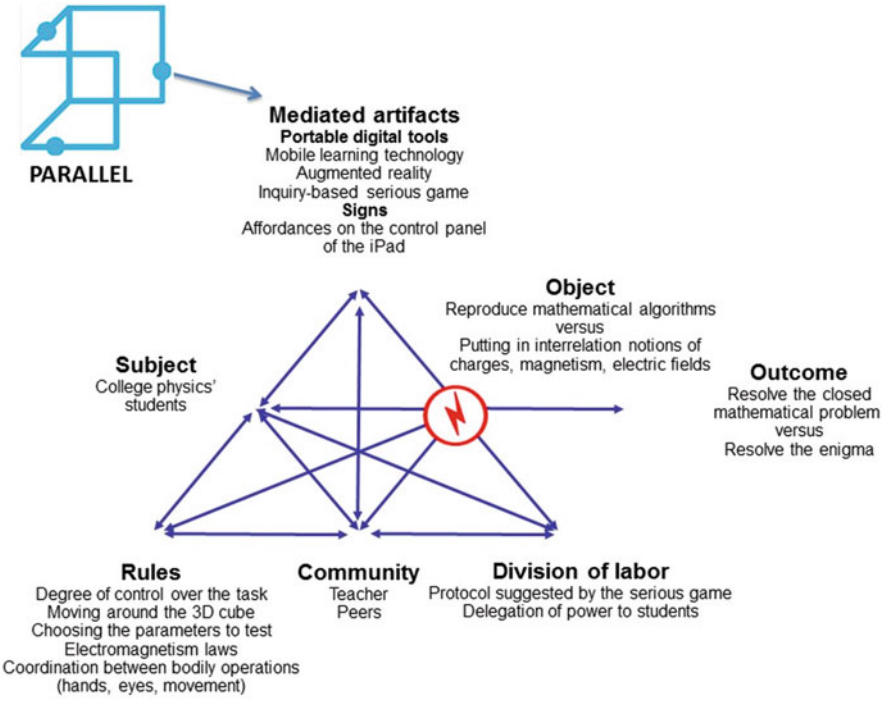

Fig. 1 Parallel: a potential instrument to change the object and the outcome of physics teaching

(students), the object or the goal is the resolution of the enigma in order to promote learning science in context (outcome). Another pole of the model corresponds to the tools or artifacts used by the students to achieve their goal. The lower part of the triangle puts into evidence the mediation role played by the socioinstitutional dimension of human activity. The rules pole refers to expectations, school policies, norms, values, beliefs, and ideologies that regulate actions and interactions within the system. The community component consists in our case of the teachers and peer students attending the targeted school. At last, the division of labor dimension has to do with the changes in role, tasks, and responsibilities when realizing the goal.

The concept of contradiction is also central and presupposes a dual existence between two alternative competing teaching strategies for the production of a new form of school activity. In Fig. 1, the lightened broken arrow in the circle highlights a potential contradiction in the object of the activity of the learners: being successful at reproducing mathematical algorithms or being able to integrate autonomously notions on electromagnetism. The results are also different in both cases: students may end up resolving a closed mathematical problem or succeed in decoding an enigma a way to become autonomous thinkers. Contradictions are considered necessary to induce change and demand qualitatively new instruments of success for their resolution (Engeström 1987). If Parallel reveals an instrument of success, it could change the object and the outcome of the activity. Monk's recent work also

suggests that such a dialectical cultural-historical model has a great potential to promote intergenerational learning and development of individuals (Monk 2011). It challenges the commonly held view of intergenerational transmission of knowledge.

Description of Parallel

Organizational Components of the Research Project

The project, funded by the university–college collaborative program of the Ministère de l'Éducation, du Loisir et du Sport (MELS), relies on a multidisciplinary team consisting of three professors and a research assistant professional from Laval University, three teachers from the Cégep de Sainte-Foy, and a researcher from the Centre en imagerie numérique et médias interactifs (CIMMI). This collaboration brings together a variety of skills, covering the fields of computer vision, multimedia communication technologies, GIS, physics, and educational sciences. Project synergy, benefiting from the diversity of expertise, is further strengthened by the involvement of college-level students who participate as both creators and users of new learning tools developed within the project. Consequently, skills and knowledge are developed during both phases: creation and use.

During the first phase of the project, a scenario competition was launched among students of the communication techniques department (multimedia integration and graphics technology programs) of the College. Based on guidelines established in conformity with the chosen electromagnetic concepts and the context of mobile augmented reality use, five proposed scenarios were submitted, including the scenario which was selected for Parallel. Given the small size of the team, the dedicated skills of its members, the limited scope of the game and learning objectives, an Agile software development approach was selected. Agile Software Development is a set of software development methods in which requirements and solutions evolve through collaboration between self-organizing, cross-functional teams. It promotes adaptive planning, evolutionary development, early delivery, continuous improvement, and encourages rapid and flexible response to change (Retrieved from: https://www.agilealliance.org/agile101/what-is-agile/).

Playing Parallel Serious Game and Game Components

Parallel Scenario and Objective

Parallel is based on an exploration in which the player progresses in a mysterious environment. There is no character to control and the order of progress is not well defined. When the student starts Parallel, a storyboard briefly explaining the

Fig. 2 Start screen of Parallel which presents the opening of the storyboard describing the game context

scenario appears (see Fig. 2). Students discover that a sealed chest inscribed with Sumerian writings has been recovered from a northern sea. This discovery coincides strangely with the excavation of three tablets with Sumerian inscriptions corresponding to those of the chest. Inspections reveal that weak electromagnetic fields emanate from three separate locations on the sides of the chest. The tablets suggest that symbols are hidden in corresponding places inside the chest. These symbols turn out to comprise the secret combination to open a door in a huge stone arch. The objective of the game is to discover the three symbols that will open the door.

Parallel Mechanics

To uncover the symbols, the player has a digital tablet and three steles, and markers bearing different inscriptions (see Fig. 3). The three markers represent the three steles mentioned in the scenario described above. They come into play to trigger the apparition of the augmented reality elements.

Here is how the notions of physics were presented to students via the simulator. Through the electromagnetic field control panel (Fig. 4a), students can choose the type of field to insert in the cube by selecting E (electric field) or B (magnetic field). They can also choose which cube surfaces will have a positive or a negative charge (in the case of an electric field), as well as a north or a south pole (in the case of a magnetic field). Three field components can be defined simultaneously with the

Fig. 3 The three Parallel game markers trigger the apparition of (**a**) a glass cube, (**b**) a mysterious chest, and (**c**) a door

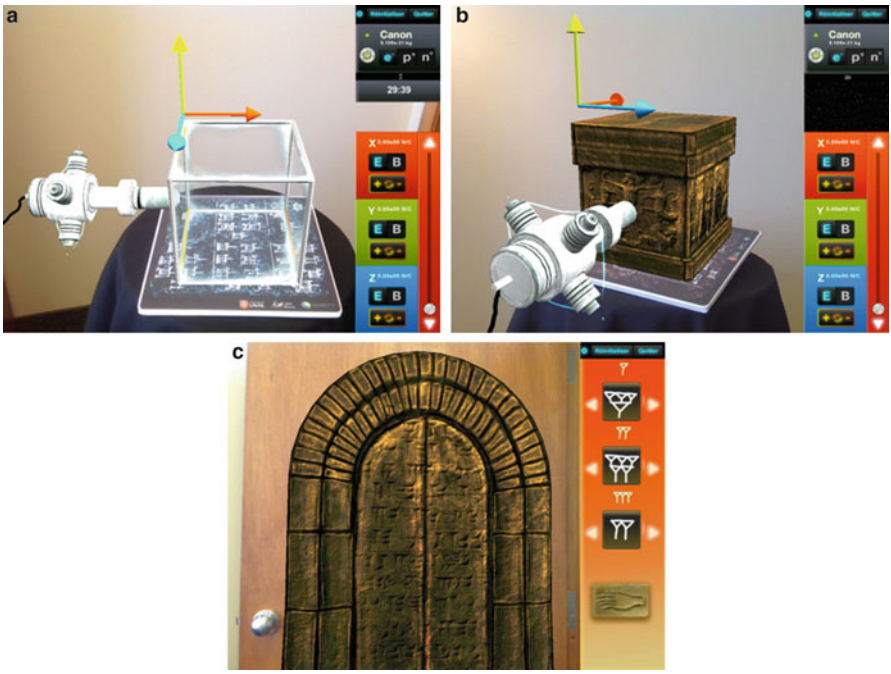

Fig. 4 The Parallel game is composed of three scenes. (**a**) The first scene shows a glass cube, which allows configuration and observation of the particle beam. This is the practice cube; (**b**) the second scene shows a chest which contains the three fundamental clues needed to win the game; (**c**) the third scene displays a sealed door which can be opened by using the three symbols found in the chest, in scene (**b**)

simulator, one for each of the *x*, *y* and *z* axes. For instance, when students select an electric field on the *y* axis, the field intensity can be increased (i.e., using a glide button on the right of the electromagnetic field control panel); consequently, students can observe the reaction of the particle beam inside the cube in real time and

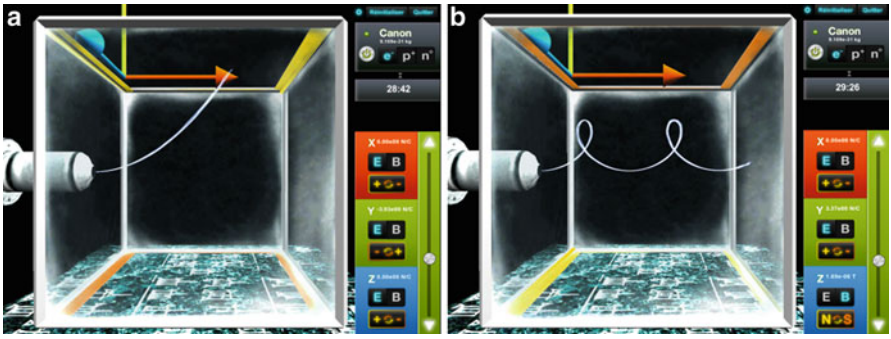

Fig. 5 (**a**) By manipulating electromagnetic fields, the player can reach all faces of the cube; (**b**) some configurations create interesting effects that respect the laws of physics

according to an infinite number of viewing angles. Students can also choose the type of particle to project.

Hand-holding the tablet allows the camera to capture images from the surroundings, which are immediately analyzed by the augmented reality component of the game. This component searches for the presence of one of three markers (see Fig. 3). When the camera is pointed at one of the markers, the player can access the game scene associated with that marker. Three virtual elements can be displayed, according to the identity of the visible marker, that is, a glass cube (see Fig. 4a), a chest (Fig. 4b), and a door (Fig. 4c). The display creates the illusion that the virtual element truly is part of the scene: the element is rendered in a way adapted to the player's point of view. Players can move around the marker and observe the cube as if it was really placed on the marker.

How Parallel is Played

A video describing Parallel and how it is played is available on Youtube:

- English: https://www.youtube.com/watch?v=Q2tBxGKFglg
- French: https://www.youtube.com/watch?v=GHwy9pRxOG0

In the game's scenario, the player starts with the first scene (see Fig. 4a) showing a transparent glass cube. The interface allows the player to activate a particle gun, which projects a particle beam in the cube. By using the interface to adjust the electromagnetic fields, the player can change the beam trajectory, which will be affected by the field forces (see Fig. 5). The trajectory is calculated in real time by a simulator that accurately conveys the real physical phenomenon. This scene allows the player to practice in order to understand how the different field combinations affect the beam.

