CHAPTER 11

Bridging Theory and Practice: Applying Cognitive and Educational Theory to the Design of Educational Media

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Within the field of children's educational media, there is all too often a disconnect between the academic researchers who study children's interaction with media and the producers who create these media. This presents an unfortunate missed opportunity, as both communities have a great deal to learn from each other.

Having straddled the line between academia and industry for decades, I have seen firsthand how knowledge from each of these communities can enhance the efforts of the other. Established theories of education, cognitive development, and social development can provide a firm foundation for educationally valid, age-appropriate approaches to the design of educational media. Understanding how children think about, interact with, and learn from media can help producers enhance the quality and effectiveness of educational media by creating media products that are tailored to fit the needs, abilities, and limitations of their users.

At the same time, because children in the United States (and, perhaps, elsewhere) spend more time using media than in any other activity except sleeping (e.g., Rideout & Saphir, 2013), the ubiquitous role of media in children's lives presents a meaningful context in which researchers can study applied aspects of children's cognitive and social development. Indeed, even the knowledge gained in developing educational media, as well as applied research conducted to inform production or assess impact, can itself carry implications that reach beyond a media product, to lend insight into the nature of children's broader development. Recall, for instance, that even the research that informed the creation of Bandura's seminal social learning theory (which later

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evolved into social cognitive theory) was media-based research on children's modeling of filmed aggression (e.g., Bandura, Ross, & Ross, 1963).

To illustrate the value of bridging the gap between theory and practice, this chapter presents examples of ways in which educational and developmental theory have been applied to the creation of effective educational television series, digital games, and projects that span multiple media platforms. The chapter will consider, first, the application of theoretical approaches that were not originally developed with media in mind, and then, more specific theories that were devised to explain aspects of children's interactions with and learning from media. (The inverse role of product-based research and practice in informing broader theory and research is also worthy of discussion, but is beyond the scope of this chapter.)

FROM THEORY TO PRACTICE

The applicability of broader theory within the context of educational media should not be surprising, because humans do not have a unique part of their brains that is devoted exclusively to processing media; rather, humans process media through the same cognitive mechanisms and social schemas that they employ in every other aspect of their lives. For example, while subjects watch television commercials, physiological research has shown evidence of brain activation associated with episodic memory, attention control, and working memory (Smith & Gevins, 2004), and adults' interactions with inanimate television sets and computers are influenced by many of the same social norms that have been found to guide interactions with other people (Reeves & Nass, 1996). Indeed, even on the most primitive level, Pratt, Radulescu, Guo, and Abrams (2010) adopted an evolutionary perspective to conduct a series of experiments (outside the context of media) on the effects of motion on visual attention. Using the stimuli of animated dots on a screen, Pratt et al. consistently found shorter reaction times for animate motion (i.e., motion that suggested a conscious actor, such as changing speed or direction without colliding with another dot) than for inanimate motion (changing direction or speed only in response to a collision). They explained their findings as an evolutionary vestige of primitive humans' need to quickly identify and attend to potential predators and prey in the wild. This attentional advantage for animate forms of visual movement in the context of animated dots on a screen parallels the long-established finding that children's attention is captured more easily by visual action on television than by dialogue among "talking heads," and that children prefer programs with visual action (e.g., Lesser, 1974; Valkenburg & Janssen, 1999). Might similar perceptual and cognitive mechanisms contribute to both phenomena?

Some classic theories have become so ingrained in the production of educational media, that they are applied almost universally—even if the producers who apply them are not necessarily aware that they are doing so. Applications of Bandura's (2009) concept of modeling are evident throughout most current educational television series, in which characters model targeted concepts and skills in the course of narrative stories, instead of lecturing directly to the audience. Vygotsky's and Bruner's notions of scaffolding are critical to designing increasingly challenging levels in well-designed educational games (Vygotsky, 1978; Wood, Bruner, & Ross, 1976). Moreover, beyond the basic approaches to production that they have inspired, these theories carry a host of specific, concrete implications for design as well. For instance, to maximize the educational impact of a television program among a diverse audience, modeling suggests the need for a diverse cast of characters to encourage identification with characters who are seen as being "like me." Scaffolding points to the need for each level of a digital game to build upon the knowledge acquired in earlier levels, gradually increase difficulty across levels, and increase hints and feedback if a player makes repeated errors that indicate a failure to understand (e.g., Revelle, 2013).

