The Use of Cognitive Clinical Interviews to Explore Learning from Video Game Play

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Abstract: As research about the learning that results when children play video games becomes more popular, questions arise about what methodological and analytical tools are most appropriate to access and document this learning. Thus far, researchers have mostly adopted pre/post assessments, ethnography, and learning analytics. In this paper we (re)introduce cognitive clinical interviews as a methodology particularly suited to answering many of the most pressing questions about games and learning. To that end we describe four challenges of studying learning in video games with pre-post assessments that we claim can be addressed by the addition of clinical interviews. We then consider how clinical interviews can help to explain and describe patterns detected from ethnographic observations and detailed game play logs.

Research Tools for Exploring Learning in Video Games

Across disciplines and domains, researchers and educators have a rich set of tools for exploring and documenting learning, including written assessments, observations, and interviews. For many types of learning explored in education research, the choice of which tools to use and when to use them has become relatively stable. That is, we tend to know what those tools will look like, when they are useful, and the type of data they will provide. But what happens to this picture when new types of learning enter the landscape? This is precisely the situation our field currently faces with regard to video game learning.

As video games become increasingly ubiquitous in children's lives, researchers have begun to explore the potential affordances and constraints of learning with and through video games (Gee, 2003; Steinkuehler, Squire, & Barab, 2012). Their popularity in educational contexts has led researchers and educators to want documentation of the learning that results when children play video games which in turn prompts questions about what methodological and analytical tools are most appropriate for exploring learning from video games.

Thus far, researchers have mostly adopted one or more of three methods. Many researchers have relied on pre-post assessments of the conceptual content presented in the game (e.g. Clark et al., 2011). Other researchers have relied on ethnographic observations of game play to identify and characterize salient learning events or changes in play (e.g. Stevens, Satwicz, & McCarthy, 2008). More recently there has also been a move towards the use of learning analytics to explore large collections of detailed logs of game play (e.g. Plass et al., 2013).

Each of these tools has provided insight into the ways that learners interact with and learn during video game play. However, each of these tools also has limitations for exploring the richness of learning in video game environments. Ethnographic observations, while rich is ecological validity, only allow observation of naturally occurring phenomena and generalization is difficult. Pre-post assessments only provide static slices of knowledge at two points in time and are limited in their ability to speak to the process of learning. Finally, while logging data provides a detailed account of each action that occurs in-game, these logs mean little without a theory of how these in-game actions relate to knowledge and conceptual change.

While we have used each of the above research methods in our own work, we have found that cognitive clinical interviews (Ginsberg, 1997) are a particularly valuable and unfortunately underutilized tool for understanding learning that occurs during game play. Ever since Piaget pioneered the method (e.g. Piaget, 1929), clinical interviews have been used extensively and successfully to examine conceptual learning in science both in formal and informal contexts (Davis & Russ, 2015; e.g. diSessa, Gillespie, & Esterly, 2004; Russ, Lee, & Sherin, 2012). We argue that the lack of clinic interviews as a primary source of data in the video game research toolkit is at worst problematic and at best a missed opportunity.

Therefore, in this paper we take preliminary steps to remedy this missed opportunity. To do so we begin by briefly describing the clinical interview. We then describe four challenges of studying learning in video games with pre-post assessments that we claim can be addressed by the addition of clinical interviews. To lend plausibility to that claim, we provide examples of solutions to those challenges employed by research conducted by the first author. Finally, we consider how clinical interviews can help to explain and describe patterns detected from ethnographic observations and detailed game play logs.

What are clinical interviews?

Clinical interviews are generally one-to-one interactions between interviewer and learner and are designed to probe the mental model of the learner by gaining many small glimpses of various aspects of a learner's conception in an effort to better understand the whole. That is, unlike traditional classroom assessments that attempt to compare learners' understandings to a predefined standard (i.e. learners are either right or wrong), the cognitive clinical interview strives to "enter the child's mind" and describe the nature of the learner's inchoate construction of a concept.

To gain these glimpses of the child's mind, Ginsberg describes clinical interviews as *deliberately nonstandardized* and highly improvisational (Ginsberg, 1997, p. 2). Although they begin with a carefully designed protocol, interviewers are encouraged to develop in-the-moment follow-up questions in response to the particulars of student thinking. Predetermined questions are designed to prompt likely conceptions, that is, the researcher has a understanding of what the learner might think ahead of time and carefully targets these questions to draw out one or more of these possible conceptions. However, rather than see answers as having a one-to-one mapping with conceptions, clinical interviewers assume mental models are dynamic and complex (diSessa, 2007). Therefore, interviewers use interviewees' responses to preplanned questions to develop hypotheses about the nature of the learner's thinking, develop follow-up questions to test these hypotheses, and then evaluate the interviewee's response to the follow-up to decide whether additional follow-up questions are needed (Ginsberg, 1997). This on-the-fly hypothesis generation and testing is essential to the success of the interview.

