Game development for experience through staying there

Tim Marsh† Kiyoung Yang± Cyrus Shahabi†±
Integrated Media Systems Center,† Computer Science Department,± University of Southern California, CA

Submission ID: vgsp_0078

Abstract

We describe two approaches to aid in game design, evaluation and development for user-players *staying there*, continuing to engage in game activities. The first is the hierarchical activity-based scenario (HABS) approach providing a theoretical framework to support the design of game narrative and scenario, model and reason about user-players' behavior and experience from acting in the scenario, and help identify problematic aspects of game design. The second is a continuous and unobtrusive approach that supports evaluation. Central to our approach is a tool called ISIS (Immersidata analySIS) to query and identify data of interest and to index events within virtual or video recordings, or graphical visualizations of game sessions. Used in conjunction with HABS, analysis of the associated data and indexed events helps us to understand user-players' behaviour and experience and aids in the detection of design problems to inform game development. To demonstrate our approaches we describe how they have been utilized in the development of an educational serious game.

Keywords
User experience, serious games, game development, activity theory
ACM Classification Keywords
H.1.2 [**Models and Principles**]: [User/Machine Systems *Human information processing*]; H.5.2 [**Information Interfaces and Presentation**]: [User Interfaces *User-centered design*]

marsht, kiyoungy, shahabi@usc.edu

1 Introduction

User-player activities within digital games (i.e. computer, video, virtual, serious) provide experience. Appropriate or stimulating experience encourages user-players in *staying there* continuing to engage in game activities; conversely, inappropriate or un-stimulating experience stemming from ineffective or problematic design can compromise user-players in *staying there* [Marsh 2002; Marsh 2003a; Marsh 2003b]. Therefore, it is argued that one of the main goals of game design and development is to encourage and allow users to pursue game objectives, free from disruption and receive appropriate or stimulating experience. To address this requires the we formulation of underlying theoretical concepts and approaches to support game development for the *staying there* experience. To provide theoretical concepts and a framework to realize the idea of staying there, our research builds on previous work and the hierarchical activity-based scenario (HABS) approach [Marsh 2002; Marsh 2003a]. Extending ideas from activity theory originating from Soviet psychology, HABS provides an approach to link the processes of design, evaluation and development of virtual and game environments throughout phases of the development life cycle.

This includes, a framework to aid in the design of scenario and narrative and to dynamically model and observe user-players performing within the scenario, concepts to reason about the degree to which game scenario and user experience have been successful, and concepts to help identify disruption or breaks (commonly referred to as breakdown in human-computer interaction HCI) to user-player's experience from problematic design features or disruptive enabling technologies.

To operationalize HABS concepts to help identify problematic aspects of design requires the application of evaluation methods. However, while standard evaluation methods provide some insightful information that can be used to inform game development as demonstrated in empirical studies with a variety of virtual reality (VR) systems, virtual environments and digital games (e.g. head-mounted display VR for training scientists, role-playing game for children, first-person shooter with teenagers and young adults), they are problematic either because they are too passive or they disrupt user-player's attention and staying there experience [Marsh 2002]. For example, used alone, observation puts the onus on the evaluator to interpret the circumstances behind, or causes of disruption. Post-study questionnaires are retrospectively administered and hence, it is difficult to link events of scenario and design features/elements with experience and breakdowns (i.e. doesn't perform/function as intended). While getting user-players to concurrently think-aloud (i.e. a kind of running commentary) provides more information about the causes surrounding breakdown as they occur, the process of verbalizing disrupts user-player's gaming and staying there experience. Likewise, novel approaches developed to capture user-player experience introduce similar problems. Therefore, in order to operationalize HABS concepts to help identify problematic aspects of design, we have developed a continuous and unobtrusive evaluation approach.