EDUCATIONAL TELEVISION

Historically, the creation of educational television has always been rooted in producers' personal notions of how children learn and grow. For example, the producers of the 1960s television series *Captain Kangaroo* intended to promote manners and the Golden Rule of "Do unto others as you would have them do unto you" (Keeshan, 1989), and the experiments demonstrated on the 1950s science series *Mr. Wizard* were gathered from a library of 1000 science textbooks, encyclopedias, and other academic publications (Herbert, 1988). However, these early series typically were not guided by any sort of formal educational curriculum or empirical research with children. That changed in the late 1960s, when the Children's Television Workshop (now "Sesame Workshop") pioneered the formal of curriculum and research into television production via the *CTW Model* or *Sesame Workshop Model* (e.g., Fisch & Truglio, 2001; Lesser, 1974), an interdisciplinary approach to television production that brought together educational content experts, television producers, and developmental researchers, who worked hand in hand at every stage of production. Curriculum seminars brought leading educators in direct contact with producers to lay the foundation for the educational approaches that were the basis for *Sesame Street*, while in-house content and research staff collaborated closely with the production team on an ongoing basis to ensure the effective implementation of these approaches. Indeed, *Sesame Street* continues to employ these same strategies today, as the series continues to evolve so that it can remain relevant to its current audience.

Even today, there is a broad spectrum of models through which educational television is produced, ranging from little or no involvement by educators and researchers to the intensive involvement exemplified by *Sesame Street* and its peers. When skilled educators and researchers are brought into the process of production, either as periodic advisors or as members of the ongoing production team, evidence-based educational practice can be woven into an educational television series. For example, noted mathematics educators have been involved in the production of math series such as *Cyberchase* and *Odd Squad*, literacy experts have contributed to series such as *The Electric Company* and *Between the Lions*, and scientists and science educators have informed the production of series such as *3-2-1 Contact* and *The Magic School Bus*. Summative research has shown that viewing each of these series produces significant educational gains among its target audience (e.g., Fisch, 2004; Wartella, Lauricella, & Blackwell, 2016).

Naturally, though, theories of education and child development are not static entities that are universally held forever. Even within a single television series, as theories of learning and child development have evolved over time, so too have the curricula, educational approaches, and research designs that they inform. For instance, when *Sesame Street*'s curriculum was first developed, the field of education was still greatly influenced, not only by Piagetian views on cognitive development (e.g., Piaget & Inhelder, 1969) but also by a focus on behavioral outcomes that grew out of the behaviorist approaches of Skinner (1971) and others. This was reflected accordingly in the language of the original *Sesame Street* curriculum, which centered on behavioral outcomes, such as "The child can recognize such basic symbols as letters, numbers, and geometric forms." In subsequent decades, both the content and language of the curriculum evolved in response to changes in the state of theory and research concerning children's growth, development, and learning, as well as changes in the demographics of the audience and societal concerns (Kotler, Truglio, & Betancourt, 2016; Lesser & Schneider, 2001).

Changes in theoretical trends were reflected in the formative research methods used to inform *Sesame Street*'s production too. Originally, the appeal of *Sesame Street* segments was assessed via a behavioral "distractor method" in which children were seated between two screens to chart individual children's attention to *Sesame Street* material versus unrelated slides that served as visual distractors. Subsequently, this approach evolved into an "eyes on screen" method that replaced the slides with the natural distractions that arise among groups of children watching together, and eventually grew into an "engagement" measure that took into account, not only visual attention but also other indicators of engagement such as laughing or moving in time to music (Fisch & Bernstein, 2001).