Clinical interviews have been successfully utilized for many years in a variety of domains (e.g. Brizuela, 2006; Gottlieb & Institute, 2007), and our claim is that their power can be leveraged for studying learning in video games. In particular, we see four core challenges to studying learning in video games that clinical interviews have the potential to address more easily than other methods.

Challenge 1: Missing knowledge not explicitly connected to the domain

When video games are conceptualized as "interventions" akin to curricula or new teaching practices, researchers often attempt to assess learning by comparing a player's knowledge state before and after play. This is typically accomplished through the use of pre- and post-tests and surveys, including concept inventories and concrete questions. While using such assessments is seen as advantageous because they allow for clear quantification and standardization we see four core challenges to assessing learning in video games that we believe can be overcome through the addition of cognitive clinical interviews.

A particularly salient challenge for assessing learning in video games is avoiding "stacking the deck." When studying learning in games, researchers cannot ask questions that necessitate the use of or prioritize the knowledge and reasoning from the game over other knowledge the student might use. That is, the "stuff" that students are supposed to have learned cannot be couched solely in game language. Doing so creates two problems: potential underestimation or overestimation of knowledge.

First, if questions are framed mostly about game action and game-specific concepts, pre-intervention measures will automatically document learners as having no useful knowledge. However, that attribution to students would be an underestimation of the knowledge they may have related to the topic but not couched in the specific language of the game. What such questions really show is something much less interesting for educators - that participants have not yet played the game.

Second, questions overtly focused on game-related knowledge in post-intervention measures cannot examine whether players apply knowledge learned in the game to non-game situations. It is certainly valuable to know whether or not players can recall game action and experiences. However, in most cases, our goal in designing educational games is to provide experiences that the player can draw on when reasoning in non-game contexts. Achieving this "transfer" turns out to be non-trivial matter (Barab et al., 2007; Clark et al., 2011), and we need measures of learning that allow us to examine whether or not it has occurred. Unless we do so, we may overestimate what students learn from our game because they are able to perform tasks close to the domain in which it was learned.

Therefore, when developing an assessment to evaluate learning in video game play, the goal should be to create questions and experiences that allow the learner to reveal their thinking without needing the intervention experience. In a game designed to engage players in reasoning around kinematics, interview questions might be framed around hypothetical stories of vehicle of motion and participants encouraged to use a toy car to act out and to describe their answers (Holbert, 2013; Holbert & Wilensky, 2014). Likewise for a game designed to engage players in reasoning around the relationship between the particulate nature of matter and material properties, participants could be asked to describe the cause of various physical properties of tangible objects present during the interview (Holbert, 2013).

In both examples the goal is to access the knowledge participants have about the particular topic of interest without needing to rely on constructs, representations, or experiences encountered in-game. Of course, in an interview conducted after game play we may be interested to see whether or not participants *do* talk about these "real world" phenomena using knowledge resources related to the game. This brings us to the second challenge.

Challenge 2: Inability to attribute knowledge change to a particular source without control groups

As the primary goal of educational video games is one of instruction or learning, it is not surprising that research in this field often aims to trace observed changes in player knowledge to particular interactions or features of the educational game. While in some cases randomized controlled trials (RCTs) have been used to explore various effects of video games on psychological constructs or health outcomes (e.g. Green & Bavelier, 2003), more often researchers have used less rigorous quasi-experimental designs utilizing control and experimental groups. These experiments can prove enlightening for simple games with only one or two features that can be selectively manipulated and activated, but less well for complex games that include a host of interconnected mechanics and features based on learning theory. For these educational games, researchers face a real challenge when attempting to attribute knowledge change to the particulars of the game.

To evaluate the learning that happens in video games researchers often rely on comparisons between an experimental condition, where learners play the game as part of instruction, and a control condition, where learners are exposed to a "typical" classroom experience, an identified popular "innovative" curriculum, or some "equivalent" digital experience (e.g. Squire, Barab, Grant, & Higginbotham, 2004). Findings from these studies then are able to claim the educational game is "better" or "worse" at various measures than the classroom or alternate activity, but are unable to draw a clear line between what has changed and the various features of the game. In other words, the researcher is unable to identify impactful features of the game (which is central for iterative development in designed experiences) and is only able to make tenuous claims about the relationship between the learning and the game.