Then the player switches to the second scene showing a sealed chest (see Fig. 4b). Hidden inside the chest are three symbols. The game provides students again with a particle gun that can scan the chest's interior and produce an image of the area struck by particles. They must apply electric and magnetic fields to the sides of the

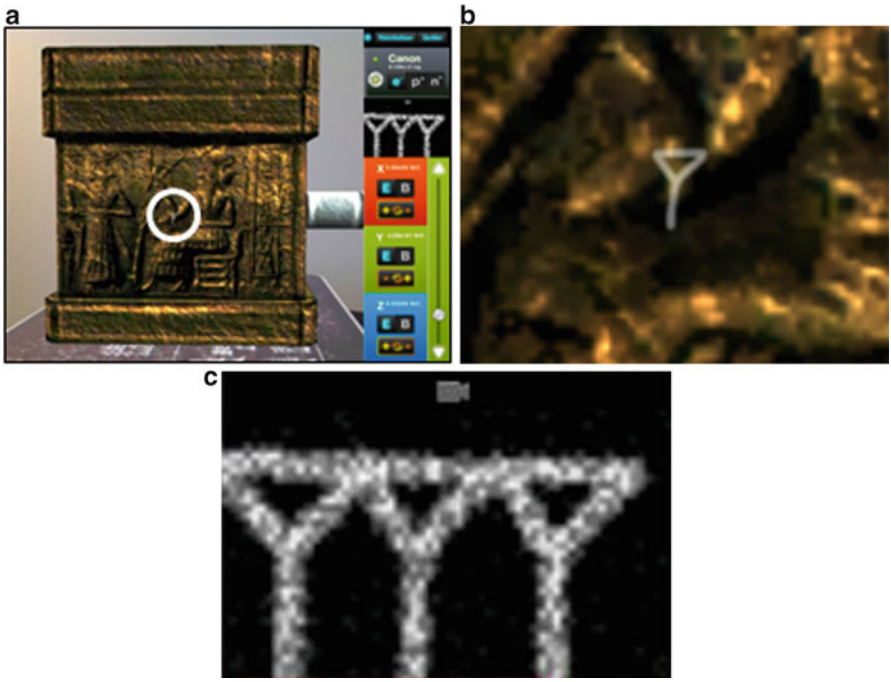

Fig. 6 (**a**) Hidden on the interior wall of the chest are three inscriptions which can be visualized by directing the particle beam to specific locations. Marks on the exterior of the chest, shown in a *white circle* here, indicate the position of one of the inscriptions; (**b**) enlargement of the mark; (**c**) one of the inscriptions on the interior of the chest as shown by the camera

chest to direct the particle beam to the identified locations (see Fig. 6). By directing the beam at the correct locations, players can see the secret symbols. Since the chest is opaque, the particle beam is not visible; players must mentally visualize the trajectory of the particles to correctly direct the beam.

Once the three symbols have been discovered, players move to the third scene, the sealed door (see Fig. 4c). To open the door and finish the game, players must select the three inscriptions that they found in the chest. If the door opens, they succeeded the challenge and the game. The game was designed for the Apple iOS platform and runs on the iPad tablet. It combines two key technologies that allow the player to interact with the scenario in a virtual manner through a user interface (Unity3D technology), and in a real way via a camera (Qualcomm's Vuforia technology).

Methodology

The experimentation in the classrooms began just after formal teaching of the section covering electric fields and at the beginning of the part of the course devoted to magnetism. It extended over two classes lasting 1 h each. The investigation was

carried out with four class groups, that is two control groups (CG1 and CG2) and two groups using the Parallel solution (PG1 and PG2). As well, two physics professors (called Teacher A and Teacher M) were involved, as were 160 students registered in the Electricity and Magnetism course taught in the winter 2012 semester. Each professor had two groups (one CG group and one PG group). The PG group of teacher A, which used the Parallel game, is labeled A in the rest of the article, whereas teacher M's PG group is identified as M.

A game evaluation questionnaire was administered to the two groups which had used Parallel (PG1 and PG2); 68 forms in total were filled out and subjected to qualitative analysis. This chapter is centered on the analysis of evaluation questionnaires. Questions primarily addressed the students' appreciation of the gaming experience in class, the utility of the game for visualizing electromagnetic concepts as well as students' opinion on the relevance of the use of the simulator in a science course. The questionnaire also evaluated the students' initial interest in video games. As a result, we were able to collect information regarding the comprehension of the intuitive functioning of the application, as well as the game's originality (introduction, graphics, and augmented reality) and its level of difficulty. Added to this were the video recordings of classes during which the simulator was used by students. The videos allowed for real-time observation of students' reactions. Moreover, a participant–observer produced a report.

Results

Experimenting Parallel

During the first session, only basic instructions were given to students in order to identify barriers to the intuitive understanding of the application and their difficulties in appropriation, as well as to identify possible instructions which could be developed in view of a better use of this tool in a classroom setting. Beyond some guidance on using the iPad, three pieces of instruction were given to students, working in teams of two. The first element of instruction defined the limits of the game, including the fact that it has three markers, of which two were on the counters in front of the students (i.e., the glass cube marker and the chest marker), whereas the third, of large format, was hanging on the display board at the front of the class (i.e., the door marker), and then identified the one with which students should start. The second element was designed to suggest a feeling or attitude of exploration, research, and questioning for this exploratory and appropriation phase, clearly indicating to students that they should observe closely, approach or move away from the virtual objects as needed, consider all three markers, go back to previous scenes, ask questions, discover the goal of the game, etc. Finally, the third element was designed to reassure students on the context of this session: our observations were not meant to evaluate them, but to evaluate the usefulness of the game with regard to helping

them in their learning. Moreover, it was clearly announced to the students that they themselves were neither being evaluated, nor would they receive a mark.

The appropriation challenge was major in several ways: only a limited number of students had previously used a touch tablet; very few, from one to four out of groups of 20 students, had already heard of augmented reality. In addition, in contrast to the textbooks, which presented 2D illustrations, in this situation students had to place the concepts in their 3D setting, identify the goal of the game, learn the interface codes (coordinate system, ways to define fields B and E, and their combination), find the symbols, and then accomplish the tasks by using the theory presented in physics class to succeed in the game. Students were given 35–45 min for this exploratory phase, depending on the group.

Regarding the students' behavior, the observer notes indicate an amazement phase common to all groups, but at times of varying intensity. During the first minutes, they did not speak much, or only softly. Then, after a few minutes, when the reading of the introduction was completed and the first virtual objects appeared, a new attitude arose in the teams. First they were "surprised," "impressed," "interested," and sometimes even "excited." This enthusiasm brought them into an attitude of research, questioning, and exploration of the quest. The students were very absorbed in the task of appropriation and an exchange dynamic arose within the teams. They were in a "parallel" world and nothing else existed: neither the professor, nor the camera, nor the observer. Students moved around the laboratory to consult the third marker.

Several of the teams maintained this attitude from the beginning to the end of this game session, even though only one to three teams per group were able to complete the game successfully at this stage. Some randomly explored the different components of the game, others systematically devoted time to each detail, trying to make connections. Some asked for one or two additional pieces of information to proceed. The generally used strategy was groping, "trial and error." They had "no idea what they needed to do" (A14) and they had to "sort things out to understand" (A19). On the other hand, some teams seemed "disoriented" and "didn't know what to do" at certain times. They tended to give up and remove themselves from the exploratory process. Some suggestions got them restarted, sometimes only for a brief period. Some adopted a random trial and error strategy, hoping that "someone would come tell [them] what to do." (M58).

How Parallel Changes the Relations Between Subject–Tool–Rules–Division of Labor and the Object of the Activity

The primary advantage of augmented reality was that it significant helps students see and visualize the physical situation and trajectory in 3D (35 answers), for all field configurations, which facilitates their understanding (11 answers). Augmented reality also helped students by providing a visual representation (glass cube) of an

abstract situation that is not otherwise easily accessible. They can "see instead of imagining" and link the theory to its physical manifestation. Students could think about what they are seeing instead of starting with their mental representation of the situation. For some students, it facilitated the adoption of a mental representation of the situation. We noticed that the glass cube scene became a reference during discussions between some students. Moreover, when they tried to limit the time spent with the glass cube (modification of rules) to practice on the fields and direct the particle beams to a specific site, they used the cube as a reference, and drew it on a sheet of paper. Some used the cube scene without starting the particle gun, or the beam (meaning no time countdown) to discuss their field configuration. A benefit of augmented reality was that it provided an experience, an interaction with a virtual setting that would not otherwise be accessible. Students could try their field configurations, concretely see in real time the effect on the particle beam and validate their understanding. There was autoregulation of their learning.

Parallel as a 3D tool provided a certain sensory experience of the situation. In addition, augmented reality allowed for greater interactivity between the student and the virtual setting than the real display usually available (electron beam in a bulb and Helmholtz coils to create a magnetic field) allows. There was devolution of power to students during the lab: they managed the unfolding of their own actions to resolve the enigma. This comment also applies to the accessibility of the real display (i.e., number of display vs. number of students) and to the limited number of manipulations and configurations possible regarding electromagnetic fields.

Even if the research project was exploratory and very targeted to a specific disciplinary knowledge, Parallel has a good potential to overcome a basic contradiction in school activity. The solution was appreciated by physics' students. By being willing to avoid guiding the students too much in their experimentation with the Parallel solution in the classroom, professors, although not deprecating a more traditional teaching/learning method, modified the use of teaching space, the division of tasks among themselves and between their students, as well as the usual classroom rules.

Parallel challenges the more traditional way of learning electromagnetism. Some rules are modified (usage of space, body–hand–eye coordination necessary to move electric particles in electric of magnetic fields), division of labor between teacher–students–peers. Interpretation of experimental results regarding augmented reality is consistent with the suggestions of Dillenbourg and Jermann (2010) regarding the added value of the technology in terms of the enrichment of knowledge regarding real-world objects and interactivity. We noted that students appreciated the simplicity of using augmented reality. In their opinion, it promoted contextual learning and autonomy. They believed that augmented reality, linked to a serious game on a mobile technology platform (e.g., touch tablet), facilitated the understanding of the concepts of electromagnetism, since it allows for a direct contact with a tangible reality. It gave a new meaning to the mobilization of resources (theoretical knowledge) in context, creating an interaction zone and generating an attraction affect triggered by immersion.

Results regarding the elements of the serious mobile game and its use as a support or obstacle to learning electromagnetic concepts lead to the emergence of two dimensions proposed by Yin (2010) regarding the possible convergence of said technologies and learning methods: learning in context and learner-centered learning. The learner can physically appropriate the Parallel solution, and move with it around the markers in order to become involved in the learning process. These results are in line with the observations of Alvarez (2012), who stated that serious games provide a considerable benefit in allowing us to find "memory."

