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CHAPTER 19

COMPUTER GAMES AND OPPORTUNITY TO LEARN

Implications for Teaching Students from Low Socioeconomic Backgrounds

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As suggested in many chapters of this book (e.g., Tobias, Fletcher, Ch 1, Ch 21; Games & Squire, this volume), there has been an emergent interest in using computer games to enhance learning and motivation. What are the implications for students of low socioeconomic status (SES) backgrounds? Will the use of computer games create new opportunity to learn for these students or enlarge the "digital divide"? What are the affordances and constraints of using computer games to promote learning for this group of students?

In this chapter, we use the concept "opportunity to learn" (Gee, 2003, p. 27) as an overarching idea to organize our review. Specifically, the main purpose of this chapter is to identify affordances and constraints of using computer games for learning by students who have limited access to educational material and related resources and who may otherwise be at risk in terms of lowered academic achievement or dropping out of school entirely.

Computer Games and Instruction, pages 477–500

(Charlotte, NC)

We first discuss instructional use of computer games in the context of "opportunity to learn" as an equity issue. We then review possible advantages and constraints of using computer games as a learning tool with this group of students. Finally, we propose a conceptual framework for a research agenda aimed at enhancing effective use of computer games for learning, particularly targeting those students who are socioeconomically disadvantaged.

COMPUTER GAMES AND "OPPORTUNITY TO LEARN"

Gee (2003) advanced the concept of "opportunity to learn." The opportunity to learn is determined not only by duration and frequency of exposure to educational content in school but also by its quality. Individuals have equal opportunity to learn if they have had similar experience with supporting texts *and* authentic, immersed (or embodied) experiences in relevant semiotic domains. These embodied experiences allow the student to situate abstract words and meanings of a topic in the richer context of social practice and to fully appreciate what it means to think like a geologist, chemist, historian, and so on. Traditionally, these immersions in semiotic domains have been more available to students from affluent backgrounds. To the extent that socioeconomically disadvantaged students lack comparable "representational resources" (including games in their learning "toolbox"; Gee, 2003, p. 44) inside and outside of school, they are cognitively disadvantaged as well.

The families and schools of higher-SES students can be expected to finance immersion experiences in and outside the classroom. Such experiences are generally not available to their low-SES counterparts. Interactive media could provide an opportunity for learning to more individuals, whether in schools or in after-school programs, and thus remedy or mitigate the situation. The costs of educational provisions may be lower when learning-related software and devices can be replicated and massively distributed.

There are fewer environmental and travel restrictions in computer-based games as long as the related computer equipment is provided. If computer and video games can indeed help reduce or close SES experience and prior knowledge gaps, they may enhance opportunities to learn. If they cannot provide the missing experiences, then the effects of computer games on learning are likely to be minimal among students from low SES backgrounds. However, there is a third possibility: the answer to this question depends on *how* computer games are used, and for what purposes they are used; that is, the ways computer games are used with a particular group of students can either significantly enhance or weaken their educational potential.

Affordances and Constraints of Computer Games for Learning Gains

Can computer games, with their motivating features, enhance instructional effects and improve learning, especially for those low SES students who do not find classroom learning particularly interesting? Our answer is yes but with a cautionary note that the answer is not as straightforward as it might appear.

At least three issues need to be considered. The first is the digital divide, which puts low-SES students at a disadvantage in terms of access to and effective use of computers and computer games. The second issue concerns the use of computer games for enhancing learning and motivation for low-SES students, or students who are not adapting well to the school curriculum or environment. In other words, what makes a computer or video game a particularly effective medium for learning for these students? The third issue deals with the distinction between games for learning and games for entertainment. There are important implications of this distinction for effective use of computer games, particularly for those with inadequate opportunity to learn. The following is a more elaborated discussion of these three issues.

"Digital Divide": Equitable Access and Effective Use

The digital divide refers to the discrepancy or disparity in access to and/or utilization of technology for some groups. Physical accessibility is relatively easy to determine—that is, to what extent computer games and related equipment are available to students of low SES. What can be overlooked, however, is the potential depth of the digital divide. Hohlfeld, Ritzhaupt, Barron, and Kemker (2008), for instance, found that, while the number of computers in low-SES schools has increased, there is significantly less access to, less student and teacher use of, and less technological support for computers than in higher-SES schools. Such results suggest that simply placing more computers in schools will not automatically solve the problem of the digital divide.

In addition to school access, the digital divide may include discrepancies in home computer access and use. DiSalvo, Crowley, and Norwood (2008) studied Black middle school boys who play digital games. Specifically, they looked at the cultural context for such play, how it affects learning with games, and how discrepancies in gaming experience between Black and White students play out in the education of science, technology, engineering, and mathematics (STEM). They concluded that students in low SES groups had less home computer access, and those with access were more likely to opt for entertainment and games and less likely to have or use educational software.