Central to our approach is a tool called ISIS (Immersidata analySIS) [Yang et al. 2005]. ISIS is a graphical user interface (GUI) that allows us to query immersidata (data generated from interactions with/within a virtual or game environment [Shahabi 1999]) to identify data of interest and index this to virtual or video recordings, or graphical visualizations of user-player's gaming sessions. In this paper we demonstrate our approach through immersidata indexed to video clips. Identified data and indexed events within video clips can then be analysed to help understand user-player's behaviour and experience and this provides an insight into which game elements and features work and which don't. This information is then used to iteratively inform game development for user-players staying there. The complement of HABS and ISIS allows us to go beyond a simple bug-testing development approach that has come to epitomize evaluation or "quality assurance" in game development. While earlier descriptions of ISIS [Yang et al. 2005] and HABS [Marsh et al. 2005b] exist, the novelty of this paper that sets it apart, are the detailed descriptions of the supporting theoretical concepts and framework of HABS and the ways in which it informs and guides game development when used in conjunction with ISIS.

To demonstrate the effectiveness of HABS and ISIS we describe their application in the development of an educational or serious game. Serious games are commonly described as games for non-entertainment purposes, thus distinguishing them from computer or video games developed primarily for entertainment purposes. However learning and entertainment are not necessarily mutually exclusive in serious games and therefore development tools and approaches should be able to address both. While the focus of this paper is on the development of an educational serious game, both HABS and ISIS are appropriate for use in the development of a variety of virtual environment and digital game genres and configurations.

The learning objective of the educational serious game we have been involved in developing in the Integrated Media Systems Center (IMSC) at the University of Southern California (USC), is to help undergraduate students learn the physiology of human organs. To achieve this, it consists of two main missions: Nature Pumps and Control Systems. The Nature Pumps mission helps students learn the processes of digestion and absorption of nutrients, and the Control Systems mission teaches students the roles of glucagon and insulin in maintaining blood glucose levels. Before undertaking these missions, students first carried out a Training mission to familiarize themselves with the fundamentals of the game, learning how to move and interact within the game. In this version of the game, the finished product and end point in our development life cycle was reached when all missions could be completed free from any disruptive design and interaction, the learning objectives of the curriculum were represented satisfactory in the missions and it was considered ready for use in students' natural classroom settings.

This paper is arranged as follows: in section three we describe HABS and how it helps in design and development of digital games with focus on an educational serious game. In section four we describe the evaluation tool ISIS (Immersidata analySIS) and in section five we describe how ISIS used in conjunction with HABS has been utilized in the development of an educational serious game. Finally, we discuss directions for future work.

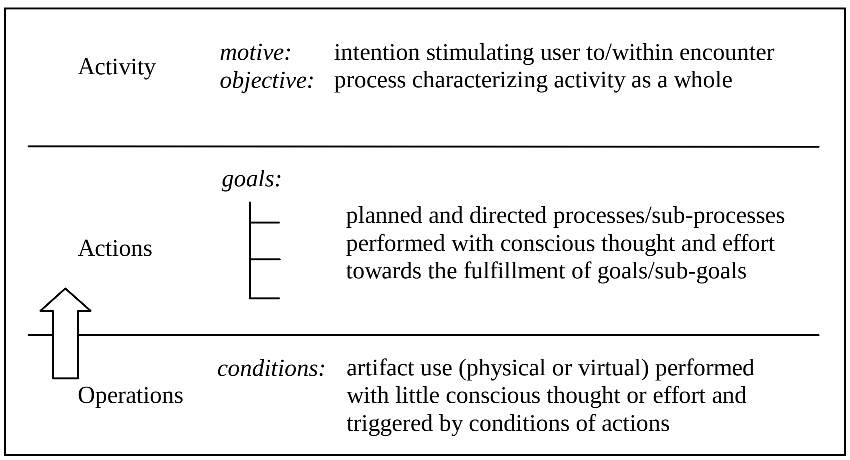

Figure 1: HABS: hierarchical activity-based scenario

2 The hierarchical activity-based scenario (HABS)

Extending concepts from activity theory and in particular the work of Leont'ev [1981], the hierarchical activity-based scenario (HABS) approach was developed to support design and evaluation of virtual and game environments throughout phases of the development life cycle [Marsh 2002; Marsh 2003a]. As illustrated in Figure 1 and described in detail by example in section 3.1, HABS provides a flexible and dynamic conceptual framework that supports game development in four main ways:

1) hierarchical structure aids design and modeling of scenarios and narratives (from high-level *activities/objectives*, through *actions/goals* to low-level *operations* of physical/virtual artifacts) to any level of complexity from conception to finished product

2) allows evaluators and developers to dynamically model user-player behavior and interactions with/within the scenario during game play

3) concepts help to identify disruption to user's interaction from problematic design features (virtual artifacts, objects and environment) or disruptive enabling technologies (interactive devices, configuration, platform) through shifts between levels from operations to actions as represented by the vertical arrow in Figure 1.