Another point greatly revealed is the support of real-time self-verification of learning. Given that this is the first verification of the tool through an exploration process, at this point we cannot presuppose the representation of electromagnetic concepts. This is a nonconventional experimental framework, given the multiplicity of the parameters involved in student learning, including the mobile technology tool, the serious game, and augmented reality. In the problem-solving context of the Parallel solution, each student had a degree of freedom regarding the use they could make of space and the application of the theoretical concepts involved. Consequently, in a group context, the researcher is faced with a multitude of strategies.

As a research team, we experienced a dilemma regarding our wish to provide support and to offer space for students to be free. The results corroborate the choice we made to give information on the use of the tool and game playing. It is important to underline that this was made possible by the user-friendliness of the tablet's affordances and the simplicity of use of the augmented reality application.

Even within the context of an exploratory effort, we noted that learning supported by a mobile platform presented us with a multitude of contexts; the student is required to take into account the following parameters: movement in space, appropriation of the virtual interface, active involvement while interacting in a space provided by the augmented reality, and retention of disciplinary knowledge to resolve the serious game puzzle. These findings constitute the basis on which the next iterations will be built and are coherent with the definition of mobile learning we have adopted.

We also observed a strong convergence of mobile technology and two learning aspects, that is, learner-based learning and contextual learning (Sharples et al. 2005; Yin 2010). These conclusions lead toward new possibilities in science teaching and provide an incentive to become involved in additional work while aiming for a more collaborative aspect via a network connection. Consequently, we are already exploring a second project phase, during which classroom time allocated to handling the Parallel solution will be increased. In addition, the evaluation questionnaires will be revised in order to target the concrete elements which stood out during the first project iteration. The immersivity of augmented reality and the mobile aspect of the game will be reinforced by offering a unique, class-scale augmented reality, simultaneously shared by several students. This type of configuration could promote interaction and collaboration among players, and will make observed phenomena more tangible and reality based.

Augmented Reality Potential Toward Cross and Intergenerational Usage

Research results (Billinghurst and Dünser 2012) already underlined the benefits of augmented reality as a teaching tool for students of all ages. While augmented books have been focused on young children, mobile AR systems seem particularly suitable for high school setting. In such context, Parallel could act as the foundation of an intergenerational collaboration between college and high school students. The enthusiasm triggered by the solution among the college students yielded to their participation in several showcasing events dedicated to academic as well as general audiences. Mentoring of high school students by college students toward the adaptation of the serious game could be envisioned. Such an approach will be consistent with the current maker culture as well as the need for improving student programming skills.

The added value of augmented reality has been demonstrated as well for adults in continuing education contexts. The technology is able to create realistic and immersive working experiences to train nurses, surgeon, and mechanical operators to name a few (Knowles et al. 2011; Ong et al. 2008). Even if attempts to develop AR applications focusing on ageing population have been limited, an increasing trend in using AR system among older people has been observed (Malik et al. 2013). With the growth of elderly mobile users, evidence shows the possible trends using AR system to support elderly in terms of mobility and independence (Kurz et al. 2014). These examples underline the versatility of this technology across generations of users, from the youngsters to the elderly. Adaptation is still required from a thematic standpoint to meet the targeted user interest (e.g., physics-based mystery solving in the context of Parallel; a techno-cultural visit of Montreal in the context of Montreal Urban (http://www.musee-mccord.qc.ca/en/mtl-urban-museum/) Targeting broad audience). Adapting the user experience to the targeted population experience and requirement is also needed (Liang 2015). Augmented reality is a powerful enabler. More and more integration of this technology in edutainment solutions all along the life should be expected in the coming years. At the end, Parallel, along the pretext of resolving an enigma in a college physic's class may hold a great potential to modify rules, division of labor usually followed by students and make then engage in more sustainable long-life learning.

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Learning in Later Life While Engaging in Cross-Generational Digital Content Creation and Playful Educational Activities

Susan M. Ferreira, Sergio Sayago, and Josep Blat

Abstract Older people (60+) are using digital technologies in growing numbers. Previous research has pointed out that digital game-based learning has positive effects on learning. Yet, older adults are often portrayed as passive receivers of digital information. Moreover, studies of digital games conducted with them have overlooked learning, focusing almost exclusively on helping older people to cope with age-related changes in functional abilities and improve intergenerational communication. This chapter reports on two case studies, which address digital video creation and digital gameplay in educational activities by older adults with mild-to-moderate age-related changes in functional abilities and different levels of previous experience of ICT use. Both case studies show older people learning more about themselves (i.e., realizing they have the skills to master computers and express themselves through digital technologies) and a number of different topics (ranging from contemporary digital technologies to literature and arts), while actively creating digital content and playing online digital games. The results show the potential of playful learning activities, and the importance of both inter- and intragenerational communication and taking into account older people's needs and interests, in order to envision a richer and diverse ICT-mediated learning in later life.

Keywords Older people • Digital content creation • Digital games • Learning in later life

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Introduction

This chapter addresses Digital Game-Based Learning (DGBL) across the lifespan within the context of Human–Computer Interaction (HCI) and Digital Games (DG). While older people (60+) are using digital technologies in growing numbers, they are often portrayed as passive receivers of digital information or remote observers (Vines et al. 2015), and previous studies argue that HCI researchers have largely been concerned with the downside of aging, focusing mostly on the design of assistive technologies (Rogers et al. 2014). Similar claims have been made in the field of DG. Despite the fact that previous research has pointed out that digital game-based learning has positive effects on learning (Van Eck 2006), studies of digital games with older people often focus on helping older players to cope with age-related changes in functional abilities and improve intergenerational communication (Mosberg Iversen 2014). By drawing upon two case studies, this chapter argues that older people can make a much more active use of ICTs and shows the potential of playful learning activities in order to envision a richer and diverse learning in later life.

The first case study focuses on digital video production (i.e., recording, editing, and sharing), whereas the second deals with digital gameplay and creation in educational activities. Taken together, both case studies show older people learning more about themselves (i.e., realizing they have the skills to master computers and express themselves through digital technologies) and about a number of different topics, ranging from ICTs to literature, while actively creating digital content and playing digital games. As our literature review will demonstrate, both learning behaviors while creating digital content and playing digital games have seldom been documented by previous research thus far (e.g., Ferreira et al. 2015; Ferreira 2015). Inter- and intragenerational communication aspects stood out in both case studies too. This result shows the value of collaborative playful learning activities, and community positive reinforcement, in learning in later life. Finally, the results suggest that taking into consideration older people's needs and interests, as well as age-related declines in functional abilities, when designing tools and ICT courses for them is key to foster and strengthen their engagement in learning and educational activities in older adulthood.

Literature Review

Digital Game-Based Learning and Older People

Digital games are becoming more and more popular among older adults (De Schutter et al. 2014; Marston 2013; Nap et al. 2014). Indeed, and despite the *grey* digital divide, much of previous research in HCI, DG, and gerontechnology portrays older people as actual or potential players of digital games (e.g., Brown 2012; De Schutter 2010; De Schutter and Malliet 2014; Ijsselsteijn et al. 2007; Nap et al.

2009; Pearce 2008). Their motivations for playing digital games range from entertainment (Pearce 2008; Nap et al. 2009) and avoiding social isolation (Kern et al. 2006; Quandt et al. 2009) to improving cognitive abilities (Luckner et al. 2013; Zelinski and Reyes 2009). A large number of digital games targeted at older people have also been designed, such as *Waterball* (Tsai et al. 2013), *Cogniplay* (Vasconcelos et al. 2012), *iStoppFalls* (Gschwind et al. 2014), and *Blast from the past* (Abeele and Schutter 2014). Common to these games is that they aim to help older people to cope with age-related changes in functional abilities, improve/enrich grandchildren–grandparent communication, and encourage cross-generational social interaction (Sayago et al. 2016). Despite this growing body of knowledge, previous research on digital games with older people has mostly overlooked learning. On the one hand, this might be surprising, because learning by playing games is well documented in the literature (especially, with children). On the other hand, however, failing to address learning might be accounted for the fact that learning in later life is a challenge, especially if age-related changes in cognition—namely, fluid intelligence (Czaja and Lee 2007)—are considered. By drawing on a 4-year ethnographical study with 420 older people in two different environments, Sayago et al. (2013) argue that older people adopt three strategies to become *successful* ICT learners (i.e., using ICTs over extended periods of time without the support of instructors/relatives) over time (a) linking learning to real-life needs, (b) learning collaboratively and informally, and (c) adopting appropriate memory aids. These results reinforce the need of understanding the learning needs of older people, where and how they learn in older adult education (Kern 2014). Yet, the relationship between learning, digital games, and older people (e.g., needs satisfied by playing games and collaboratively learning playful activities) still warrants further research. It is our conviction that by developing a better understanding of older people digital game-based learning, we could design technologies that not only compensate for "a lack of something" but also enrich their lives, thereby strengthening their social and digital inclusion.

Learning While Creating Digital Contents

Current research concerning the design of interactive technologies for older adults typically focuses on providing them with access to digital resources: "older adults are normally characterized as consumers, rather than producers, of digital content"(Waycott et al. 2013). Seeing this situation from a learning perspective, there is room for thinking that learning takes place in a rather traditional scenario (e.g., learning by reading). However, older people can actually become digital content creators, and this presents different learning opportunities (e.g., learning by creating digital contents). Karahasanovic conducted three studies that investigated elderly people's user requirements related to consumption, sharing, and co-creation of user-generated content online (Karahasanović et al. 2009). The results suggest that given the right circumstances, elderly people are eager to cocreate narratives

based on a common history or documenting the history of their neighborhood. By focusing on understanding the factors affecting elderly user's participation in online video creation, Ryu et al. (2009) conducted an online survey in which 290 online Korean people aged 50+ participated. Respondents reported being willing to adopt video creation services if some conditions, such as ease of participation, usefulness, and enjoyment, were satisfied. Harley and Fitzpatrick's studies analyzed 8 videos generated and uploaded by an older person, Peter, owner of a very popular YouTube channel and also known as "Geriatric1927" (Harley and Fitzpatrick 2008, 2009). The authors argued that intergenerational contact, reminiscence, reciprocal learning, and co-creation of content emerged from how the videos produced by Peter were used in YouTube. Despite the potential of digital content creation for opening up alternative and/or richer learning scenarios (e.g., learning by reading, doing and collaborating with others) than those which can be envisaged within the traditional digital content consumer perspective, what older people actually learn while creating digital content, and how they do it, still has not received much research attention.

Case Studies

We carried out two case studies (CS1 and CS2) in Àgora,[1] a 35-year-old highly participatory adult learning community in Barcelona, Spain. Since the 1980s, Àgora has been fostering the social inclusion of people who are, or might be, excluded from the Catalan society, such as immigrants and older people. To this end, Àgora adopts a dialogical learning approach (Aroca 1999), which empowers the students to decide what they want to learn in free courses.

CS1 focuses on older people's digital video creation. In CS1, we report on ethnographical research activities conducted over a 5-year (2010–2015) period in order to examine the relationship between active and healthy older people and ICTs. We participated in 21 computer courses and 18 drop-in sessions in Àgora as participant observers, resulting in a total of 298 h of fieldwork with 217 older people (aged 60 to 85; women: 120; men: 97) with different levels of experience with ICTs. We also conducted online observation on a daily basis of participants' use of Facebook, WhatsApp, and YouTube. Facebook and WhatsApp groups were set up to provide a closed channel of communication for the most active participants (44 Facebook, 25 WhatsApp), and those who were interested in using these technologies. The fieldworker (first author) was a Facebook friend of 50 participants and followed the YouTube uploads of three of them throughout the study. Participants reported having been using computers and the Internet for 3 months to 8 years. Participants were original from different Spanish regions and had low levels of educational attainment (70 % with at most primary school formal education).