Attewell and Battle (1999) used the 1988 dataset of the National Educational Longitudinal Study to explore three learning outcomes of 8th graders' standardized test scores in reading, in math, and self-reported overall grades. They found that having a home computer is associated with higher test scores in math and reading, even after controlling for family income and for social and cultural capital (e.g., attending classes in music, arts, and dance outside of school and visiting museums with parents). However, it seemed that high-SES students achieved larger educational gains from home computers than low-SES students. Whatever the reasons for the difference (e.g., habits, prior knowledge, and technology proficiency, which potentially influence how they use computers and computer games), the authors warned that home computers may generate another "Sesame Street Effect" where a new opportunity to learn for poorer children to catch up educationally with affluent peers turns out to increase the learning gap. The same can be said about the effects of computer games. With potential disparities in computer use both at home and in school, it is apparent that the digital divide does affect how computer games may benefit students from low-SES homes educationally.

The digital divide does not pertain only to children. Parental attitudes also play a role in their children's computer use. Linebarger, Royer, and Chernin (2003) found that parents from low SES backgrounds, compared to their middle or high SES counterparts, were less likely to view the computer and the internet as educational tools. This finding suggests that the problem may not be resolved simply by giving students access to computers (or computer games for that matter). Research should examine the effectiveness of initiatives to reduce the digital divide in a larger social context that involves family, peers, and community.

Computer Games as New Opportunities for Learning

Although it is clear that simply having access to computer or video games does not necessarily benefit low-SES students educationally, computer games do offer some potential for increasing learning by these students compared to traditional classroom teaching. Due to elements inherent in games, such as active participation, story lines, role-playing, and a sense of identity as an agent for action or change, games are inherently goal-directed, motivating (Barab et al., 2007), cognitively and affectively engaging, and may boost the player's confidence when success is achieved (Pintrich & Schunk, 1996). Moreover, computer games, particularly those played in multi-user virtual environments (MUVEs) involving experiences that mimic real life, can offer a range of direct or vicarious experiences not otherwise available to low-SES students. Finally, because some of these games expose players to the world of knowledge by incorporating meaningful learning, they significantly increase the likelihood that students of low SES, particularly those who perceive classroom learning as either anxiety-provoking or irrelevant, would perceive learning materials embedded in game environments as both less stressful and more meaningful (Squire, 2006).

Educational benefits of games are not solely a digital phenomenon. Motivation research has long established the positive effects of play activity (Lepper & Henderlong, 2000) and competitive games (Harackiewicz, Manderlink, & Sansone, 1992) on learning and motivation. Siegler and Ramani (2008) demonstrated positive effects of playing a numerical board game on numerical skills such as estimation with a group of low-SES children. They gave a board game dealing with numerical knowledge to a group of preschoolers from low-SES backgrounds and found that four 15-minute sessions of game play eliminated the numerical knowledge gap between this group and a peer group from more affluent backgrounds. Presumably, playfulness in the game added enjoyment to the learning process and may explain the learning gains.

The benefits seen in educational games could be captured in their conversion to digital form. Furthermore, compared to the standard versions, digitized versions of games may be more motivating. Korat and Shamir (2008), in a randomized experiment, showed a greater improvement in emergent literacy after using an educational e-book for low SES compared to middle SES groups. Noticeable is the finding that the "read and play" mode was more effective than the "read story only" mode. The addition of play involves some simulation and role-play, which presumably enhanced learning.

Virvou, Katsionis, and Manos (2005) studied two tutoring systems in geography; one used a computer game, and the other did not. They found that the game condition reduced posttest errors. They also found an attribute-treatment interaction effect indicating that students with the poorest performance before the introduction of the game gained the most. It was suggested that the instructional support (Tobias, 2009) consisting of advice and suggestions incorporated into the game contributed to its effectiveness, while similar support for non-game tutoring was not as effective (Tobias & Fletcher, 2007). Since lower-SES students tend to compare unfavorably with higher-SES students in academic performance (e.g., Frederickson & Petrides, 2008; McLoyd, 1998), Virvou and colleagues' findings support our hypotheses that the use of computer games for instructional purposes could be particularly effective for students from low SES backgrounds.

Distinction Between Learning Games and Entertainment Games

It is almost a truism that games are engaging and motivating. The kind and extent of motivation, however, depend on the specific type of game, and perhaps the characteristics of the user as well. Some games afford entertainment, and other games pose intellectual challenges and entail productive use of knowledge in reasoning and problem solving, including obtaining right-in-time knowledge (see also Prensky, this volume). When games are designed primarily for educational or training purposes, they are often classified as "serious games." Although the distinction between "purely" entertainment games and "serious games" may not be clear-cut when a specific game is concerned, it is safe to assume that games vary in their potential for educational and instructional use (Games & Squire, this volume).

On the player's side, in general, the motivation to play games is to have fun, not to attain learning goals. Koo (2009) found that enjoyment, escape, and social affiliation, but not concentration and epistemic curiosity, predicted the intention to play. This may be truer of low-SES students than of others. Attewell and Battle (1999) found a lower percentage of educational software in low-SES homes than elsewhere. The use of the media for entertainment alone will not lead to academic learning gains. Gentile, Lynch, Linder, and Walsh (2004) reported that, "In general, a preponderance of studies show a fairly consistent negative correlation between recreational video game play and grades. Others have documented a similar negative correlation with college students between amount of time playing video games and grades" (p. 6). This is disturbing in light of studies such as that by Dumais (2008), which show that low-SES students, compared to their more affluent peers, are more likely to engage in activities such as TV watching and video game playing that are associated with lower test scores and grades. Barab and colleagues (2007) showed that instruction regarding the purposes of game play (i.e., whether the game play is for learning and problem solving or for fun or entertainment) can make a difference in players' gaming behavior and consequently the extent of learning gains. For example, telling students the learning goals of game play in an educational setting can enhance the achievement towards the set goals.