GAMES AND DIGITAL MEDIA

Just as there is a wide range of models for the production of educational television (from intensive involvement by educators and researchers to little or none), the same is equally true for digital media. Although the App Store currently features more than 80,000 apps that are labeled "educational," a content analysis of 2400 literacy apps found that fewer than one-third (29%) were presented as based on any sort of established curriculum, and only 2% mentioned that research was conducted to evaluate children's learning from the app (Vaala, Ly, & Levine, 2015).

Perhaps this is not surprising, considering the expense of research or educational consultants, and the fact that anyone can post an app to the App Store, regardless of their credentials or whether they are employed by a production company with adequate resources for product evaluation. Yet, among digital media too, theory and research can contribute significantly to the quality of an educational game. For example, drawing on inquiry-based approaches to education (e.g., Bybee, 2000), the National Science Education Standards (NGSS Lead States, 2013), and the theoretical construct of distributed cognition (e.g., Hollan, Hutchins, & Kirsh, 2000)—a perspective through which cognitive processes such as learning and reasoning are shared among several learners who work together as a group—the multiplayer game *River City* was designed to engage middle school students in inquiry-based science learning. In this game, players work in teams to develop, investigate, and test hypotheses about one of several illnesses plaguing a town. In the course of playing the game, children exercise inquiry skills and acquire knowledge about ecosystems and the role of microorganisms in spreading disease (e.g., Ketelhut, Dede, Clarke, Nelson, & Bowman, 2007).

Even outside the context of such obviously instructional games, existing theory and research can also play an important role in more surprising products, such as digital plush dolls. Strommen and Alexander (1999) have recounted how developmental research on children's emotional interaction helped shape the development of Microsoft Actimates interactive plush dolls of PBS characters such as Barney and Arthur. By incorporating elements of naturalistic social interactions among children into the dolls' prerecorded speech and including variations on responses, these talking and moving dolls were able to interact with their users through interfaces that more closely mimicked human social interaction, thus making them appear more lifelike.

In some cases, interactive educational media can grow out of multiple generations of theory as well. For instance, one of the pioneers in the study and use of digital media for education, Seymour Papert, studied with Jean Piaget early in his career. Later, Papert drew heavily on Piaget's theory of *constructivism* (in which children are seen as constructing their own knowledge, rather than passively receiving it; e.g., Piaget & Inhelder, 1969) to formulate his own theory of *constructionism*, which extended constructivism to digital media and posited that children learn best through the process of actively constructing something themselves (Papert, 1980). The theory of constructionism, in turn, directly motivated Papert's students and collaborators to create numerous prominent digital media products for education, such as LEGO Mindstorms programmable building sets (e.g., Resnick, Martin, Sargent, & Silverman, 1996), the online MamaMedia platform for children to make and share digital media (e.g., Harel Caperton, 2010), and the children's programming language Scratch (e.g., Resnick et al., 2009).

THEORIES OF LEARNING FROM MEDIA

In the preceding examples, the theories and research that were applied to TV or digital production were broad theories of development or education that had not been formulated specifically with regard to media. If these theories hold implications for the design of educational media, then all the more so, theories designed specifically to explain children's processing of educational media should hold implications for design.

In particular, from a cognitive perspective, any television program or digital game can be conceptualized as a complex audiovisual stimulus. As such, processing cognitive input from a TV program or game is subject to the limited capacity of working memory. Thus, it is not surprising that working memory limitations play a central role in several theories of children's processing of media (e.g., Fisch, 2000, 2004; Lang, 2000; Mayer, 2005, 2014), as well as in applications of Sweller's Cognitive Load Theory to problem solving in digital games (e.g., Sweller, 1988, 2010).[1] Let us consider several theories that directly address children's comprehension of and learning from media, and their implications for creating educationally effective television programs and digital games.