[1] Agora, Escola d`Adults de La Verneda-Sant Martí, Barcelona, Spain (http://www.edaverneda.org/).

CS2 focuses on playing and creating digital games. CS2 was conducted within the context of WorthPlay,[2] a 2-year project aimed to conceptualize, design, and evaluate digital games that are sufficiently appealing, meaningful, and playable in the everyday lives of older people. In CS2, the experiences of digital gameplay of older people interested and uninterested in digital games were explored. The study was divided into three phases: conceptualization, Participatory Action Research (PAR), and evaluation, which are described in full in (Sayago et al. 2016). The conceptualization phase was grounded in a 6-month ethnographical study of the play experiences of 178 active and healthy older people (75 % women and 25 % men) with different play interests. The design (and implementation) phase consisted of three Participatory Action Research (PAR) activities conducted with approximately 100 older people over a 2-month period. The evaluation was conducted in 3 European cities (Barcelona, Madrid, and Dundee) in order to validate/challenge the results of the ethnographical and PAR activities. Fifteen games were created and played by 99 older people with different cultural backgrounds. The age of the participants ranged from 60 to 85 years old. They reported to have different previous experience with ICTs, ranging from those who had never used computers and the Internet (approximately, 12 %), or had been using them for a few months or years (80 %) to those who had been using computers for more than two decades and owned smartphones (8 %).

In both case studies, fieldnotes were taken mostly immediately after the sessions, due to our active participation in most of them. Regarding data analysis, the analysis of fieldnotes in CS1 follows the interpretation of Nigel Gilbert (Researching Social Life) (Gilbert 2008) of Strauss and Corbin (Strauss and Corbin 1998) Grounded Theory's methodology. The fieldnotes were coded line-by-line (Open Coding), resulting in several preliminary categories (Axial Coding). The preliminary categories that emerged from Axial Coding were discussed among the authors until a clear outcome was agreed. In CS2, we adopted a thematic analysis (Braun and Clarke 2008) approach to analyze the data. All fieldnotes were read to identify common topics, and findings were discussed amongst the project team, which in turn led to the development of a corpus of "stories" from the activities. The main results are presented next.

Results

CS1: Digital Video Creation

While there are older people who are not motivated to use ICTs, there are others who are interested in learning ICTs by interacting with multimedia content and digital entertainment (Ferreira et al. 2014, 2016). As our ethnographical study in Àgora progressed, we witnessed how our participants moved from seeking and

[2] http://worthplay.upf.edu.

watching YouTube videos to creating and editing their own digital videos and sharing them. They produced approximately 320 digital videos over the course of the study. We show that by engaging with digital video content technologies, participants learned more about ICTs and different ways of expressing themselves with these technologies. We observed, and participants confirmed, that two key results of this digital video content creation learning were enriched intra- and intergenerational communication and perceived digital social inclusion.

Learning More About Themselves, ICTs, and Digital Self-Expression

Participants' digital video creation was highly associated with how they appropriated digital video creation technologies. They appropriated these technologies in a social way, for example, creating videos, which were meaningful to them, and then sharing these videos with specific members of their community. Regardless of their previous knowledge of ICT, participants were motivated to operate new digital devices and applications in order to create videos and express themselves digitally, as the following two vignettes of representative cases illustrate.

Vignette 1: Learning More About Themselves and ICTs

Maria finds it very difficult to interact with computers. She actually does not like them very much. Yet, she thinks that nowadays it is important to know how to use technologies in order not to lag behind. Maria often takes part in courses in order to learn how to use computers and the Internet. She started taking the video creation courses. She had numerous difficulties in following the course. However, she was interested in the topic and took the course many times.

Maria often sits next to a more experienced participant, who creates the videos. Maria shares her opinions with this expert participant. Motivated by the course and the videos that the other participants were creating, Maria wanted to create her own video. Her first idea was to create a video about her birds. One day she used her camera for recording the birds while they were playing in the water. This was a very unusual activity for Maria, as she normally does not practice at home what she learns in the course. On the next video creation class, Maria brought her camera. She was very proud of her birds and her video. She wanted to show her birds to the other participants and needed help to transfer the video from the camera to the computer. However, the teacher of the course told her that she made a mistake and that there was no video in the camera. That was the first time Maria tried to use the camera to record a video on her own. Despite this shortcoming, a few weeks later she decided to practice again. She realized that she could do it, and this was an important change in her life and attitude toward computers. This time she decided to take pictures of one of her flowers, and then combined these pictures into a video. She had learned how to do so in the course. She eventually created a video. Maria was happy and more confident in herself.

Fig. 1 Participant's video experiment

Vignette 2: Learning More About Different Ways of Expressing Themselves

Pedro really enjoys interacting with technologies. He knows more about computers than most of his friends. He teaches MS PowerPoint to other older adults of his neighborhood. In his free time, Pedro enjoys practicing ICT and learning new things. Digital video creation has become his favorite activity: "*A good thing about creating videos is that there are so many effects and cool things that we can add to the video that it doesn't matter how much I practice, there is always something new to learn.*"

Pedro saw in YouTube a tutorial about how to change the background of a video. He got very interested in carrying out this task in his videos. He bought a plain fabric to make his experiments. One of his first experiments was to record himself talking and acting as if he was carrying an invisible ball—Pedro is mad about football and sports. He then looked for a nice background on Internet (he selected a picture of a beach). Pedro them created his video by combining his videos with the beach in the background. To make the video funnier, he included an animated picture of a ball. He had a lot of fun doing it and came up with more ideas to explore this technique further. Fig. 1 shows one of Pedro's video experiments.

Key Results of Digital Video Creation Learning: Enriched Cross-Generational Communication and Perceived Digital Social Inclusion

Participants perceived that sharing their digital videos with people they cared for, especially their children, grandchildren, and close friends, could strengthen their ties with them. They appropriated digital videos in a very social manner, and

sharing their videos was a very important step in their creation process. Sharing the videos they created was often used as a strategy to:

- Give a present, "*My daughter's birthday is in February and I want to give her a video as a present. She is a bit sick so I want to do something nice for her.*" [60, F25]
- Say "Hi," *"I liked the video a lot, it nearly gave me goose bumps!" [41, F70e] "Hi! Show it to your mom please! A special kiss for both of you!" [64, F16] (Conversation on [64, F16] Facebook's wall)*
- Catch up with friends and relatives, "*We're watching a video on my iPad. I recorded a couple of videos of my grandchildren this weekend and I was showing the videos to them before the session with you was due to begin. We took advantage of this to catch up on things, you know.*" [76, F39]

Moving from using analog videos and paper photographs to sharing media online also facilitated participants' intergenerational communication: "*(…) this is the video I recorded from the lunch last weekend* (showing the video in a *WhatsApp* conversation). *I sent it to my partner's son, who was also there. He told me that he liked it a lot*" [75, M3]. This interaction was promoted by using the same communication channels as those used by younger generations, such as e-mail, Facebook, YouTube, or WhatsApp.

Sharing their digital videos also gave rise to follow-up intra- and intergenerational conversations. The topics of most of these face-to-face or online conversations were about the memories the video brought up, the quality of the video, or the technologies applied, all of which contributed to their ICT learning. By talking with friends and relatives, participants received positive reinforcement and exchanged their knowledge about ICTs (teaching and learning new concepts). These social interactions increased their engagement in the video creation process and made them feel—as they told us—more socially and digitally included.

CS2: Creating and Playing Digital Games in Educational Activities

Previous research has addressed diversity amongst older people's use of digital games (De Schutter and Malliet 2014). In WorthPlay (Sayago et al. 2016), we observed that the relationship between older people with different cultural backgrounds and digital games is very diverse. While there are older people who do play games, others refuse point-blank to do so because they do not perceive the usefulness of engaging in gameplay. Thus, in an attempt to cater for this diversity, we decided to create an online platform whereby older people can create (and play) different types of quiz-based online games. Given the educational setting in which we conducted our research, we considered that quiz games could be the most appealing type of games to our participants. In this case study, we argue that (a) participants reported learning about ICTs and the topics of the games (e.g.,

mathematics, history, and arts) as a result of creating and playing them in the platform and (b) intragenerational interaction took on an important role in creating and playing games in collaborative learning scenarios.

Learning About Different Topics as a Result of Both Creating and Playing Digital Games in Collaborative Learning Scenarios

With respect to creating games, participants worked together in order to seek online information about the topic of the game. They also discussed how to write appealing questions. It might be worth noting that writing motivating questions is a cognitive-demanding task, as it calls for a comprehensive understanding of a topic plus writing abilities. Thus, creating games encouraged participants to brush up on their knowledge of a topic and make the most of their social, writing and reading skills.

With respect to playing games, most of the playing activities consisted of reading, discussing, and looking for information using contemporary ICTs in order to answer the questions of a game. When playing games, participants reinforced their learning by (a) reassessing aspects of a desired topic, (b) transferring the knowledge they acquired in the class or in the books to a digital learning scenario, and (c) learning new content adding up to their previous knowledge about a topic, for example, "*We have learnt several new things… I didn't know that there was a palace here… and I've been living here for a long time ago"* [Player, playing session in the book reading club].

Both creating and playing games were developed in collaborative learning scenarios, which corresponded to the already existing educational activities in Àgora. A noteworthy example is the *geolocated book quiz*, which was conducted with older people who met at a weekly book-reading club in Àgora, Fig. 2a and b. Participants were separated into two groups and were tasked with creating geolocated questions about the book they were reading by using smartphones or tablet devices and a geolocated web-based system (Santos et al. 2013). This quiz helped us to understand key elements of their playful experiences (e.g., learning and socializing) beyond winning or losing, in which participants had no interest.

Given that the platform was designed to be easy to use for novice ICT users and to introduce more expert users to popular online technologies, such as YouTube, Google Images, Wikipedia, or newspapers, creating and playing games in the WorthPlay platform was seen:

As a motivating way of introducing older people with little or no previous experience of ICT to these technologies, "*It broke the fear for working with the computer… it allows you to see what can be done in the computer and that you can do it… people enjoyed the activity, had fun with the questions, with the work, with the group… it is not just avoiding fear. It can be done and I can do it!"* [Coordinator of playing/interview about the experience of general knowledge game].

As a stimulating activity for more expert ones, "*If I click here… Is it going to open, so I can see more things? Look! Here in the side I can also see other news from today! (…) This is very useful for me! I didn't know how to see the news in the computer. I found this very interesting!*" [Player, playing session in the ICT learning course].

Fig. 2 (**a**) Geolocated book quiz: creating game session. (**b**) Geolocated book quiz: playing session

Design Recommendations

We consider that drawing design implications (or recommendations) from ethnographical research is difficult and controversial for, amongst other reasons, ethnography cannot (and should not) be reduced to a finite number of "bullet points"

(Dourish 2006). Yet, in this section, we aim to highlight key results that emerge from CS1 and CS2 in an attempt to (a) share with the reader important lessons we have learned in our case studies and (b) encourage future research studies to take them forward.