When discussing and assessing so-called educational benefits of computer games, it is important to explore the match. By match, we mean what the instructor intends to achieve by using a particular game, and the extent to which the game can afford intended educational benefits (see Tobias, Fletcher, Dai, & Wind, this volume for a discussion of integrating games into the curriculum). Many entertainment games (particularly those played in virtual environments) allow players to explore and navigate a particular simulated environment and learn something along the way (through incidental learning). However, there is no way to measure the success of a particular game in terms of its learning benefits without specifying what is to be gained as a result of game play. There are two main considerations regarding the match. First, the instructor has to decide on what is to be gained after game playing. Second, the instructor has to decide whether a particular computer game or games in general are particularly fit to achieve the set instructional goals. For example, game environments often provide opportunities for learning that are more integrated and authentic than traditional instruction, and require players to actively seek information and participate in problem solving. Presumably, transfer is more likely in such a learning condition (Gee, 2003). On the other hand, it is unlikely that the design of particular computer games is tailored to highly specific curriculum units. Thus, it is not reasonable to expect particular games to cover all content knowledge and teach it effectively while students are playing them. However, games may have a distinct advantage due to their "situatedness" when an understanding of how a particular piece of knowledge applies to similar domains or situations in everyday life (i.e., conditional knowledge).

Games may present players with situations similar to those encountered outside of game contexts (Barab et al., 2007). In addition, the potential benefits of navigating particular virtual environments engaging "life skills" may not be seen if learning gains are defined merely in terms of academic subjects, but they can become evident if they concern skills used in everyday life, or those taught in vocational education (Arum & Shavit, 1995). In that sense, game playing is not just a motivational wrapper to make learning "more interesting," but a truly simulated life experience that develops one's adaptivity in multiple ways (Gee, 2003; Squire, 2006).

Virvou and Katsionis (2008) scrutinized the likeability and usability of educational games. They compared a virtual reality game with non-game instructional software for geographic learning, on equivalent learning tasks embedded in the software, and categorized participants into three groups, novice, intermediate, and experienced game players. They found that the educational game was more likable than non-game software, but usability of the game depended on other considerations, such as how guidance (inventory, map, and tutors) is provided. They also found that novice players wasted more time compared to other more experienced players, suggesting that simply presenting opportunity to learn through gameplay is not enough; it is always important to provide proper training and guidance that enhances game players' navigation skills and chance of success.

There are implications of how computer games are harnessed to achieve instructional objectives. It seems that computer games, particularly the virtual reality kind, are conducive to such learning objectives as procedural knowledge (how-to), ill-defined real-life problem solving (Barab et al., 2007), epistemological understandings of the nature of knowledge and skills acquired (Gee, 2003), learning by doing, and learning how to learn (Squire, 2006). It also nurtures critical thinking and develops decision-making power as serious games often present situations that require players to discern and search for relevant information, deciding on what kind of knowledge is needed to advance particular practical goals.

An analogous situation is case-based learning (Shulman, 1990), where authentic cases are presented that are examples of clinical problems, which rarely conform to any single theoretical perspective or conceptual analysis. Both games and cases provide "teachable or learning moments" for introducing and using various theoretical perspectives in elucidating the problem situations. What makes games different from cases is the enactive or agentic role of the player, in which decisions the player makes have practical consequences in terms of success and failure in navigating the problem space in the game. As decision making in game situations is analogous to decision making in real-life problem situations, it is important to investigate whether the process and outcomes of such decision making within games also improves the decisions players make outside of games in their everyday life—namely, whether there is a transfer of decision making skills (see Tobias et al., this volume, for a further discussion of transfer from games).

A CONCEPTUAL MODEL

Up to this point, we have suggested a good number of concepts that may be related to the instructional use of computer games with students from low SES backgrounds. In this section, we propose a conceptual model of the relationship between SES, computer games, and achievement. This conceptual model is presented in Figure 19.1. Arrows represent a directional relationship. Boxes are the variables of interest. This serves as a tentative proposal of how SES might figure in the relationships between computer games and learning. The following is a discussion of model components and relationships including their proposed function.