4) incorporates a method to structure and reason about the degree to which a games scenario or backstory has been successful through the fulfillment of tasks and objectives, as well as the degree to which experience from game play (e.g. fun, excitement, emotion, learning objectives) has been successful (through the objective outcome of activity coinciding with motive).

2.1 HABS: informing game development

In reference to Figures 1 and 2, central to activity theory is Leont'ev's [1981] hierarchical framework composed of: *activity, actions* and *operations and* characterized by *objective, goals and conditions*, respectively. These provide the basis to design and model scenarios and narratives as outlined in (1) above. The *activity* is directed towards achieving an *objective.* The objective is a process characterizing the activity as a whole. In keeping with the scenario or backstory of the educational serious game, the objective was referred to as mission. While the game has two missions the dissemination of the course curriculum using a variety of teaching methods (e.g. lecture, handouts) meant our end user student population undertook just one mission with the game, either:

i) Nature Pumps: provide energy source and reactivate digestion and adsorption processes

ii) Control Systems: regulate available blood sugar and restore systems that maintain blood glucose

So while subjects in empirical studies that were carried out from mid to later phases of the development life cycle in laboratory settings undertook either one or both missions (depending on the study design), in the final study with the end student group in their natural classroom settings, they were divided into two groups with one group performing one mission and the second group the other. As shown in Figure 2, in studies where subjects undertook both missions, the missions became the main actions/goals and the objective characterizing the activity as a whole became *help revive a world-renowned scientist from a coma.* The fulfillment of these main goals (i and ii) then provides an indication or measure of the degree to which the outcome from the objective (i.e. to revive world-renowned scientist) was successful. Likewise, in our final classroom study, the degree to which the objective (either: i or ii) was fulfilled provides an indication or measure of the degree to which the outcome from the objective was successful. Thus, providing an example of the adaptability and flexibility of HABS to model scenarios irrespective of complexity or study design.

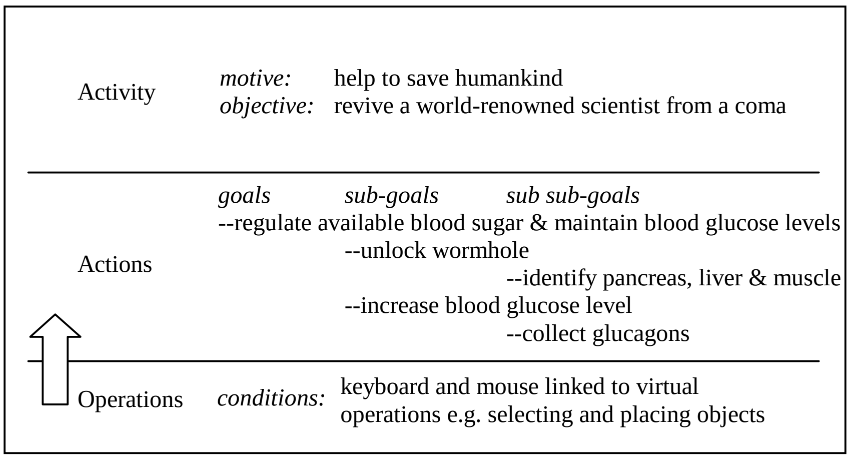

Figure 2 Portion of the hierarchical activity-based scenario for a serious game

Activity is made up of one or a combination of a*ctions/tasks*. Actions are processes carried out with conscious thought and effort, and are planned and directed towards achieving a *goal*. Actions may be made up of sub-actions directed towards sub-goals. Their collective fulfillment is the fulfillment of the activity's objective. For instance as shown in Figure 2, in our educational serious game example, the sub-goal of unlocking the *wormhole* to enter the scientist's organs is fulfilled by carrying out the sub sub-goal to identify the *pancreas, liver and muscle,* and the sub-goal to *increase blood glucose level* is fulfilled by *collecting glucagons,* and so on.