Older People ICT Learning is a Learning Area

Based on a literature review, Thalhammer draws attention to the fact that since older adults tend to learn in nonformal rather than formal settings, it is important to understand the extent to which ICTs actually influence their daily life and whether this is in fact perceived as a learning area (Thalhammer 2014). While there are reasons to believe that older people might not be able to learn to use ICTs because of age-related changes in fluid intelligence, our results, along with some previous research (e.g., Sayago et al. 2013), show that this is not the case, and that older people ICT learning is actually a learning area. ICTs (can) influence multiple facets of older people's everyday lives, and how they learn to use these technologies is highly determined by these activities, as well as other factors, such as social relationships, personal interests, and life experiences. With respect to the dichotomy nonformal vs. formal learning alluded in Thalhammer's statement (Thalhammer 2014), CS1 and CS2 show that there is a lot of nonformal ICT learning in Àgora. Perhaps, informal ICT learning is more suitable for older people than formal learning, given that most of them (at least, our participants) are more interested in actually learning how to use the technologies in their everyday lives than in getting official certificates and passing exams. This is a research issue that can be addressed further in future studies.

Putting Older People First

The results of CS1 and CS2 suggest that when thinking in terms of designing ICTs for learning, it is very important to put older people first. This is not to say that technology is not important. However, instead of coming up with a new technological development that can potentially help older people to take their learning forward and trying to fit that technology in their daily lives in some way or another, we could (and should) first of all understand the characteristics of the user group, identify their learning interests and practices, and then think which and how technology could enrich their actual learning process. While this design philosophy is not new at all within HCI (e.g., user-centered design), we perceive a risk of putting technology first when it comes to older people, especially because of widespread stereotypes associated with ageing and ICTs (Durick et al. 2013).

Going Beyond Stereotypes

We (or, at least, a large number of us) tend to have preconceived ideas of old age and older people. This is due in part to our own experiences of ageing, which include, for instance, our grandparents, elderly neighbors, and older people in the street (e.g., shopping, walking, and commuting). These experiences of ageing determine the way in which we think about older adults. For instance, it might be surprising for a great many of us to realize that older people can actually learn to create digital games (CS2) because our grandparents struggle to learn how to operate a digital TV or a new mobile phone with a different menu. Creativity, which is addressed in CS1, might also be surprising, since old age tends to be associated with a period of declines in functional abilities. Both case studies encourage us to go beyond stereotypes when it comes to ICT learning and older people.

Cross-Generational Communication is Very Important in Effective Learning in Later Life

As one might expect, communication cuts across CS1 and CS2, wherein it played different roles. By keeping in touch with younger relatives and members of their local community by using contemporary digital technologies, our participants reported feeling more social and digitally included. By sharing their videos with their friends and discussing about the answers of a question in a game, our participants learned further aspects of technologies, a book they were reading, etc. These results indicate that the learning of our participants was both an individual and social activity, thereby reinforcing the importance of communication in ageing (Nussbaum et al. 2000). Thus, these findings suggest that designing tools that promote cross-generational communication is important to foster effective and engaging ICT learning amongst older people.

Conclusion and Future Work

In this chapter, we have presented two case studies that challenge widespread views of older people within HCI, wherein they are seen as consumers rather than producers of digital content (Waycott et al. 2013), and take forward previous HCI and DG research by showing older people learning more about themselves, a wide range of topics, ICTs, and self-expression by actively producing digital content, and creating and playing digital games in educational activities. Those older people who participated in our study were highly motivated to engage in digital content creation activities. They saw in these activities an opportunity to enrich their intra- and intergenerational communication. By seeing the value of the digital video creation in

their daily life, participants engaged in the creation process and were very motivated to keep learning more about video creating and sharing tools. The WorthPlay platform was successfully integrated into already established collaborative learning scenarios. Learning therefore happened by reinforcing part of the content presented in regular courses and by adding a playful and digital element to them. Overall, both case studies show the potential of digital playful learning activities to enhance learning (of ICTs, and other topics) in later life.

These results should be understood by bearing in mind the profile of our participants and the setting in which we conducted our research. That is, one of the most important limitations of this chapter is that the results presented herein might not be easy to generalize to other profiles of older people and settings. Future research can deepen and widen the results presented in this study.

In terms of future research perspectives, the creativity shown by our participants is worth noting, especially because current HCI research with the older population is dominated by removing usability and accessibility barriers due to ageing, "as if creativity (and outstanding performance) were not significant parts of aging" (Cohen 2006). Thus, future research studies could explore creativity and its relationship with DGBL and older people. It might also be important to point out that participants were able to personalize the activities according to their interests. This personalization turned out to be essential for engaging them in the learning process and strengthening their relationship with ICTs. As games are effective not because of what they are, but because of what they embody and what learners are doing as they play a game (Van Eck 2006), in our studies, the content of the activities and the discussions among the participants were crucial in their engagement with the learning activities. Future studies can also look into different ways of personalizing educational activities by adding a ludic element to them.

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Digital Games as a Means of Raising Awareness About Ageism and Gender Discrimination: Three Principles for Teachers and Game Developers

Andreas Schuch

Abstract This chapter presents three principles for how digital games could be used by teachers or designed by game developers to raise awareness about and discuss discrimination, stereotyping, inequality, and other issues connected to age, aging, gender identity, and sexual preference. In other words, an intersectional approach is developed with special focus on age and gender aiming to facilitate learning and game design processes about harmful social constructions. The three principles are (1) encourage minimizing hurdles for players to access and play games, (2) diversify the content within a game or across multiple games, and (3) encourage intergenerational learning processes. These principles primarily draw on educational research, but are intended to be used by teachers and game developers alike. Regarding principle 2, a model is derived from sample games with the goal to inform lesson plan creation and game selection processes for teachers as well as design choices for game developers. The independent digital game development scene served as the primary source for the development of the model. Because games revolving around age- and aging-related topics appear to be exceedingly rare, the proposed principles were initially developed with LGBTQ* topics in mind. However, it is demonstrated that the developed model can also be applied to other social dimensions such as age.

Introduction

The depiction of old age in Western society is frequently accompanied in popular culture by negatively connoted biological imagery. Aging is often framed as undesirable; old age as a problem (Gullette 2004, p. 7). Others see old age as a

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disease—something that needs to be "cured" (Vincent 2006, p. 687)—or as a failure that needs to be controlled through technology; "[aging] is a result of an unnecessary failure technically to control a biological process" (Vincent 2006, p. 692). Woodward (1999, pp. xi–xii) highlights another theme of ageism when she identifies a "pedagogy of mortification [with the goal] to teach an older woman to recede into invisibility." While she speaks of ageism against women specifically, it is not difficult to imagine that similar demands be made on elders of other genders.

These are problematic views of age and aging, but discrimination occurs in many other aspects of social life as well. People may be discriminated against because of their gender, race, class, religious belief, disabilities, looks, language abilities, etc. In the last two decades, more and more scholars have come to approach these aspects of social life and their relationship to one another from an intersectional perspective. Intersectionality is a term coined by Crenshaw (1991) which offers "a way of mediating the tension between assertions of multiple identities and the ongoing necessity of group politics" (Crenshaw 1991, p. 7 italics removed). Or, as McCall puts it, at the center of intersectionality lies the notion of expanding "the subject of analysis […] to include multiple dimensions of social life and categories of analysis" (McCall 2005, p. 1772).

When compared to approaches which focus on single analytical categories, intersectionality necessarily results in an increase in analytical complexity. However, it also promises to break up artificially (i.e., socially) constructed boundaries and thus allows for new approaches to be applied to the study of inequality among various social dimensions. The paradigm shift introduced by intersectional methodology is leveraged in this chapter by approaching teaching practices and game design from an intersectional-technological perspective. More specifically, this chapter proposes three "anti-ageist" principles for educators and game developers. The goal of these principles is to help to prevent or counteract—or at least to reduce—budding or established negative stereotyping and discriminatory (thought) practices or expressions in virtual game worlds, as well as among players and learners.

First, it should be noted that scholars have over time developed different approaches to intersectionality, some of which reject the concept of social categories completely. This chapter uses social categories strategically by provisionally acknowledging the "durable relationships that social categories represent at any given point in time" (McCall 2005, p. 1774) while also remaining critical toward processes of simplification and categorization. Analysis and teaching/design principles in this chapter follow a lesser known methodological approach to intersectionality termed *intercategorical complexity* by McCall (2005):

> The intercategorical approach […] begins with the observation that there are relationships of inequality among already constituted social groups, as imperfect and ever changing as they are, and takes those relationships as the center of analysis. The main task of the categorical approach is to explicate those relationships, and doing so requires the provisional use of categories (McCall 2005, pp. 1784–1785).

Second, why choose digital games? At the core of digital games lies a powerful form of interaction, something Zimmerman (2004, p. 158) identifies as "Explicit interactivity; or Participation with Designed Choices and Procedures," which is an umbrella term for "choices, random events, dynamic simulations, and other procedures programmed into the interactive experience." Digital games harbor enormous potential for enabling learning processes because of their interactive nature. They allow for interactive role reversals and generally provide players with a high degree of agency, both of which may contribute to diffusing processes of victimization, vilification, stereotyping, and discrimination.

Specifically regarding the educational benefits of digital games: In the last two decades, digital game-based learning has come to be seen by a significant number of scholars as offering powerful learning opportunities (see, e.g., Gee 2007; Prensky 2001). Many schools tend to focus on their weakest learners the most. According to DiSessa, those schools are "designed around incompetence in the sense that any real understanding is a sign to move on to the next topic. Pride in accomplishment is seldom reached" (DiSessa 2001, p. 40). This chapter argues that digital games are part of a solution to "this problem of dealing with school systems that are not sympathetic to teachers who de-emphasize memorization and competition in favor of developing new interpretations of reality and continued self-actualization" (Schmeck 1988). Many digital games approach learning and repetition from the opposite direction, regularly and actively rewarding players for their accomplishments (e.g., with high score lists, achievements, and trophies, extra rewards for players who level up, complete optional objectives, or succeed in difficult-to-perform actions). A number of games provide fertile learning environments for learners; or as Gee (2007, p. 67) puts it, "a good video game often operates within, but at the outer edge of, the learner's resources, so that at many points the game is felt as challenging but not 'undoable'." As a result, such games encourage player agency and foster curiosity. Barab et al. assert that autonomous inquiry is preferable over rote memorization when they state that "learners learn best when the learning process involves inquiry, as opposed to the memorization of the facts and principles that were generated from someone else's inquiry" (Barab et al. 2005, p. 89). In addition, young players and learners today grow up as digital natives (Prensky 2001)—digital games arguably "speak" their language more than more traditional media.

Game developers and teachers can use games to promote a more positive attitude among players and learners toward diverse and inclusive social environments. Games open up new possibilities for shifting perspectives. However, probing the internet for digital games which put aging or ageism at the center of their narrative or design proved difficult. Only an exceedingly small set of two games which depict aging in a sensible, nontrivial manner could be identified: *Passage* (Rohrer 2007) and *To The Moon* (Freebird Games 2011). Game developers are encouraged to create more aging/ageism-themed games to fill this gaping hole. For the purposes of

this text, the problem of the seeming lack of games about aging and ageism shall be sidestepped by drawing on intersectional methods and breaking up the boundaries of single social categories.