SES

Student SES is the core concept of this chapter, and what sets it apart from the others in this volume. SES is difficult to define, however, as there are a wide range of definitions in practice. These definitions may be based on income, education, occupation, wealth, and ethnicity. Income indices may be relative or absolute. Education roughly applies to level of schooling

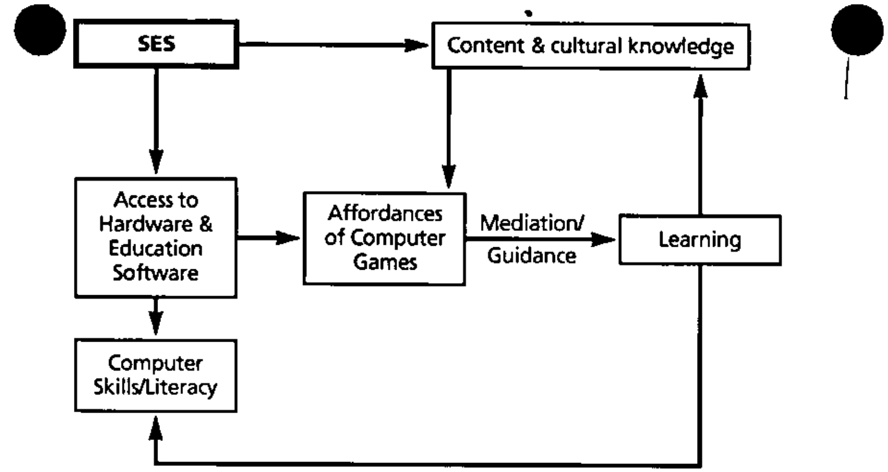


Figure 19.1 A conceptual model of learning from game play by students from low SES backgrounds.

attained by parents for the purposes of this chapter. Occupation refers to parents as well and could refer to the prestige rather than the financial gain of any particular job. Wealth refers to the financial holdings of an individual or family. Ethnicity is included given certain groups' over-representation in certain brackets. Furthermore, there are no universally agreed upon measures on any of the aforementioned criteria. Occupation and ethnicity are seldom used given the subjectivity of these measures. While financial measures are less subjective, since they are usually based on numeric data, the cut-points for low, mid, and high levels are not standardized.

Another means of determining SES is newer and perhaps most relevant to our discussion. Access to home computers and educational games is directly related to SES (Attewell & Battle, 1999). Low family income and wealth and lower parental education are predictive of limited computer and internet access (Hoffman, Novak, & Schlosser, 2000). Not only is there a difference between low and high SES groups in the number of computers and relevant software to which they have access, but also in time devoted to their use, software quality, technical support, and adult knowledge and encouragement for the use of the electronic medium (Hohlfeld et al., 2008). Computer-based instruction in the low-SES classrooms is less likely to be hands-on than in higher-SES counterparts (Becker, 2000). There is often a low level of interactivity in that computers are simply used to present information to learners, not as an interactive tool by which students can actively engage in transactional experiences and taking on a meaningful, agentic role (Fletcher, 2004; Kemker, Barron, & Harmes, 2007).

Access to Hardware and Educational Software and Computer Skills/Literacy

Figure 19.1 points to one consequence of having low SES: the lack of access to computers and computer games, leading to low computer literacy/skills. First, and most obviously, access is a prerequisite to any educational benefits computer game may afford. We further hypothesize that lack of access may significantly hamper low-SES students' chance to develop their information technology or computer proficiency, including technical knowledge and skills necessary to navigate through a computer game (the arrow from Access to Computer skills/literacy).

Computer and information technology (IT) competency encompasses a broad range of skills. There are general skills such as using a mouse, typing, using menus for information, and the like. These skills are transferable to most other computer uses. There are also game-specific skills. In Quest Atlantis, for instance, users learn the premise for the game, metarules, and how to control an avatar within the MUVE to achieve their specific learning and game goals (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005). Knowledge of these skills will not necessarily help players outside the specific game they are playing.

Content and Cultural Knowledge

As suggested by the model in Figure 19.1, low SES is also associated with the lack of content and cultural knowledge, an important part of "representational resources" (Gee, 2003, p. 44), needed to understand the situations and implicit logic of the game presented to them. The model assumes that students of low SES have a lower content knowledge base to work with when encountering particular problems in a computer game that require a certain knowledge base, be it biology or history. Compared to content knowledge, cultural knowledge refers to more tacit aspects of social practice to which a particular group of people have access through their cultural experiences. Thus, some characters, plots, and tacit rules in a game may be intuitively more accessible to students of high SES backgrounds because of the exposure than to students of low SES, causing disparity in learning outcomes (Gee, 2003). Students from different cultures may have qualitatively different knowledge bases. Students from a culture better matched to the game content should have an advantage in acquiring new knowledge and developing deeper insights from it. In short, part of the achievement gap between high and low SES groups may be due to a better match between more affluent students' cultural knowledge and the subject matter taught in school (Gee, 2003). Research shows that lower prior knowledge reduced learners' tendency to set learning goals and self-regulate (Corredor, 2006). Students with low prior knowledge also need more structure and explicit guidance to be effective in learning (Kopcha & Sullivan, 2008). Clearly, further research is needed to verify these expectations about learning from games and SES. Some research hypotheses may be found at the end of this chapter.