Clinical interviews offer an alternate solution to this common problem. Because these interviews are necessarily composed of rich and descriptive language, in-the-moment reasoning, and artifacts (such as drawings) created by the interviewee, they provide a host of potential markers that can more clearly identify the game as a source of a particular conception (Holbert, 2013; Holbert & Wilensky, 2014). For example, after playing *Particles!*, a game designed to engage players in reasoning around the particulate nature of matter, players were more likely to suggest the relative hardness of blocks used in the interview was due to increasing bonding between the atoms that make up the block. When asked why this might be, participants frequently references in-game mechanics and representations. One participant, indicating a plastic Lego block in his hand suggested, "So this one's kind of like the hard block from the game and like the atoms, if you like—they're like, more connected. Like in the game to make a harder block you had to connect them" (Holbert, 2013). Likewise, player drawings of the particles that might make up Lego and Styrofoam blocks included features of in-game objects, tools, and representations (Holbert, 2013). The ability to make a direct connection between learners' conceptions of target phenomena and game features allows the researcher to not only argue with more confidence that the game is a useful learning environment, but also to identify the particular representations, tools, interactions, and so forth that are most effective. This in turn strengthens theory development, which is the central goal of such work.

Challenge 3: Reductionist nature of descriptions of knowledge states

While carefully designed pre- and post-intervention assessments provide some insight into changes in the learners' conceptions, relying solely on such pre- and post-assessments to characterize learning often reduces learners' knowledge states to coarse categories that tell us very little about the nature or structure of those states.

When using standardized assessments to evaluate the learning that occurs in video game play we are able to state to some degree that learners do or do not understand a topic but not to describe the nature of that understanding. For example, after playing a game on Newtonian Physics a learner may be able to successfully answer a subset of questions on the Force-Concept-Inventory (Hestenes, Wells, & Swackhamer, 1992) that she was unable to answer before playing the game. Such a result would suggest the learner may have gained some knowledge of the relevant topic through gameplay (though there might be other explanations for her changed test score), but would not tell the researcher what that knowledge is made up of or how it is connected with other knowledge in the learners' conceptual system.

The learner may be able to accurately predict the motion of a moving projectile but is that knowledge connected to any other knowledge? Is her understanding of projectile motion disconnected from her intuitions about and experiences with watching objects fall or has she integrated particular physics formalisms into these intuitions? To answer these types of questions clinical interviewers engage interviewees in questions that encourage and allow them to draw on multiple pieces of knowledge. Doing so allows interviewers to gain a rich description of the particulars of the learner's knowledge in relation to her other knowledge that can supplement judgments about learners' "knowledge states" gained from pre-post assessments.

As an example, we turn again to *Particles!*, a game designed for players to explore the particulate nature of matter. One could imagine using standardized assessments to assess whether or not players have basic knowledge about atoms, molecules, or even states of matter. For example, players could be asked to identify diagrams of particles in each of the three states of matter, or even to choose between various descriptions of particle motion for a particular state of matter (both are common evaluation of learning in this domain, see AAAS, 2002).

However, in clinical interviews *Particles!* players were asked to compare and contrast properties of real world objects such as a block of hard plastic and styrofoam. Follow-up questions asked players to describe the particles that might make up the blocks, in doing so, the interviewer used the term offered by players for these particles (i.e. "atom," "molecules," etc.). This question allows the researcher to see not only students' understanding of canonical science properties but also how those properties are related to more intuitive ones. For example, when asked about the particles that might make up a bouncy object, one participant replied, "I think the atoms are bigger [...] it's bigger—it'll be easier to bounce, or like, give when it bounces, or like spring back out" (Holbert, 2013). By shifting the topic of the questions to be about the relationship between particles and the properties of tangible, real world objects, the participants' answers move beyond simply a static description of how particles move in a liquid versus a solid. These answers allow the researcher to gain insight into how the participant perceives the relationship between particle properties and object properties, as well as the participant's understanding of emergence.