This chapter argues that digital games which revolve around discrimination and social categories other than aging can still as effectively be utilized to help design specifically age-/aging-related games or to discuss and teach about age/aging-related issues. In order to provide a guide for game developers and teachers to help achieve this goal, three principles were developed with both game development/design as well as teaching with games in mind. Because of the apparent dearth of games examining age- and aging-related topics, these principles were initially developed with games about LGBTQ* issues in mind.[1] As a second step, these teaching/design principles were adapted to be applicable to ageism. This is made especially apparent in the discussion on the second principle and the subchapter "Modeling Game Diversity," which both explore the idea of diversification in games (homosexuality, transgender identity, depression, isolation, overweight, etc.).

Teaching and Game Design Principles on Aging/Ageism

The next pages will elaborate on three teaching/design principles which teachers and game developers/designers are encouraged to apply to their game development processes and classroom teachings, respectively. It should be noted that the suggested principles are primarily derived from and grounded in educational research, and only to a lesser extent in game studies. For this reason, the discussions in the three subsequent subchapters focus on teachers and learners, rather than players in general. At the same time, the act of centering games' narratives around one or more

[1] The digital games discussed in this paper mostly present an "inside" perspective of (parts of) the life of LGBTQ* people, which is a perspective most players should be unfamiliar with (similar to old age-related rhetoric). By playing games about LGBTQ* topics, players can assume and enact LGBTQ* identities individually—they can get a "glimpse behind the scene." By enabling players to experience LGBTQ* life from the perspective of an "insider," digital games are able to provide them with a potentially more authentic understanding and emotionally relatable narrative of what it means to be LGBTQ*. And because age-based discrimination is in many ways similar to LGBTQ* discrimination, the argument of this chapter is that the discussed games, approaches, and principles can just as easily be applied to raise awareness about cultural constructions of aging as they could be to LGBTQ*-related issues. In other words, the idea is that intersectional approaches developed from an LGBTQ* point of view should still be transferable into the realm of teaching about ageism. The chapter explores to which extent this statement holds true and outlines possible limitations.

types of discrimination or incorporating discrimination-related topics in games is arguably often coupled with a didactic intention (e.g., "sexism is problematic and here is why"). For this reason, this chapter argues that the principles derived from educational research can also be applied—in general—to game design. This sentiment is reflected in the wording of the summaries of the principles, which can be found at the beginning of each subchapter. Each summary condenses and at the same time generalizes the discussion of a given subchapter. The goal was to develop principles which are equally applicable to a teaching and game design context. In addition, a number of sample games are discussed which sensibly depict and explore LGBTQ* topics, and—by extension—also age-/aging-related topics. The three teaching/design principles can and should be combined if possible, but they can also be employed separately.

While games revolving around the topic of aging or ageism seem to be still a rarity, there do exist a handful of games which sensibly incorporate or discuss LGBTQ* characters or topics. However, the digital games industry seems rather cautious in this regard. If big budget games do include LGBTQ* people or themes, in most cases they only appear at the sidelines or are realized in superficial ways. While notable exceptions do exist, sensible and appropriate representations of LGBTQ* issues could mostly be traced to the independent digital game scene, which has seen exponential growth in the past decade. For this reason, independent games take the center stage in this chapter.

First Principle: Minimize Hurdles for Players

Summary

Games should allow for short play sessions (e.g., between 5 and 30 min), they should be free or inexpensive, have low hardware requirements, and gaining access to them should be straightforward.[2]

[2] Game developers/designers do not face this same set of difficulties as teachers do because they can target a specific audience and hardware. However, if the goal is to reach as large an audience as possible, the above-mentioned suggestions of (short, free, easy to access, and low system requirements) still hold true. The larger the project, the more difficult these suggestions will probably be to implement. If not all aspects can be implemented, game developers/designers are encouraged to consider to design the project at least partially around these suggestions.

As noted before, there do exist a number of potentially promising triple-A games (i.e., games with large production budgets targeting mainstream audience) which sensibly depict LGBTQ* topics and themes. However, for teachers, exploring triple-A games in a classroom setting is infeasible for a number of reasons. For one, these games are in general expensive (teachers may not be provided the funds to purchase them). They also often require sophisticated hardware to run (the performance of PCs at school may not meet the game requirements), and require potentially lengthy and complicated procedures when setting up the digital games for lessons (e.g., creating individual user accounts for each PC to log into the game client).

Games made by independent developers appear more useful and flexible in light of the constricted situations teachers usually find themselves in. Independent games can often be accessed via a web browser and many are completely free (or at least significantly less expensive than triple-A games). They also offer generally shorter, more focused play sessions. "Short" games will here be defined as games that can be expected to be completed within 5–30 min of play time. Free and simple access, easy-to-meet system requirements, and relatively short play sessions minimize potential hurdles for teachers (when developing and enacting lesson plans) and for learners (when engaging with games during the lesson). These qualities seem preferable in a teaching contexts with limited time and resources available to educators. The games mentioned in this chapter fulfill either most or all of these criteria.

Second Principle: Diversify Content

Summary

Players should be exposed to one or more games covering as diverse a set of themes, topics, and perspectives on a given topic as possible to account for players' different ways of making sense of the world, to expose them to many unique and mediated experiences, and to encourage transfer of knowledge.

There exists no consensus in educational research about which learning theory and style describes human learning most authentically. A prominent and widely accepted conceptual framework was developed by Felder and Silverman (1988), which outlines a set of 32 (2^5) learning styles "(one, for example, is the sensory/auditory/deductive/active/sequential style)" (Felder and Silverman 1988, p. 675). Felder argues convincingly that different people have distinctly different learning style compositions. One of the conclusions of this model is that in order for teachers to provide each of their learners with an opportunity to learn effectively, they must create lesson plans with diversified content which takes into account learners' differing learning styles.

Several scholars also argue that experience plays an integral role in the learning process. Gee supports in his work the view that "humans learn, think, and solve problems by reflecting on their previous experiences in the world. That is, humans have experiences, store these experiences and make connections or associations among them" (Gee 2007, p. 71). Stephenson further argues that "[e]xperience has long been considered the best teacher of knowledge. Since we cannot experience everything, other people's experiences, and, hence, other people, become the surrogate for knowledge" (Stephenson 1998, p. 1). Closely related to these sentiments is Schmeck's remark on facilitating learning through encouraging change:

> [T]eachers may influence […] learning […] by encouraging a change in the scenarios, or scripts, that are part of the frame of mind that accompanies a perception. […] Changes in scenarios or scripts occur through gradual developmental-experiential processes, which teachers can promote by structuring the educational situation so that the personal growth motive is engaged more frequently […] (Schmeck 1988, p. 16f).

According to these views, then, exposing learners to a large number of games which offer distinct (personal) experiences or perspectives on a given topic seems preferable over in-depth analyses of only a few experiences.[3] It should be noted that the concept of exposing students to many unique experiences is not to be confused with what literature on educational research sometimes terms the "experiential learning model." Strong instructional guidance is of paramount importance.[4] Authoritative teacher instructions which encourage meta-level thinking and discussions among students, as well as secondary materials such as newspaper articles and videos should go hand in hand with engaging students with digital games.

The greater the number of experiences, the more transfer of knowledge can occur. Transfer is one of the core concepts around which our educational system is built (Bransford and Schwartz 1999; McKeough et al. 1995). Arguing in support of transfer, Gee (2007, pp. 38–39) states:

> Semiotic domains in society are connected to other semiotic domains in a myriad of complex ways. One of these is that knowledge of a given domain can be a good precursor for learning another one, because mastering the meaning-making skills in, and taking on the identity associated with, the precursor domain facilitates learning in the other domain. Facilitation can also happen because being (or having been) a member of the affinity group associated with the precursor domain facilitates becoming a member of the affinity group associated with the other domain, because the values, norms, goals, or practices of the pre-

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[4] Recent research questions the efficacy of minimally guided approaches to instructing and teaching, that is, learning theories referred to as experiential learning, discovery learning, constructivist learning, etc. (Kirschner et al. 2006; Mayer 2004). Evidence "almost uniformly supports direct, strong instructional guidance rather than constructivist-based minimal guidance during the instruction of novice to intermediate learners" (Kirschner et al. 2006, p. 83).

> cursor group resemble in some ways the other group's values, norms, goals, or practices (Gee 2007, pp. 38–39).

Based on this observation, he proposes two learning principles:

> **Semiotic Domains Principle** Learning involves mastering, at some level, semiotic domains, and being able to participate, at some level, in the affinity group or groups connected to them (Gee 2007, p. 42).
> **Metalevel Thinking About Semiotic Domains Principle** Learning involves active and critical thinking about the relationships of the semiotic domain being learned to other semiotic domains (Gee 2007, p. 42).

The term "active thinking" in the above citation means "experiencing the world in new ways" (Gee 2007, p. 31); "critical thinking" refers to the requirement that learners "be able to consciously […] attend to, reflect on, critique, and manipulate" (Gee 2007, pp. 31–32) typical or acceptable content and social practices of a particular semiotic domain (e.g., first-person shooters and social categories such as age and LGBTQ*).

The underlying assumption of this principle is that learners have—to some degree—"mastered" one or more semiotic domains related to negative experiences (such as loneliness, being bullied, and ostracism). Teachers can then introduce learners to games which address one or more of these semiotic domains that they are familiar with. A small selection of suitable games would be, for example, *Lim* (Kopas 2012), *Loneliness* (Magnuson 2011), and *Trauma* (Uithoven and Uithoven 2015).

Online platforms such as itch.io or game jams such as Global Game Jam[5] encourage independent game developers to create and then share their games online. Teachers can in turn make use of the fact that there is a large pool of potentially useful games available to them. The biggest hurdle for educators is probably identifying the games which fit their purposes the best in the huge pool of available games. The online platforms mentioned before typically accommodate this need to a degree because they often allow visitors to apply filters and tags to tailor the searching process to their needs.

Assuming that teachers have now selected a number of suitable games, how should they proceed? There exists a virtually limitless number of ways of how to approach teaching about ageism. One approach that follows Gee's principles is detailed here. Teachers could have learners play some of the games they selected while following certain instructions. The instructions should ideally remain vague but still trigger critical reflections among players on the subject matter of the game. For example, instructions could encourage learners who play *Dys4ia* (Anthropy 2012) to critically reflect on and consider aspects of social ostracism, which is one of the recurrent themes found in *Dys4ia* and which they may also have been a victim of at some point in the past (or currently still are). This (or other games and topics) will lay the foundation for bridging the gap between the topics covered by the played games and age- and aging-related topics at a later point. At this early stage

[5] See, for example, http://globalgamejam.org/2015/games.

of teaching, however, the actual lesson topics (i.e., age- and aging-related topics) are not important. Only as a second step, learners should then be asked to apply (i.e., transfer) their knowledge of the domains covered by the games to the new domain related to age- and aging-related issues.