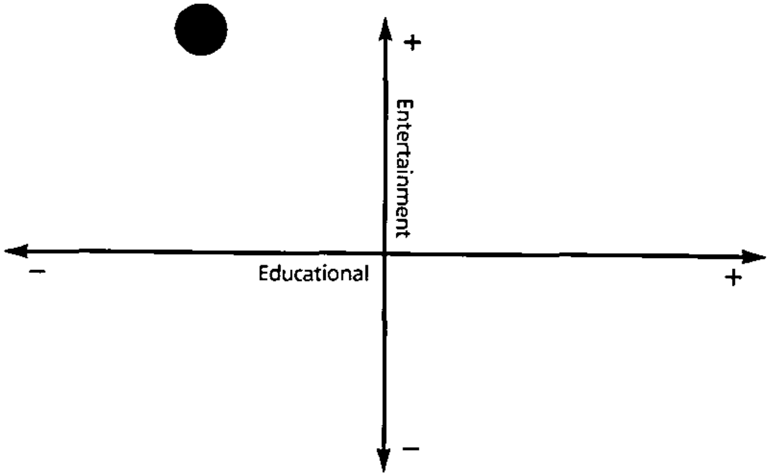
Affordances

Affordances and constraints are the central concepts of ecological psychology (Neisser, 1999). Affordances are opportunities a situation offers individuals to achieve certain goals or satisfy certain needs; constraints are conditions that need to be satisfied in order to benefit from the situation. Sitting is an affordance a chair provides, but the realization of sitting is *constrained* by the design and structure of the chair in question as well as your ability to take advantage of having a chair (e.g., your ability to bend your knees, among others). By the same token, a game typically invites (i.e., affords) certain goal-directed decisions and actions that bring into play various human capacities and motives, such as imaginative play, problem solving, reasoning, competitive motivation, interpersonal communication. At the same time, a game constrains one's action; that is, it provides specific pathways, choices, and conditions (e.g., what constitutes winning conditions in a competitive game) for game play.

To win a game, one has to develop sets of knowledge and skills commensurate with the demands of the game. A general assumption of our model regarding affordances of computer games is that even though computer games might offer many opportunities to learn and accrue educational benefits, a lack of perquisite knowledge and skills can potentially hinder low-SES students' opportunity to learn.

Video and computer games provide a variety of affordances to the user. Broadly, we can rate these affordances along two dimensions: educational and entertainment. While educational affordances are important, we argue that the entertainment spectrum is a viable area of the equation as well. As illustrated in Figure 19.2, the two dimensions are treated as orthogonal, and the intersection of these two dimensions leads to a fairly straightforward categorization of any given game.

Naturally, the ideal game would be rated highly on both dimensions, falling in the upper right-hand quadrant. Conversely, games that afford neither educational nor entertainment value (lower left-hand quadrant) are useless for achieving either of these goals. Tradeoffs between education and entertainment are suggested by quadrants two and four. These tradeoffs might be different for low-SES students than for others. It is an issue that merits investigation.



ȝure 19.2 Two dimensions of affordances of computer games.

There might be a temptation to focus on the horizontal or entertain-ent axis. For educational purposes, however, a highly entertaining game n also run the risk of being so entertaining as to be distracting as far as ırning gains are concerned, analogous to effects of seductive details in ading (Hidi, 2001; see also Tobias et al., this volume). Successful utili-tion of the game medium, however, is likely to be contingent on both es. Some might approach game design and implementation for enter-nment, fitting in educational aspects later. Zaman and Abeele (2007) ovide a scale for assessing games' entertainment value called the "uses d gratifications" paradigm.

Numerous studies show learning of educational information is more suc-ssful when the process is fun, involving entertaining game elements (e.g., lmiraal, Raessens, Van Zeijts , 2007; Tüzün, Soylu, Karakuş, Inal, & Kizil-ya, 2009). The effect of entertainment and fun on motivation is surely not vial. Ideally, this fun is an inherent part of the game. Just as the fun in a ›ical detective story is to find out who the killer is, the fun in the educa-nal game is intrinsic to activities leading to learning gains. A balance of th elements is needed to maximize games' educational utility. For this rpose, a proper level of challenge is in order. A game that can be played nost automatically with little cognitive involvement is not going to have ıch educational value. Conversely, a game that has many hard-to-over-me impasses will deter players and diminish its educational potential.

The second issue regarding the educational–entertainment paradigm is ether games may function differently for different SES groups. We know no studies speaking to the relationship of SES and fun. Returning to e's (2003) conception of opportunity to learn, we might suppose that gam[e]s with culturally relevant characteristics will be more accessible and perhaps more fun for particular social classes familiar with these cultural features. These are important issues that may significantly affect the affordances of games for learning and motivation.

We suggest that there is a tradeoff between the entertainment and educational merit of software (see also Prensky, this volume). More entertaining games may evoke greater levels of affective involvement, but provide little opportunity to learn. On the other hand, games with high levels of educational content may not induce similar levels of involvement or intrinsic reward. Low-SES children have been found to spend more time on entertainment media, including non-educational games (Dumais, 2008). Possible rectification of this issue could involve encouraging access to games that effectively integrate entertainment and education.

In the emergent instructional game literature there seems to be an interaction between prior knowledge and benefits of games, suggested in Figure 19.1. Those with less prior knowledge stand to gain more than those with more prior knowledge (see Tobias et al., this volume). We might hypothesize that games with a distinct entertainment component would entice students from low SES backgrounds into situations that involve meaningful learning. Over time, the interest in playing games can become intrinsic to learning rather than mere entertainment. Alternatively, we might hypothesize that games with a distinct education component may be more attractive for middle and high SES students, given that they are more likely to use games to advance their knowledge (Attewell & Battle, 2008).