Challenge 4: Tapping inert rather than usable knowledge

A final challenge for studying learning in video games is that the knowledge valued and exercised in games is knowledge that is constructed in the moment. Games allow students to engage in learning by *doing* something: saving the princess, building a civilization, etc. In most cases, the in-game tasks are not simply about recalling memorized knowledge or replicating a specific series of actions, they are about putting ideas or processes in connection with one another to do something new or to overcome a novel challenge.

Given that the learning we are interested in is inherently couched in a task, research seeking to document and study that learning must also be task oriented. By designing interviews around *tasks* and not *questions*, interviewers can see how learners construct knowledge through drawing on a range of connected resources and integrating it in the moment of the interview. These resources might be in-game tools, representations, or experiences or they might be equations, definitions, or heuristics learners have encountered in more formal spaces. By engaging interviewees in a task, we allow participants to dynamically use—and researchers to see—a range of knowledge resources accessed.

As an example, we offer data collected from participants interviewed after playing a racing game, called *FormulaT Racing* (Holbert & Wilensky, 2010), designed to engage players in reasoning around kinematics. A typical pre-post assessment question for such a game might ask students to describe speed at different points in an object's trajectory. While answers given to such a question might indicate an understanding of changing speeds or of the relationship between speed and acceleration, the answers themselves privilege inert conceptual knowledge.

In contrast, using a task-oriented approach researchers asked participants to construct a velocity versus time graph based on a changing speedometer. When engaging in this task, participants must coordinate multiple representations and tools (speedometer, line graph, pencil & paper, etc) and connect these representations to their intuitive knowledge of motion from real-world and in-game experiences.

Graphs created by 7-13 year old players before and after playing FormulaT Racing for only two hours revealed most players gained expertise creating qualitatively correct velocity vs. time line graphs. These graphs included complex features such as areas of constant velocity as well as areas of changing acceleration. Furthermore, in describing their created graphs players frequently drew on language common to video game action, such as "getting a boost," as well as formal physics vocabulary such as "constant velocity" and even mathematical constructs such as "slope" (Holbert & Wilensky, 2014). Rather than simply suggest players "learned" kinematics, or even developed skill in graphing, these task-oriented clinical interviews provide a detailed account not only of the myriad knowledge resources players draw on (Challenge #1) but also how and when learners see these resources as relevant and useful.

Triangulation with Ethnography and Logging

We have spent a substantial amount of time exploring how clinical interviews address some of the challenges associated with pre-post assessments. However, researchers use other methods—including ethnographic observation and logs of game play—to provide evidence of learning in educational games (Plass et al., 2013; Serrano-Laguna, Torrente, Moreno-Ger, & Fernández-Manjón, 2014; Stevens et al., 2008). These methods are particularly valuable because they provide detailed accounts of learning in action across game play and as such are not limited to examining static knowledge at two time points (pre and post). However, one challenge faced when employing these methods is the selection and analysis of this massive quantity of qualitative and quantitative data.

For example, "big data" from game play logs can tell us the locations in a game level where players stop moving for an extended period of time, how many players used a particular in-game feature, or even provide an overview of patterns of actions employed by learners in researcher-identified "important points" in the game. But what does that information mean for learning? Without direct access to the players themselves—not merely their actions—we cannot make strong arguments for how, why, and when learning occurs. Similarly, data from ethnographic studies can document how players interact with game mechanics and can provide a window into the role played by the specific game-playing context. However the way in which these resources and interactions are mobilized, and the extent to which they lead to conceptual change is not as easily identified through observation alone.

How can clinical interviews flesh out and support those data sources in developing rich accounts of learning in video games? We suggest that clinical interviews of the type described in the previous sections are particularly effective for developing theories that help us make sense of these data sources. In the example of the game logs, one must have a theory about game play to know that if the player stops moving it may indicate they are confused, or that not using a particular feature might indicate the feature is not understood or may instead indicate it's not as valuable to gameplay. Clinical interviews can provide insight into what that theory might entail by giving researchers a chance to probe links between behavior and learning. Likewise, performing clinical interviews in conjunction with ethnographic observations allows researchers to test hypothesis derived during observations by directly interacting with the participant. This strengthens the research by providing avenues for the exploration of disconfirming evidence and on the fly theory-building.

Conclusion

The use of video games in education is both popular and contested. Solidifying their place in the educational landscape will require substantial research that explores and documents the type of learning that can happen during game play. For that research to be meaningful, the field will need to draw on a variety of methodological tools and techniques. In this paper we have set out to (re)introduce cognitive clinical interviews as a methodology particularly suited to answering many of the most pressing questions about games and learning.

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