COMPREHENSION OF EDUCATIONAL TELEVISION

Whereas the cognitive demands of processing audiovisual information in real time pose challenges for processing any television program (educational or noneducational), Fisch's (2000, 2004) Capacity Model posits that children face even greater processing demands when watching educational television programs because these programs typically present narrative (i.e., story) content and educational content that must be processed simultaneously. For example, consider the example of a program about a boy who wants to join a band (narrative content) and, in the process, learns how different musical instruments create sound through vibration (educational content). The capacity model proposes that comprehension of educational content depends, not only on the cognitive demands of processing the educational content itself but also on the demands presented by the narrative in which it is embedded. In addition, the model argues that comprehension is affected by distance, that is, the degree to which the educational content is integral or tangential to the narrative (Fig. 1). To understand the notion of distance, imagine a television mystery in which the hero suddenly stops to give a lesson on mathematical rate-time-distance problems. If the mathematical content is not directly relevant to the mystery, it would be tangential to the narrative and distance would be large. Conversely, if the hero uses the rate-time-distance concept to prove that only one suspect was near enough

[1] Originally, research by Sweller (e.g., 1988) and his colleagues investigated the impact of cognitive load on performance and learning in abstract problem-solving tasks, such as trigonometry problems, with increased load inhibiting performance on concurrent tasks. Later, Sweller (e.g., 2010) and others applied the principle of cognitive load (as Cognitive Load Theory) to applied contexts, including educational games and other forms of multimedia instruction. In particular, this work identified factors contributing to several types of cognitive load that stem from either the intrinsic difficulty of the embedded task, the design of the materials, or amount of invested mental effort, as will be discussed later.

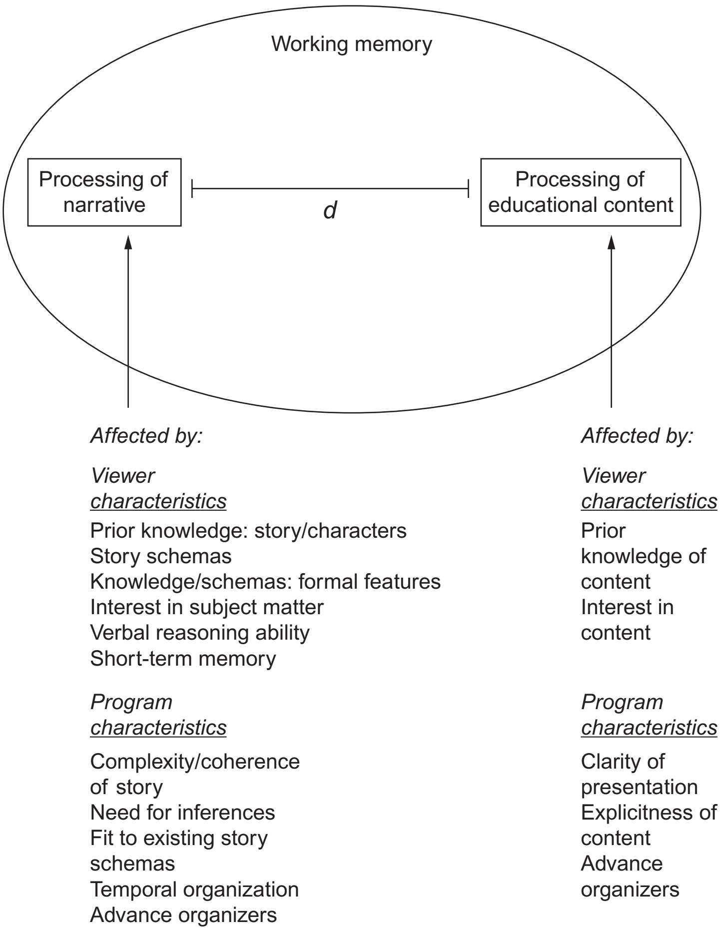

Fig. 1 The capacity model, as applied to educational television. *(From Fisch, S.M. (2000). A capacity model of children's comprehension of educational content on television.* Media Psychology, 2*, 63–91; Fisch, S.M. (2004).* Children's learning from educational television: Sesame Street and beyond*. Mahwah, NJ: Lawrence Erlbaum Associates.)*

to commit the crime (i.e., if it provides the key clue to solve the mystery), then the mathematical content is integral to the narrative and distance would be small.