Instructional Mediation and Guidance

As we have suggested, computer games provide entertainment and educational affordances to the user. Our focus is on educational affordances, as the entertainment element in the game is only a means to an end from an educational perspective. Because the gap between educational *affordances* of computer games, and *constraints* on the part of students of low SES backgrounds (prior knowledge, computer or IT literacy, etc.), we propose that game play is more likely to yield educational benefits if it is accompanied with appropriate instructional mediation and guidance; this is particularly true for students of low SES. In Figure 19.1, the instructional mediation and guidance is represented as mediating affordances and learning.

To be sure, learning can occur incidentally during game play, without instructional mediation. Incidental learning could take place when reasoning and problem solving are involved at various decision points during game play. For example, an obstacle may prompt the player to diagnose the problem and gather relevant information; a scenario can be created to trigger curiosity for exploration and hypothesis generation; specific events may be included to induce a state of flow (Shute, Ventura, Bauer, & Zapata-Rivera, 2009). In short, game developers or proponents should specify the types of processes/knowledge that may be acquired incidentally. Then researchers can design studies to determine whether such incidental learning actually occurs.

However, based on our knowledge of students from low SES, effects of gameplay on learning are more likely mediated and facilitated by instructional guidance and other forms of instruction support. This effect is similar to Tobias' (2009) hypothesis and findings (Tobias, 1989) that greater instructional support is needed by students with limited prior knowledge than their more knowledgeable counterparts. Instructional mediation and guidance in game play can take two forms, either through guidance and feedback systems directly built into the game, or through guidance provided by an instructor or expert on site.

Mediated learning can occur through instructional support provided by built-in cognitive and metacognitive tools (Karpov & Haywood, 1998). Certain forms of instructional mediation and guidance may be particularly amenable to built-in mechanisms, such as providing just-in-time information or knowledge, suggesting possible actions (how-to knowledge), providing corrective feedback, setting up a reflection cycle (Shaffer, Squire, Halverson, & Gee, 2005). Some of the built-in guidance can be achieved by an animated agent (Prendinger, Ma, & Ishizuka, 2007; see also Tobias et al., this volume). Ideally, we would like to engineer optimal conditions and processes through game design for particular educational gains. However, it is almost impossible to foresee how different learners will approach a specific game and micro-manage every learning activity accordingly. This is why on-site instructional guidance provided by an instructor or expert may still be needed.

As prior knowledge benefits planning and monitoring in hypermedia and other interactive learning environments (Moos & Azevedo, 2008), how to fill the possible knowledge gap for students from low SES backgrounds is a main task for game designers and instructors alike. To be sure, game designers can make a game adaptive by creating different "levels" of play from beginner to advanced. However, judgment of the knowledge gap remains with the instructor who can make instructional adaptation in a more flexible manner. On-site guidance becomes necessary for monitoring the progress students make and particular problems they encounter while playing a game, in order to ensure that they successfully navigate the game space and make learning gains. On-site monitoring becomes more important if students from low SES backgrounds encounter problems because of a lack of content knowledge, and may not seek help from the built-in tutorial system or other guidance (Aleven, Stahl, Schworm, Fischer, & Wallace, 2003). In general, executive control (planning, monitoring, and evaluating) can be externally facilitated by more capable others in computer-based learning (Azevedo, Moos, Greene, Winters, & Cromley, 2008).

Comfort and facility with the electronic medium is another factor to be reckoned with. As noted earlier in our discussion of the "digital divide," low-SES students have less access to electronic devices, are less likely to receive instruction in or with computers, and have less access to IT support and appropriate software (Becker, 2000). This lack of facility may create a problem of cognitive overload (Kirschner, Sweller, & Clark, 2006; Seller, 2005) for students of low SES faced by the rich stimulus environment of many games. Because of the overload, they may not be able to allocate enough cognitive resources for manipulating, exploring, or managing information in a game. The instructor can monitor game play and provide timely guidance to ensure that students are keeping up with the demands and challenges a game presents. Unfortunately, few games provide information to instructors regarding student progress; if games are to be used in this manner a recommendation to game developers would be to provide such information to instructors.

Based on the above analysis, we hypothesize that for students from low SES backgrounds, the presence of on-site instructional mediation and guidance provided by the instructor would produce better learning gains than its absence. Nelson (2007) found that accessibility of an individualized guidance system in a multi-user virtual environment had no effect on learning from an instructional game, though post hoc analyses indicated that those who used the guidance more did increase their posttest performance. Participants with access to guidance utilized it less frequently than they could have (approximately one quarter of the students never used guidance). Virvou and Katsionis (2008) found that novice players wasted more time in playing an instructional game on geography compared to other more experienced players. It seems that for students of low SES backgrounds, who often are found to have lower prior knowledge, instructional support (Tobias, 1989, 2009) and guidance may be particularly important given that their lower content knowledge and/or limited IT skills may create cognitive overload (see Jin & Low, this volume) and hamper their ability to take full advantage of the built-in guidance system.