Actions are performed by a combination of *operations.* Operations are processes performed with little thought or attention in the use of artifacts both physical (e.g. keyboard, mouse, novel devices) and virtual (e.g. artifacts, objects, environment) triggered by conditions of actions. Hence, using HABS, evaluators and developers can dynamically observe and model user-player behavior and interactions with/within the scenario as outlined in (2) above.

The early phases of learning to use an artifact (physical e.g. interactive controls/device and virtual e.g. weapon, magic wand) will have been performed with deliberate and conscious attention. At this point they are actions. When they become well practiced and experienced, actions become routine. That is, they do not need to be planned and at such a point are performed with little conscious thought or effort (i.e. actions become operations). These are issues relating to the mastery of techniques of devices and artifacts/tools. While this is similar to the idea of transparency in HCI, activity theory goes one step further by providing concepts encapsulated in the notion of *functional organs* to reason about artifacts that following mastery not only extend and amplify humans capabilities per se, but also become part of and belong to the human enabling us to achieve higher accomplishments [Marsh 2002; Marsh 2003a]. This provides the basis to design and reason about smooth and uninterrupted interaction with/within the virtual or game world. Conversely, when something impedes interaction or design elements or features behave inappropriately, operations become actions as represented by the vertical arrow in Figure 2. Referred to as breaks or breakdown, they disrupt user-player's attention and the *staying there* experience and so provide ways to identify problematic interaction (with and between the physical and the virtual) and design [Marsh et al. 2001] as outlined in (3) above. Because the main requirement of the educational serious game is for student use in their natural classroom environments, standard desktop computers were used and therefore, physical operations are performed with keyboard and mouse, and linked to virtual operations including: selecting and placing objects, etc.

Objective is closely related to motive and both have to be considered in the analysis of *"activity proper"* [Leont'ev 1981; Marsh 2003a]. The degree to which an encounter provides users with experience that is appropriate, matches their expectations/intentions and/or is stimulating gives an indication of its success. For example, a user's motive for using or playing with digital games may be, for example, for some special need, to understand, comprehend or to learn, for interest, to feel excitement and emotions, fun, enjoyment or pleasure. The motive(s) may be intrinsic to user-players or extrinsic, as well as being external to digital games or internally generated in-game during game play within the scenario. If the objective outcome of performing processes of an activity with digital games is the inducement of appropriate and/or stimulating experience, the objective outcome will coincide with the motive that stimulates the user to an encounter. Consequently, users' attention is maintained in pursuing their objective (i.e. continue the experience) or an encounter has fulfilled a user's intention that drove them to the encounter in the first place. Either way, the encounter is successful. Conversely, if the objective outcome does not provide appropriate and/or stimulating experience because it doesn't match up/deliver on expectations or purpose, or it is dull, boring, uninteresting, then it does not coincide with motive. Likewise, if a digital game is difficult to use, then again attempts to fulfill objectives are frustrated. In either of these circumstances an encounter or use will either have been unsuccessful or have frustrated attempts to fulfill objectives. In our educational serious game the *objective* and *motive* is narrated through the backstory to user-players at the beginning of the game. If the outcome from pursuing the objective (i.e. attempt *to revive the world-renowned medical research scientist from a deep coma)* is unfulfilled then it does not coincide with the motive (i.e. *to help save humankind*), it is not an "activity proper". The degree to which a games scenario or backstory has been successful is judged according to how well the actions have been fulfilled towards the fulfillment of objective. The degree of success can be fed back to user-players through text, narration or through some kind of reward mechanism (e.g. points). Following this, the usual game etiquette is for the user-players to be given the option to repeat the game objective at the same level of play. On the other hand, if the objective outcome of processes coincide with the motive and the world-renowned medical research scientist is revived and so able to carry on research to help humankind, then it is "activity proper", at which point the activity ends. The successful completion of the mission is fed back to user-players. Hence, providing a method to structure and reason about the degree to which a games scenario or backstory has been successful through the fulfillment of tasks and objectives as outlined in (4) above. The usual game etiquette and reward mechanism is then to allow user-players to proceed to the next level of game play or to level-up.