According to the capacity model, if distance is large, the mental resources needed for comprehension are devoted primarily to the narrative, with less resources available for processing the educational content. However, if the educational content is integral to the narrative, then the two complement, rather than compete with, each other; the same processing that permits comprehension of the narrative simultaneously contributes to comprehension of the educational content. Thus, comprehension of educational content typically would be stronger under any of the following conditions: (1) when the processing demands of the narrative are relatively small (e.g., because few inferences are needed to understand the story or the viewer's language skills are sufficiently sophisticated to follow the narrative easily; see Fig. 1 and Fisch, 2004, for a full list of contributing factors), (2) when the processing demands of the educational content are small (e.g., because it is presented clearly or the viewer has some knowledge of the subject already), or (3) when distance is small. The predictions of the model have been tested and confirmed empirically in several studies, most directly by Aladé and Nathanson (2016), Nichols (2011), and Piotrowski (2014).

Applied to the production of educational television, the Capacity Model points to several factors that can be incorporated into a television program to help maximize young viewers' comprehension: The program should be appealing and interesting to children so that they will attend to the program and devote more cognitive resources to understanding it. To reduce the demands of processing educational content, the educational content should be presented clearly and explicitly, with advance organizers used to orient viewers and encourage the activation of relevant schemas. To reduce the demands of processing narrative, the story should be clear and sequential, without requiring extensive inferences to untangle implicit content, and the structure of the story should conform to established story schemas. Finally, and perhaps most critically, the educational content should be well integrated at the heart of the story (i.e., the distance should be small)—what Sesame Workshop has referred to as "content on the plotline" (e.g., Hall & Williams, 1993)—so that the narrative and educational content do not have to compete for limited cognitive resources. In working with television writers and producers, I typically explain the concept of content on the plotline via this rule of thumb: If a viewer tells a friend what the story in the program was about, he or she should not be able to do it without mentioning the embedded educational concept. If the main points of the plot can be related without mentioning the educational content, then the content is not on the plotline.

LEARNING FROM DIGITAL GAMES

The Cognitive Theory of Multimedia Learning, or CTML, is intended to describe the processing by which users encode and learn from digital multimedia (e.g., Mayer, 2005, 2014; Moreno, 2006). CTML has its roots in three assumptions that grow out of the research literature in cognitive psychology: that humans take in visual and auditory information through two separate information-processing channels, that each channel has a limited capacity for processing information at any given time, and that active learning entails carrying out a coordinated set of cognitive processes during learning. Since multimedia presentations typically present information via more than modality (e.g., visual images and auditory narration, or on-screen text and animated images), the model tracks the processing of elements of information through the visual and auditory channels as they make their way through the three classic cognitive structures of cognition and memory: sensory memory (responsible for the initial encoding of external stimuli), working memory (in which active processing of information occurs), and long-term memory (where information is stored beyond a matter of moments). CTML posits that, when a user engages with an instructional message via multimedia, bits of visual and auditory information are encoded and processed separately, to yield a pictorial mental model of the visual information and a verbal mental model of the auditory information. These two models are then integrated into a single representation in which corresponding elements of the pictorial and verbal models are mapped onto each other (see Fig. 2).