Lim[6] is an example in which the structure of the game itself encourages transfer of knowledge. The game does not merely ask players to connect with its protagonist on issues such as gender identity and sexual orientation—something many players probably have not much experience with. *Lim* questions violence and practices of exclusion enacted upon nonconformist people of any kind. Its abstract aesthetics could encourage learners to connect with the main character on levels which they probably do have experience with, for example, the desire to fit into a group, irritation caused by bullies, and/or feelings of exclusion or infuriation. Players could then connect their personal, individual experiences on the screen with ones from their own past.

More specific interpretations and discussions in the classroom regarding transgender identity, ageism, and aversion in society toward these concepts can then follow as a *next* step. Once learners are encouraged to transfer their knowledge of one domain (e.g., ostracism) to a related one (e.g., elderly people), they could potentially be expected to now more easily be able to link their personal interpretations and their own negative experiences with ones they are not directly familiar with. In this context, the goal could be to make learners become more empathetic toward the elderly people who experience social ostracism and rejection.

Summarizing this subchapter then, it appears most desirable for teachers and game designers to represent people, topics, and issues which are traditionally assigned to certain social categories (e.g., the elderly) or themes (e.g., ostracism) in a quantitative and diverse manner (to encourage transfer of knowledge) while exercising strong instructional guidance and control. Fortunately, the independent game development scene provides teachers with a number of suitable games to achieve this goal. See chapter *Modeling Game Diversity* for a nonexhaustive list of LGBTQ* and aging-related aspects which games should address to make the content of the lessons as diverse as possible.

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[6] *Lim* (Kopas 2012) is a minimalist game "about fitting in" (Zoya 2012) and the consequences of challenging established norms. Players control a square, a "multivocal body" (Zoya 2012) which wildly fluctuates between colors, symbolizing nonconformity. In the game, players meet a number of single color squares and are constantly confronted with making a decision: either they take on a single color to blend in with the crowd or they continue flashing in many colors. Either option has its benefits and drawbacks:

"When the protagonist is spotted not fitting in, it is attacked by the surrounding squares. There's no depleting health, no chance of dying, but the attack is loud, uncomfortable […] and makes it harder to move around the game space." (Zoya 2012)

"[C]hange colors by holding down Z, afford yourself some respite, just realize that doing so leads to an entirely different kind of unpleasantness." (Porpentine 2012)

Third Principle: Leverage Intergenerational Learning Opportunities

Summary

Encourage and guide intergenerational learning processes (e.g., reflection, discussion, storytelling, and game creation by and among people of significantly different ages) in the family space and/or in public spaces (e.g., classroom guest invitation and communication within online communities).

Available research suggests that intergenerational learning projects prove incredibly instrumental in teaching about preconceptions and stereotypes against certain age groups. According to Kerka (2003, p. 1), successful intergenerational learning "fulfills age-appropriate developmental needs of youth and adults, is relational and reciprocal (drawing on the strengths or assets of each generation), and creates a community in which learning results through collective engagement in authentic activities." Similarly, Kaplan (2001) identifies several benefits of intergenerational learning for children and youth in fields such as academic skills and performance, attitude toward aging, emotional development, and social skills and for older adults in health and activity level, the attitude toward younger people, self-discovery, and improved life circumstances (see Kaplan 2001, pp. 19–25).

Loewen (1996) suggests that learning should reflect the intergenerational aspects of the everyday world:

> [E]ngagement with the everyday world should not be a world absent of generational variety. Making learners aware of the reality of the everyday world means involving them with adults, just as making adults aware of that same world means involving them with adolescents (Loewen 1996, p. 10).

After conducting a meta-analysis of approximately 20 intergenerational learning programs, he identified five important characteristics and argued that the more of these characteristics are implemented in a program the more successful it will be (see Loewen 1996, pp. 25–32):

- Curriculum-based: intergenerational learning should be based within the school's curriculum
- Relationship-based: the relationship with the person of a different generation greatly "impact[s] one's motivation to learn" (27)
- Reciprocal relations: "both adults and adolescents can offer expertise and the need to acquire knowledge. The learning process needs to be as dynamic as possible" (29)
- Community-based: the project needs to be relevant to the real world instead of being limited to the classroom to take full advantage of the "expertise and new teaching and learning that could be occurring" (30)

- Authentic work: the final outcome needs to be "pertinent and worthy of great mental and physical energy" (32)

Learners' families constitute a convenient space for game designers and for teachers for facilitating intergenerational learning opportunities without directly consuming class time. Recent developments in school-parent relationships may prove useful in this regard. As (Cairney 2000, p. 172) observes, "there has been a growing desire to move toward genuine partnership between home and school, and a search for processes to facilitate the reaching of mutual consensus between parents and teachers."

Cairney (2000) argues that there lies much untapped potential in treating parents as partners in education. In the specific context of this study, the family space could be utilized to encourage conversations and reflections on social categories (e.g., age) between different generations (e.g., teenager, parent, and grandparent). Teachers can from a distance guide discussions in broad strokes, for example, by constructing deliberately worded (homework) assignments. Game designers can build in opportunities for discussions. Discussions could revolve around family members experiencing social injustice in the past, or also on their attitude toward certain social minorities or social categories. A homework task could be about people of different generations playing games together (as selected and suggested by the teachers) and possibly documenting the process. Such tasks are important not only because they lead to more productive private discussions among family members. Learners could also reproduce some of the arguments in class and could thus provide to each other a wealth of unique stories, information, perspectives, and mediated experiences.

Another option for teachers who wish to reap the benefits of intergenerational learning processes is to invite some guests (e.g., elderly people) to join the class. However, this would presumably entail significant organizational work and limit the flexibility of lesson plans (e.g., incorporating 10-min chunks of age- and aging-related topics in every regular lesson, for example, would probably be out of the question). But teachers who are not deterred by the additional workload could have learners and guests play and discuss games in class and thus take on more active and directing roles than they could with homework assignments. For example, they could assume the role of the "adversary," that is, someone who seeks to challenge overly simplified views expressed by others in class, or they could remain as a more neutral facilitator.

Collective game creation is another way of harnessing the potential of bringing together people of different generations in the classroom. There exist a number of applications with simple yet powerful toolsets and relatively intuitive user interfaces—such as the visual programming tool *Scratch*[7] which enables users (even those with no prior computer science knowledge) to quickly create simple applications or games (see Resnick et al. 2009). While not much literature could be found on the benefits of collaborative (and intergenerational) game-creation, Kangas

[7] See https://scratch.mit.edu/.

(2010) conducted a study on learning through game cocreation and noted that this project felt rewarding to all participants and fostered activity, social skills, and other aspects.

Modeling Game Diversity

This subchapter draws primarily on the second proposed design/teaching principle and is dedicated to offering game designers a model for developing more LGBTQ*-friendly and "anti-ageist" games and teachers guidance in procuring a set of suitable games for teaching. The model was initially developed with LGBTQ* games in mind, but then adapted for the social category of age.

Developing a Model for an LGBTQ* Context

In order to gain an overview of the breadth of LGBTQ* topics covered by existing games, it was deemed useful to group them together based on a specific theme or a set of commonalities they share. The following categories are suggested as a starting off point, but the list could easily be expanded with new entries (examples for each category are provided in parentheses):

- Sexual orientation (e.g., bisexuality and homosexuality)
- Gender identity (e.g., female identity and transgender identity)
- Stereotypes and themes (e.g., coming out, anxiety, and social ostracism)
- Experiential point of view (e.g., LGBTQ* person, family member, and unrelated stranger)
- Narratorial focus (e.g., verbal narrative and narrative mechanics)
- Genre (e.g., biography)

Game developers and designers are encouraged to consider the categories listed above during all stages of the game development process. Greater diversity within a given game can be achieved by considering and incorporating as many categories (sexual orientation, etc.) and as many aspects in each category (e.g., heterosexuality, homosexuality, bisexuality, asexuality, pansexuality, etc.) as possible. Next to focusing on creating more diversity *within* a given game, game developers and designers could also increase diversity *across* various of their games. For example, it may be that games created thus far explore, for example, sexual orientation in greater depth from the perspective of the LGBTQ* person. A new game could instead approach sexual orientation from the perspective of a family member or switch the narratorial focus away from heavy dependence on verbal delivery and more toward narrative delivered through its mechanics (see Table 1 for sample games).

Teachers may further diversify the content of their lessons on LGBTQ* topics by applying this list to the game selection process. It is suggested that teachers select

Table 1 A nonexhaustive list of games deemed suitable for game design analysis and teaching about aging, ageism and LGBTQ* issues

Game	Themes	Perspective	Narratorial focus	Comment
Called Out	Marginalization	Inside	Verbal	Nonfiction; pseudodialog
Climb	Transgender identity	Mixed	Mixed	Fiction mixed with nonfiction
Coming Out Simulator 2014	Homosexuality, coming out	Inside	Verbal	Fiction with autobiographical elements
Conversations We Have In My Head	Transgender identity, memory, relationships	Inside	Verbal	Fiction; pseudodialog of protagonist with themselves
DiSCOVERY	Transgender identity, gender binaries	Inside	Mixed	Fiction
Dys4ia	Transgender identity, hormone replacement therapy	Inside	Mixed	Autobiography
Fit In	Transgender identity, gender binaries	Stranger	Mechanics	Fiction, abstract
Gay Sniper	Homosexuality, marriage	Stranger	Mechanics	Fiction, subversive
Gone Home	Homosexuality, coming out	Sister	Mixed	Detective fiction, strong focus on environmental exploration
Lim	Transgender identity, social ostracism	Inside	Mechanics	Fiction, abstract
Loneliness	Social ostracism	Inside	Mechanics	Fiction, abstract
Mainichi	Transgender identity, social ostracism	Inside	Mixed	Fiction, JRPG aesthetic
NAOMI	Transgender, coming out, anxiety	Inside	Verbal	Fiction, protagonist comes out to a friend, anime aesthetic
One	Homosexuality	Stranger	Mechanics	Fiction, abstract
Our Wedding Plan	Homosexuality, same-sex marriage	Inside	Mixed	Fiction
Parable of the Polygons	System theory, diversity	Stranger	Mixed	Nonfiction, abstract, descriptive
Passage	Life, aging	Inside	Mechanics	Fiction

(continued)

Table 1 (continued)

Game	Themes	Perspective	Narratorial focus	Comment
Radiator 1-2: Handle With Care	Homosexuality, same-sex marriage	Inside	Mixed	Fiction, 3d, mod (requires base game half-life 2)
Read Only Memories	Crime, science fiction	Stranger	Verbal	Fiction; anime and cyber punk aesthetic
Reparative	Transgender identity, religion, psychiatric counseling	Stranger	Verbal	Fiction
Striptease	Transsexuality	Stranger	Mechanics	Fiction, subversive
To put it simply	Transgender identity, history	Stranger	Verbal	Nonfiction, discusses suicide of a transgender teenager
To The Moon	Life stages, trauma, repressive memories	Stranger	Mixed	Fiction, JRPG aesthetic
TransForms	Transgender identity	Mixed	Mixed	Nonfiction
Tranxiety	Transgender identity, social ostracism	Inside	Verbal	Fiction, JRPG aesthetic
Trauma	Failure, hateful behavior, trauma	Inside	Mixed	Fiction
What's in a Name?	Bisexuality, social ostracism	Inside	Verbal	Fiction with autobiographical elements

several games for each category/bullet point. Categories may further be divided into subsets, which enables teachers to be as flexible and granular in structuring their lessons as needed (e.g., first discuss a set of games about homosexuality, then examine a set of games about bisexuality). Teachers should choose how, in which order, and to which level of detail they facilitate discussions about individual games or sets of games based on the unique composition of each class.