The hierarchical structure and gaming backstory provides an overall motive for students to interact with the game (i.e. *help to save humankind*) by attempting to fulfill the objective (i.e. *to keep a world renowned Medical Research Scientist alive so he can continue his research)* while at the same time ingeniously fulfilling the requirements of the educational or learning experience/outcomes (i.e. how blood glucose levels are stabilized by glucagon and insulin).

2.2 Limitations in HCI to define "activity proper"

While work has identified that the activity is the smallest meaningful unit of analysis in activity theory [Kuutti 1996], very little published work appears to address the defining concept of activity as being *objective outcome* coinciding with *motive* and this is particularly true in human-computer interaction (HCI). For example, little, if indeed any, work in HCI appears to deal with these separately, either suggesting analysis of "object or motive" [Kaptelinin et al. 1999], linking them together as illustrated through "objectified motive" [Christiansen 1996] or not dealing with motive at all. The limited use of concepts from activity theory has even led to the suggestion that the unit of analysis in activity theory is the action rather than being the activity. While Marsh [2002; 2003a] has attempted to draw attention to inaccuracies in the use of these concepts to frame an activity or in Leont'ev's [1981] words define "activity proper", published work from HCI still appears not to address this imprecision. The reason for this appears to be that work in HCI focuses on Leont'ev's earlier writings and translation from the original Russian text into English [Leont'ev's 1978] where no mention to the defining concept of "activity proper" (through objective outcome coinciding with motive) is contained and which appears only in later writings translated into English [Leont'ev 1981]. The continued shortcomings or even perhaps reluctance to address the defining concepts of activity may invalidate already published and future activity-based research.

3 Immersidata Management and Analysis

In digital games users are immersed in activities with characters and objects within places depicted virtually. As mentioned, we refer to the data generated from user-player interchanges in these environments under the all-embracing term *immersidata* [Shahabi 1999]. Immersidata can be considered as several continuous data streams (CDS) generated from interactions and events, etc. The capture and interpretation of immersidata representing user-players' behaviour and experience can tell us something about the user-player and game design in use or during play and limitations can then be identified and used to iteratively inform game development to make improvements. In this section we describe a continuous and unobtrusive method to seamlessly capture data generated from interchanges between a user-player and a game environment. As mentioned, we refer to this data as *immersidata* The amount of immersidata that is captured to represent user behaviour and experience in virtual and game environments is considerably large and hence, this creates the difficulty of how to efficiently store and retrieve the immersidata. To help in this, Shahabi [2003] proposed the Immersidata Management System (AIMS) with database support. A schematic of the game immersidata collection is illustrated in Figure 3.

While the user-player attempts to fulfil the game's tasks, we can capture any immersidata generated from interchanges between user-player and the game that is under investigation. Typically, this includes, the continuous capture of the user-player's position in the game and events generated from their interaction within the game. For example, the position stream typically consists of a timestamp in milliseconds, the position (X, Y and Z) and direction that the user-player is facing (RX, RY, RZ) and the direction in

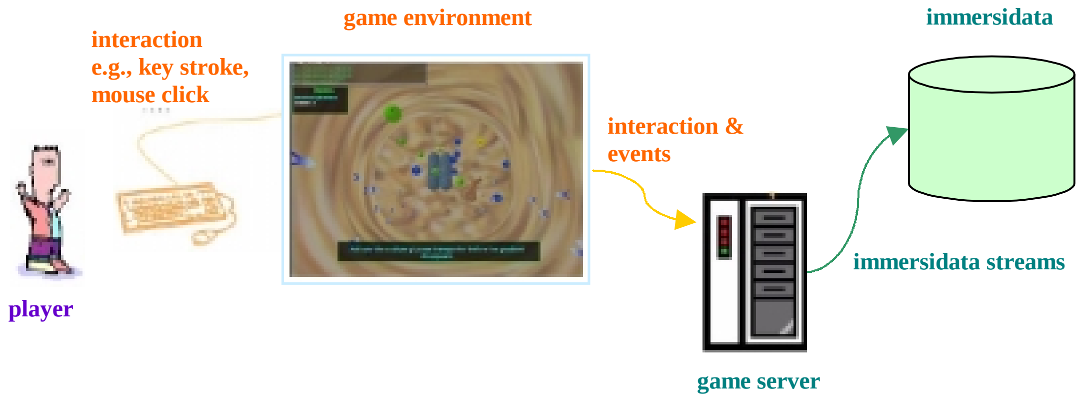

Figure 3. Game immersidata collection

which the user-player is looking in the game (EYEX, EYEY, EYEZ). Similarly, the event stream typically contains: a timestamp, the position and angular coordinates as described, and the occurrence of an event (e.g. object selected, object placed, weapon fire, etc). In addition to the immersidata, we also collected demographic data (e.g., gender, age, games experience) and subject content results taken from pre-study questionnaires