On-site instructional mediation and guidance provided by the instructor can take a variety of forms. These may include scaffolding for learners of how strategies can be used to tackle problems they will encounter in a game, providing assistance during game play, supporting self-regulatory skills such as help-seeking and monitoring (Azevedo et al., 2008), organizing effective teams to coordinate efforts (Barab et al., 2007; Ho & Huang, 2009), and creating social support groups (Wangberg, Andreasson, Prokosh, Santana, Sørenson, & Chronaki, 2007). More generally, some of the "teachable moments" have to b[illegible]eated by the instructor during game play to maximize the educational benefits of game play. For example, the instructor can organize a session for sharing game play experiences and raise metacognitive awareness and understanding of why some strategies worked and others failed. Again, research is needed to verify these expectations, and specific hypotheses may be found at the end of the chapter.

Learning Gains

Learning gains from game play can be defined in both a broad and a narrow sense. In the broad sense, as shown in Figure 19.1, any gains in terms of computer knowledge, skills, and content or cultural knowledge (the arrows creating the feedback loops) are considered meaningful learning gains. In the narrow sense, learning gains can be defined as those that match the educational or instructional objectives identified for the use of a particular game. Criteria for learning gains should correspond to educational activities surrounding the use of a game and be contingent on engaged processes, direct or mediated, executed within the game environment. Learning gains may be demonstrated immediately after playing a game, or at a later time on similar or dissimilar performance tasks to assess retention and transfer (Hickey, Ingram-Goble, & Jameson, 2009).

Success at "winning" a game is surely an indicator of good performance, but to demonstrate learning gains, more specific criteria need to be specified. Accordingly, learning and transfer performance metrics need to be identified or developed. Assessment can either be embedded in the game as part of the conditions for completing the game (e.g., see Shute's "stealth assessment," this volume), or administered after the game play. On games high on the educational axis (the right-hand quadrants in Figure 19.2), this success could be equivalent to successfully completing a classroom activity. Games of high educational value are value-added in the sense that they may enable students to complete a task or instructional objective that he or she would not have completed without the motivation induced by games. Learning gains in the form of transfer involve demonstration of increased ability in performing tasks outside of a particular game environment. This includes demonstrations of proficiency in other games or in other media such as in-school assessments.

Judgment Criteria

The efficacy of a computer game as an educational tool may be determined by comparing the outcomes to some standards or to an alternate instructional delivery system. The standards may, or should, be specified as the instructional objectives for using a particular game. The degree to which the measures and the outcomes match yields a notion of success. In this section, we discuss a spectrum of learning gains as a result of game play based on our understanding of affordances of serious games, ranging from content knowledge, and critical thinking.

First, content knowledge may be acquired in the process of navigating the game space. Such content knowledge is often embedded in a broader, authentic problem-solving context. Many games enable users to not only acquire knowledge but also gain a sense of how it is used in real-life problem-solving situations. Of course, such procedural knowledge leads to a higher likelihood of transfer in similar situations outside of the game in question; in other words, they may prove useful in a broader context such as the ability to deal with particular situations and resources in the real world (Gee, 2003).

Second, as game play involves active cognitive engagement in reasoning, problem solving, and decision making, we should expect the educational goals of computer games to include more refined reasoning skills vis-à-vis relevant problem situations, practical decision-making skills, and an enhanced ability to self-regulate learning (planning actions, monitoring progress, and evaluating performance). In other words, we expect games not only to enhance content representations and knowledge construction, but also to engage and enhance cognitive and motivational processes that can be potentially applied outside of the game environment.

Third, as serious games involve use of academic knowledge in real-life problem solving, we expect a special kind of "learning gain"—the increased motivation to learn particular academic subjects. For students of low SES, this aspect seems to have particular significance, as the achievement gap between high and low SES students can be partly seen as a result of differences in academic motivation. As educational games are inherently goal-directed, motivating, and cognitively and affectively engaging, success in game play may boost the player's self-efficacy and potential interest in academic subjects.

Finally, with proper mechanisms such as built-in reflection cycles (Shaffer, Squire, Halverson, & Gee, 2005) or organizing reflective activities periodically to share experiences and perspectives, game play should enhance metacognitive insights, reflection, critical thinking, and even identity building (Barab et al., 2007). To be sure, this is an aspect of learning gains that is most difficult to assess (and some may argue unrealistic to expect from game play.) However, serious games may engage such high-level thinking nonetheless to a greater degree than serious topics and issues discussed in classrooms (Brown, 1997).

To sum up, Gee (2003) argues that students without equitable access to authentic learning experiences are cognitively disadvantaged. Computer games can potentially help students of low SES gain access to authentic learning experiences with multiple educational benefits. However, in order to benefit from the educational affordances of computer games, constraints of computer games as well as those of the learners (in this case, students of low SES backgrounds) have to been addressed. In the model we propose in Figure 19.1, instructional mediation and guidance, whether built into a game or provided by the instructor, can play a crucial role.