Many of the LGBTQ* games mentioned below would warrant formal analysis and could provide enough topics for discussion to fill whole papers. Due to scope limitations, however, this chapter will refrain from delving too deep into analysis. Instead, a number of LGBTQ* games which have been deemed suitable for classroom teaching shall be outlined briefly. See Table 1 for a quick overview. The short play times of most of the listed games (mostly 2 to 10 min) should give teachers the flexibility to have learners play and discuss a number of different games within one teaching unit.

Games which sensibly discuss homosexuality are, for example, *Gone Home* (The Fullbright Company 2013), *Our Wedding Plan* (Dreamgate Games 2015), *Coming Out Simulator 2014* (Case 2014), and *Read Only Memories* (MidBoss 2015). *What's in a Name?* (Gaming Pixie 2013) presents a narrative in which a bisexual character is discriminated against. Transgender identity is explored in titles such as *Mainichi* (Brice 2012), *Dys4ia* (Anthropy 2012), *Fit In* (Axel 2015), Conversations We Have In My Head (Squinkifer, 2015b), *TransForms* (PixelSnader 2015), *Tranxiety* (Jayne 2015), *To put it simply,* (Mallory 2015) and *DiSCOVERY* (Olivia Fel Games 2015). Games such as *Lim* and *Called Out* (Squinkifer 2015a)—due to their abstract and minimalist presentation—can be used to more generally talk about discrimination based on socially constructed categories and thus may serve as an ideal entry point.

Existing LGBTQ* games discuss a wide variety of themes. The moment of coming out as LGBTQ* is re-enacted in games such as *Coming Out Simulator 2014* and *NAOMI* (Paper Star Studios 2015). The theme of hiding one's (gender) identity from others is at the center of *Tranxiety* and *Lim*. Games which play with and subvert players' expectations are, for example, *Gay Sniper* (Anthropy 2009) and *Striptease* (increpare games 2009). Same-sex marriage is a core theme in *Our Wedding Plan* and *Radiator 1-2: Handle With Care* (Yang 2009), which is a *Half-Life 2* (Valve Corp 2004) modification. *Dys4ia*, *Tranxiety*, and *To put it simply,* provide players a glimpse into the transition period of transgender people. Conversion therapy is taken up as a core theme in *Reparative* (Saldaña 2015). The point of this enumeration of themes is to show the wealth of topics which can constitute necessary and productive classroom discussions.

In the majority of games about LGBTQ* topics listed in Table 1, the fictional world is experienced from the point of view of an LGBTQ* protagonist or an unrelated stranger. Games providing an "inside" perspective are, for example, *Dys4ia*, *Lim*, *Tranxiety*, and *What's in a Name?* These games tend to frame the playable character as victims. There are also a number of games which depict LGBTQ* topics from a more privileged point of view—an "outsider" perspective from a stranger. Such games are, for example, *Called Out*, *Fit In, Reparative,* and *Gay Sniper.* Here, the playable character is usually framed as holding power over LGBTQ* characters. Narratives in LGBTQ* games told from the perspective of a friend, family member, or (arguably) counselor take on a middle ground between "inside" and "outside" perspective. While these people obviously do not have to go through the same experiences as the LGBTQ* person, they still tend to share a degree of involvement with them. Games belonging to this category are *Reparative* and *Gone Home*. After extensive research, *Gone Home* remains the only known LGBTQ* game in which players assume the role of a family member (sister).

Another aspect contributing to a diverse representation of LGBTQ* topics in games is what in this chapter shall be referred to as narratorial focus. Digital games may present their narrative predominantly through *language* (e.g., verbally through text, audio, or symbols). This is the case in games such as *NAOMI, Reparative, Tranxiety, Gone Home,* and *Coming Out Simulator 2014*. But narrative can also be conveyed mainly through the rules of the game and interactions between various

game elements (i.e., through game *mechanics*). Such is the case in games like *Our Wedding Plan, Fit In*, *Lim*, *Striptease*, and *One* (Lloyd and Douglass 2013). A number of other LGBTQ* games resort to a mix of both verbal narrative as well as narrative mechanics to tell their stories, for example, *Dys4ia, Radiator 1-2: Handle With Care, TransForms*, *Mainichi*, and *Climb* (jamforleelah76 2015).

LGBTQ* games often emerge from somebody experiencing social injustice in life. This becomes especially interesting in a teaching context when a game includes (auto)biographical elements. Games constructed through an (auto-)biographical lense may leave players with a more emphatic impression on the issues discussed. Games which include obvious (auto)biographical elements are, for example, *Dys4ia, Mainichi,* and *Coming Out Simulator 2014*.

Adapting the Model to an Aging and Ageism Context

Games that sensibly depict aging and related topics are rare. *Passage* and *To The Moon* seem to be, by my search, the only two games which put age and aging at the core to their narratives. The seemingly few games that do exist also only depict *some* aspects of aging while other aspects are ignored when tested against the aging/ageism model listed below. In addition, these games are sometimes also not free of problematic and stereotypical views of aging themselves (e.g., aging solely as a degradation metaphor).

If games discussing aging and ageism are so rare, it proves difficult to use existing games to develop a meaningful model—especially with regard to the second design/teaching principle which requires per definition a large and diverse set of topical games. This subchapter sidesteps this problem by arguing that the developed game-based teaching model on LGBTQ* issues can be adapted for teaching about discrimination based on age. Principles 1 and 3 do not require alteration as they are derived from general teaching and learning principles, and should thus hold true for both designing games and teaching about topics such as gender and sexual identity discrimination as well as ageism (or many other social domains, for that matter). An adaptation of principle 2, on the other hand, requires minor adjustments. While its core principle remains the same (i.e., diversify content), the categories as established in the LGBTQ* model need some adjustments. The following updated list is suggested for games incorporating age- and aging-related topics:

- Sexual orientation and gender identity (e.g., LGBTQ* elders)
- Stereotypes and themes (e.g., decline narrative, loss of identity, and loss of sexuality)
- Genre (e.g., biography)
- Experiential point of view (e.g., elderly person, young person, and medical staff)
- Narratorial focus (e.g., verbal narrative and narrative mechanics)

While most changes should be self-explanatory, two aspects may require a further description.

Sexual orientation and gender identity remain important concerns when teaching about ageism because stereotypical views with regard to LGBTQ* elderly pervade society and discriminatory laws are still in existence. For example, Ory et al. (2003, p. 165) find one of the most commonly held stereotypes against LGBTQ* elders is their apparently nonexistent sexual drive: "[w]hile interest and engagement in sexual activities do decline with age, the majority of older people with partners and without major health problems are sexually active, although the nature and frequency of their activities may change over time." Knauer (2008) identifies a number of additional problems such as invisibility: "[…] our LGBTQ* elders are aging—and dying—alone and invisible, and are often denied the basic dignity of being able to share their memories of a life well lived without fear of rejection and reprisal."

Some academics identify popular beliefs in society such as the decline narrative calling it "a dominant cultural assumption: that the body declines as if with no cultural intervention" (Gullette 2004, p. 4). Others fight popular stereotypes by highlighting ageism in relation to elderly women and their loss of identity (Maierhofer 2004, p. 319; Woodward 1999, p. xi). They, instead, ask that aging be depicted as its own stage in life free from negative associations made by society today: "aging—in contrast to stereotypical notions—does not bring a loss of identity, but emphasizes difference instead of communality, and expresses individualism more prominently than in youth" (Maierhofer 2004, p. 319).

Conclusions

According to Gee (2007, p. 45), "[a]ll learning in all semiotic domains requires taking on a new identity and forming bridges from one's old identities to the new one." Digital games are extremely well suited for this task. Players are constantly encouraged to take on different identities (even impossible ones!) to explore topics from new perspectives. And while digital games provide a virtual space to explore these identities in a safe environment, this does not necessarily lessen the emotional impact digital games have on the players. The opposite may even be true because of digital games' interactive nature (or the subversive taking away of any interactivity). Games have also quickly achieved popular culture status (Entertainment Software Association 2015). If games are ubiquitous in Western society and if they are especially suited to facilitate learning, it may only make sense then to integrate them in lesson plans more. However, games are not the "one size fits all" solution; rather, they should support and inform conversations on discrimination based on age, gender, etc. and be employed *in addition* or as a *starting off point* to other modes of discussion.

The majority of games discussed in this chapter depict (or can be interpreted to depict) topics related and relevant to members of the LGBTQ* community. They also mostly approach their main subjects from a semifictional, autobiographical perspective and especially emphasize a social environment which is often framed as hostile, oppressive, and normative. Nonetheless, they also often frame their narratives

as universal experiences, that is, narratives which every human being can relate to (see, e.g., the theme of innocent teenage love in *Gone Home* or the narrative about hiding part of one's identity for fear of rejection in *Coming Out Simulator 2014*). Teachers and learners could greatly benefit from more game developers aiming to create games which at their core are about positivity and solidarity instead of negativity and fragmentation. This is not to say that games highlighting discriminatory practices are less important, but rather acknowledging the second design/teaching principle and its call for diversity.

In the independent digital game sector, games which depict LGBTQ* issues sensibly—for example, by refusing or questioning prevailing stereotypes—are still relatively rare to come by. Aside from a small number of targeted game jams and a few games produced by individuals such as Anna Anthropy and Merritt Kopas, the selection of potentially interesting titles is rather limited. Especially games which specifically target bisexuality as their core theme are still exceedingly scarce. In addition, LGBTQ* games mostly narrate stories from the affected person's point of view. Other perspectives (e.g., family member, friend, and unrelated stranger) would further contribute to a more diverse representation of LGBTQ* concerns. Similarly, most games strongly empathize a verbal narrative delivery—narrative mechanics (or a mix between the two) were identified far less frequently in digital games about LGBTQ* issues. Nevertheless, the current independent LGBTQ* game scene has still started to gain momentum in recent years, which is an encouraging sign for the future. This does not seem to be the case for a game development scene specializing in age- and aging-related topics, however. Games which overtly discuss, problematize, or center on age topics still seem exceedingly rare, which ultimately undermines the usefulness of the proposed game selection model about age- and aging-related topics for teachers until more games with a focus on age become available. Game developers and designers, on the other hand, can create more inclusive and diverse digital games with the help of the proposed model.

As a next step, the proposed principles and the model on game diversity need to be field tested, the results reported, and adjusted, amended and/or removed. Scholars are encouraged to contribute their own theoretical models or collect empirical data first-hand in the field of teaching and raising awareness about harmful social constructs. Only little literature exists on this topic and the field would greatly benefit from more contributions. More (independent or mainstream or other) games need to be identified and formally studied as to their positive effect as an artifact for facilitating learning processes. Especially game modifications prove an interesting field worthy of further study in the sense that they offer players the opportunity to subvert, criticize, critique, amend, reinforce, or make other changes to ageist notions in the original game. This may prove especially effective with the most popular games or the favorite games of learners. There is also a need for more work to be done on the benefits of intergenerational game creation (or game modification!) as studies related to this topic are scarce.

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