Under this model, an effective piece of educational software must be clear and well organized, with little extraneous information. Drawing on Sweller's (2010) Cognitive Load Theory, CTML predicts that, just as a child may fail to learn if the educational content in a digital game is too complex (what Mayer, 2014 refers to as *essential overload*), the child also may fail to learn if the software includes too much extraneous material (e.g., unnecessary animation, text, graphics, or music), or requires users to engage in too much extraneous cognitive processing (which Mayer terms *extraneous*

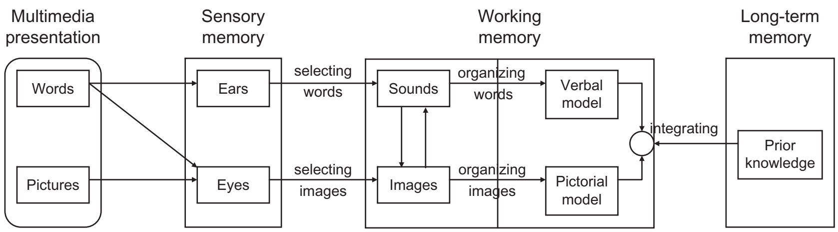

Fig. 2 Cognitive theory of multimedia learning. *(From Mayer, R.E. (2005). Cognitive theory of multimedia learning. In R.E. Mayer (Ed.), The* Cambridge handbook of multimedia learning *(pp. 31-48). New York, NY: Cambridge University Press.)*

overload). In either case, the cognitive load posed by the game exceeds the limited capacity of working memory, and the material will not be well learned (or, perhaps, even well understood).[2]

Parallel to the Capacity Model, CTML can be applied to the production of educational games, with concrete implications for design. Growing out of CTML, Mayer and his colleagues have conducted an extensive program of research to identify game features that either support or inhibit learning from games (see Mayer, 2014, for a review). Their data indicate that players learn better from games when words in the game are spoken rather than written (i.e., presented as auditory information instead of visual, to avoid interfering with visual processing of other elements of the game screen), when words are in conversational style, when pretraining is used so that in-game learning builds on prior knowledge, when players receive advice or explanations throughout the game, and when players are asked to explain their choices (i.e., think reflectively) during the game.

APPLYING THE CAPACITY MODEL TO EDUCATIONAL GAMES

As is evident from the preceding discussion, CTML, Cognitive Load Theory, and the Capacity Model share much in common. All three are grounded in the limited capacity of working memory. All three view comprehension of educational content as impacted, not only by the cognitive demands of the educational content itself but also by the demands of the surrounding material in which the educational content is embedded. All three identify program or game features that can increase or reduce cognitive load, with concrete implications for the design of effective educational media.

However, a key aspect of the Capacity Model that differentiates it from CTML and Cognitive Load Theory is the Capacity Model's construct of distance, which does not appear in either of the other two theories. When the distance between narrative and educational content is high (i.e., educational content is tangential to the story), all three models predict that comprehension of educational content will be impaired. But, when distance is small (i.e., the educational content is "on the plotline" or at the heart of

[2] The distinction between essential and extraneous processing (e.g., Mayer, 2014) is very much in line with the Capacity Model's distinction between educational and narrative content. However, neither Cognitive Load Theory nor CTML includes a construct parallel to distance, which leads to differences in both theoretical constructs and predictions, as will be discussed shortly.

gameplay, as will be discussed shortly), the Capacity Model no longer views narrative content as "extraneous" material that must compete with educational content for limited cognitive resources in working memory.

Yet, the original Capacity Model (Fisch, 2000, 2004) was devised to explain comprehension of educational television, not digital games. Although many aspects of processing may be common to television and games, each medium presents its own unique issues as well. Thus, a modified version of the Capacity Model, applicable to digital games, is currently being developed (Fisch, 2016).

Because of the unique nature of digital games, the new model differs from the original in several ways. First, whereas the original model has two components (narrative and educational content), the new model has three, reflecting the demands of processing educational content, narrative (which can be substantial in a virtual world, or minimal in a smaller "casual game"), and gameplay (i.e., cognitive demands of playing the game itself, which rest on factors such as usability, well- vs. ill-defined problems, and so on). Second, the original model predicts that priority is given to processing narrative over educational content [as confirmed empirically by Nichols (2011) and Aladé and Nathanson (2016)]; in the new model, priority during an educational game is given instead to gameplay—that is, to the thinking and behavior that are necessary to use the interface and play the game. Third, distance between narrative and educational content is a critical component of the original model, but three types of distance are central to the new model: the distance between gameplay and educational content, between educational content and narrative, and between narrative and gameplay (see Fig. 3). The most pivotal type of distance is between gameplay and educational content—the degree to which the game requires players to exercise the targeted educational concept and/or skills in order to play the game successfully.