FUTURE RESEARCH DIRECTIONS

The model presented in Figure 19.1 is highly tentative at this point, as there is little direct research support for it. Future research could expand on any of the elements or relationships identified in the model. One of the main purposes of such a model is to identify leverage points for interventions. Adjusting instructional conditions to individual differences in prior knowledge and skill levels is always an important consideration for any instructional design (Snow & Swanson, 1992; Tobias, 2009). If students from low SES backgrounds are found to have particular knowledge or skill deficits in handling a specific game environment, an instructional adaptation can be made—such as game "add-ons" discussed by Tobias and colleagues (this volume) in the way the game is assigned and used, even though modification of specific features of a game itself may be unpractical. Although the model is intended to stimulate experimental, quasi-experimental, and correlational research, qualitative evidence from case studies (e.g., Grimes and Warschauer, 2008) can also provide new insights not captured by this conceptualization. Tradeoffs between experimental or rationalistic and naturalistic or field research approaches are not unique to this topic. The following working hypotheses based on our model may facilitate the start of this line of research:

- Students from low SES background will gain more when learning is embedded in a game environment than from traditional instructional conditions.
- Such gains will be largely due to the enhanced motivation and cognitive engagement of the students.
- The extent to which students from low SES backgrounds can benefit from educational game play is constrained by their content and cultural knowledge relevant to the game in question.
- The extent to which students from low SES backgrounds can benefit from educational game play is constrained by their technological sophistication in manipulating the signs and tools in the system.
- It is likely that students will benefit educationally from computer games if there is instructional mediation that provides appropriate structuring, guidance, and instructional support.
- As a corollary, merely providing access to computers and computer games without proper training of computer skills and the teaching of necessary knowledge will yield lower learning gains for low-SES students compared to middle- or high-SES students.
- To extrapolate further, underlying reasons that students from low SES are less likely to benefit educationally from game play without instructional guidance could be perceptions that computer games can be used only for entertainment, a lack of prior knowledge for navigating the problem space in a game, and cognitive overload in dealing with challenges on several fronts.
- Depending on the nature of a particular game, there could be a mismatch in terms of cultural familiarity with the content of a game, which can disadvantage students from low SES background for educational benefits, particularly when games are intended for children of affluent or middle class families.
- Games, particularly those situated in authentic virtual environments involving the use of content knowledge in reasoning and problem solving, may present learning opportunities not easily accessed in regular classrooms, and therefore may produce learning gains that should be defined and assessed in a new way.
- Although built-in instructional mediation and guidance can facilitate learning, instructional adaptation may be needed to adapt the use of particular games to local situations, particularly the individual educational needs represented by students from low SES backgrounds.
- Instructional mediation and guidance in the form of scaffolding and discussing strategies beforehand and reflecting on strategies used after game play, in conjunction with built-in reflection mechanisms, may prove crucial for learning and transfer, particularly for students from low SES background.
- Learning gains are more likely to be observed when the match between game activities and learning outcomes is clearly defined and identified (see Tobias et al., this volume).
- Success in playing educational games may boost students' self-efficacy regarding their academic competence, and the enhanced self-efficacy and increased interest could be generalized to other academic learning settings. Consequently, classroom learning can become less stressful and more meaningful. The motivation to play can turn into motivation to learn about a particular topic of interest.

These initial hypotheses are formulated to stimulate inquiry. There are, to be sure, many other questions that are worth exploring. For example, do students of different SES status enjoy or prefer different types of games? This would allow educators to successfully choose games from a range of options to maximize the medium's potential. Also, the role of instructional mediation in mediated processing we propose is still too broadly defined, and needs to be specified given a specific instructional condition.

We assume that, in general, instructional mediation can aid disadvantaged students in overcoming baseline inequities in content and technological knowledge. Both electronic-based and human-based mechanisms are viable components of instructional mediation and guidance. However, exactly how mediating processes work needs research attention. Is it because they alleviate cognitive overload, or is it because they equip students with adequate tools for navigating the problem space in a game? These issues could be investigated through controlled experimentation, in which mediating mechanisms and processes are fully articulated and mediating conditions are systematically varied to determine the differential effects of mediating conditions (e.g., prompting reflection by asking one group to explain their decisions compared to another without this prompt) for groups of high, medium, and low SES. When on-site instructional mediation is implemented, a tiered approach such as that of Ho and Huang (2009) might be useful.

Finally, we propose a broadening of judgment criteria for computer and video game learning gains. Computer games have a unique potential in that they can provide students with access to varied experiences and learning opportunities. When we look to determine whether games can be successfully used in education and training settings, we should be careful not to adhere to the narrow definition of learning as recall of content knowledge based on paper-and-pencil testing. Assessment should be provided as tasks in authentic settings similar to those used in the games and in everyday life. Tests should also address the cultural richness that these authentic experiences allow. Most importantly, the tests should assess not just what students know, but also what they can do with what they know.

CONCLUSION

In this chapter, we reviewed the potential of adaptive use of computer games to educationally benefit students of low SES backgrounds. Due to the potential and the inequality in access to digital experiences, this area of research should receive more attention. In exploring the instructional use of computer games and determining their educational affordances and related constraints, researchers should focus on various ways learning can be effectively mediated through carefully designed cognitive and motivational mechanisms, electronically built-in or human-based. Research should also consider expanding the criteria for success to allow for broader definitions of learning that might not particularly fit the traditional standards. We can be hopeful about computer games as a new, interactive learning tool, but cautious about their design, implementation, and uses with respect to whether and to what extent they lead to meaningful learning gains and demonstrate their educational utility for children from socioeconomically disadvantaged families.

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SECTION IV

EVALUATION AND SUMMING UP