When applied to the production of educational games, many of the new model's implications are similar to those of the original model, as well as Cognitive Load Theory and CTML: the need to present educational content clearly, minimize extraneous cognitive load, and so on. A unique implication of the new model is the need to minimize, not only distance between narrative and educational content by embedding "content on the plotline" but also the distance between educational content and gameplay by placing "content at the heart of gameplay." Just as content on the plotline requires that television viewers should not be able to recount the story of a program without mentioning the educational content, content at the heart of gameplay requires that players should not be able to play a game without employing the targeted content or skills. As an example of deceptively high distance

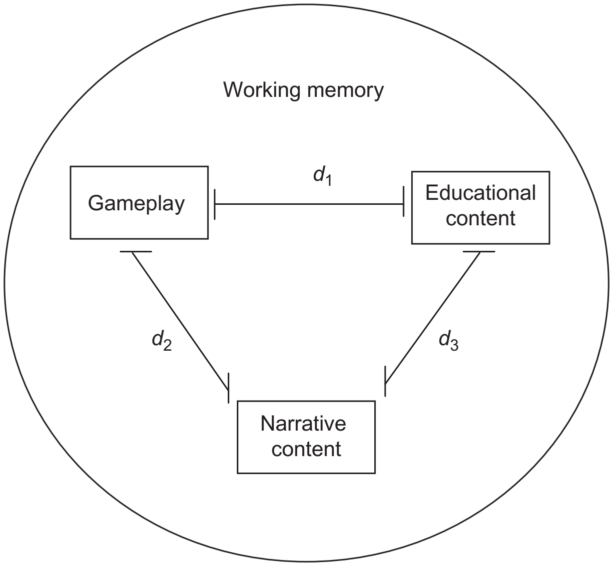

Fig. 3 The capacity model, as applied to educational games. *(From Fisch, S.M. (2016). The capacity model, 2.0: Cognitive processing in children's comprehension of educational games.* Paper presented at the Society for Research in Child Development special topic meeting: Technology and Media in Children's Development, Irvine, CA.*)*

between educational content and gameplay, consider a game that I once tested with preschool children: In this game, to help children learn how to count by 2, players clicked once to remove two obstacles at a time. Children played the game with little difficulty, but comprehension of the math was poor. Although the designers' intent was that children would practice counting by 2 as they played the game (which would comprise a small distance between educational content and gameplay), this was not actually the case. Rather, because children only had to keep clicking until all of the obstacles were gone, the computer counted by 2 *for* them—the gameplay never actually required children to count by 2 themselves. Thus, although the educational content was clearly shown on the screen, it was not integral to gameplay and was not clearly understood.

Subsequently, when working with a different client on the development of several games about counting by 2, 5, and 10, we took the lesson of the earlier experience. In the subsequent games, players had to jump between numbered or unnumbered objects by 2, 5, or 10 s while skipping the objects in between. In this way, players were forced to count the objects and/or think about numbered labels on the objects in order to win the games (Fisch, Damashek, & Aladé (2016).

CROSS-PLATFORM LEARNING

Until this point, we have considered the two media of television and digital games separately. Today, however, producers often do not create "just" a television series or "just" a game. Amid industry buzzwords, such as *multi-platform*, *convergence*, and *transmedia*, it is increasingly common for projects to span several media platforms, so that an educational television series might be accompanied by related digital games, hands-on outreach materials, or a museum exhibit or live show. My colleagues and I use the term *cross-platform learning* to refer to a child's learning from combined use of multiple, related media platforms (e.g., a television program and digital game) that address the same educational concept, using the same characters and world.

Data from several empirical research studies have indicated that cross-platform approaches have the potential to promote significantly greater learning than the use of any one media component in isolation. By applying established theories and educational practices, we can suggest some mechanisms that may underlie these effects. Cross-platform approaches provide multiple entry points to informal educational materials, accommodate children with diverse interests and learning styles, provide repetition and reinforcement of educational content, and allow content creators to match each particular educational concept to the medium through which it can be conveyed most effectively. Perhaps most importantly, cross-platform approaches also can facilitate transfer of learning (i.e., the ability for learners to apply concepts or skills acquired in one context to a new problem or context): children can take what they have learned from one medium (e.g., an educational television program) and apply it to support and enrich their performance while they are in the midst of learning from a second medium (e.g., while playing a related digital game). This richer engagement contributes to greater learning of the targeted concepts and/or skills (see Fisch, 2013, for a review).

However, the same research studies also suggest that to obtain the benefits of cross-platform learning, it is not sufficient to simply flood children with a greater number of media products; "more" is not always better. To maximize the potential for cross-platform learning, educational media must be designed in ways that take advantage of the unique strengths and affordances that each medium presents (e.g., using video narrative to explain and model concepts or digital games to provide opportunities to practice emergent skills). In addition, the various media should be integrated in ways that make the components complementary to each other. For example, in the multimedia mathematics project *UMIGO*, interactive moments are integrated into animated video adventures. When characters in the video encounter a problem, an embedded interactive moment requires children to apply a targeted math concept to help the characters solve their problem. In this way, the video motivates children to do the task in each interactive moment (and explains and models the necessary math concepts); conversely, solving the interactive task helps to advance the story in the video narrative (Fisch et al., 2016).

CONCLUSION

As demonstrated throughout this chapter, the application of theory—both broad theories of education and child development, and more focused theories of the cognitive processing of educational media—can provide a firm foundation for the production of educationally effective media, and point to specific techniques that can be incorporated into a given media product to maximize learning. The Capacity Model and CTML alone suggest guidelines for the production of educational television series, such as:

- Both the story and the underlying program should be appealing and interesting to children.
- Educational content should be presented clearly and explicitly.
- The story should also be clear, without requiring extensive inferences to untangle implicit content.
- The structure of the story should be sequential, conforming to established story schemas.
- Advance organizers can be used to orient viewers and encourage the activation of relevant schemas.
- Perhaps most critically, the distance between narrative and educational content should be small ("content on the plotline").

Guidelines for the creation of digital games include:

- Instructions, dialogue, and other words should be spoken rather than written.
- Instructions and dialogue should be presented in conversational style.
- Pretraining can be used to allow in-game learning to build on prior knowledge.
- Players can be supported by advice or explanations throughout the game.
- Players can be asked to explain their choices, to encourage reflective thinking during the game.

- As above, gameplay should require players to apply the targeted concepts and skills, so that the distance between educational content and gameplay is small ("content at the heart of gameplay").

For cross-platform projects, guidelines include the following:

- Media components should be combined in ways that build upon the strengths and affordances of each medium (e.g., video for explanation and modeling, games to practice emerging skills).
- Media components should also be integrated in ways that make them complementary to each other.

To apply theory effectively to production, however, it is not sufficient for theories to be well grounded or carry value, since media producers generally cannot be expected to wade through complex, highly technical theoretical models and extract practical design implications on their own. In some of the examples discussed earlier (e.g., Scratch or *River City*), the producers have been academics or researchers themselves. However, this typically is not the case. Indeed, that is where the value of collaboration lies, with producers and researchers each bringing their unique skills and knowledge to complement each other.

Yet, when academics and producers attempt to collaborate, they often quickly discover that they are essentially speaking different languages, with little accomplished through the effort. Rather, for theory to be applied effectively in production, abstract theoretical models must be translated into specific, concrete, practical recommendations that are feasible to implement within the design of the media product being developed (e.g., Fisch & Bernstein, 2001). If such an approach is implemented in a collaborative atmosphere, with mutual respect among the participants, it can give rise to educational media that are educationally impactful and well suited to the needs and abilities of their target audience.

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