3.1 ISIS: Immersidata analySIS

We have developed an application called ISIS (Immersidata analySIS) to expedite the consultation and summarization of immersidata to help understand user-players' behaviour and experience. ISIS is an easy-to-use graphical user interface (GUI) that indexes the results from queries of immersidata within virtual or video recordings, or graphical visualisations for analysis. As shown in examples in Figure 4, in this paper we focus on immersidata indexed to video clips. Identified events can then be analyzed to help understand user-player's behaviour and experience. Hence, instead of manually linking video with immersidata and then sequentially analyzing recorded video material, ISIS utilizes the immersidata linked to video to expedite the process of analysis. ISIS's user interface consists of several frames displaying video clips of user-players during study sessions with pointers or indexes to immersidata retrieved from the database and are placed on a track bar under the display screen, control icons allowing the selection of a user-player, query and associated parameters, three frames displaying user-player profile with demographic information, statistics and questionnaire results.

While assessment of user-player experience in serious games provides a means to validate learning and design, there is negligible research literature on the pedagogical value of serious games and moreover, a dearth of available tools and techniques. In this paper we describe how ISIS when used in conjunction with HABS provides a tool and theoretical concepts for analyzing user-player behaviour and experience, to assess and inform design to make improvements to games. To demonstrate this, we describe three main queries to identify: user-player actions and activity, disruption or breaks in activities and experience caused by contemplation/reflection or ineffective and problematic design. Elsewhere we describe ISIS with additional queries to identify difficulties in navigation and events or tasks that have been identified as the most difficult to perform in a game [Marsh et al. 2006]. However, as mentioned, our intention for this paper is to describe the supporting theoretical concepts and framework of HABS that informs and guides game design, evaluation and development.

3.2 Queries

The implementation of queries is an on-going evolving process informed through results from results from experimentation. We describe three main queries that used in conjunction with HABS provide a means to analyze user-player behavior and the learning experience to inform design to make improvements to the game. Although our research has focused on an educational game, it is anticipated that these queries can generalize to other serious games and across different game genres that are primarily for entertainment purposes.

3.2.1 Activity or Mission Completion

This query identifies the moment when a user-player completes the final tasks associated with a particular activity or mission. As well providing the overall completion time of the activity, it provides a frame for the goals and sub-goals associated with an activity.

3.2.2 Action or Task Completion

This indicates the points when a user-player finishes each task and the duration of each task. Evaluators and developers can choose which task completion points they want to retrieve from the database and from analysis of video clips, learn which behaviors and strategies a user-player employed to fulfill a particular task and reason about the kinds of experience they had. Used in conjunction with HABS, it provides a way to map, trace or track user-player's game play through the serious game. Irrespective of scenario's complexity, HABS provides us with a lens to focus or zoom in to the finer level of detail of interaction, as well as zoom out to view at activity level.

3.2.3 Break Point

A break is defined to be the moment when the user-player does not make any movement and no events occur with and within the game for a specific period of time. Breaks are represented by the vertical arrow in the HABS for the serious game as shown in Figure 2. This builds on earlier work contained in [Marsh et al. 2005a] that hypothesized that zero or near-zero immersidata (direction and angular position, and events) generated from immersive environments could be used to identify the cause of breaks in user experience. By identifying breaks in immersidata and then analyzing the point or duration in which the breaks occur in video recordings of study sessions, we were able to validate our hypothesis. Break points provide clues to the causes of what interrupts the user-players while they are playing a game. In serious games for learning, the cause of breaks can be either that the user-player is appropriately *contemplating* the educational content of the game or there is a *design problem*.

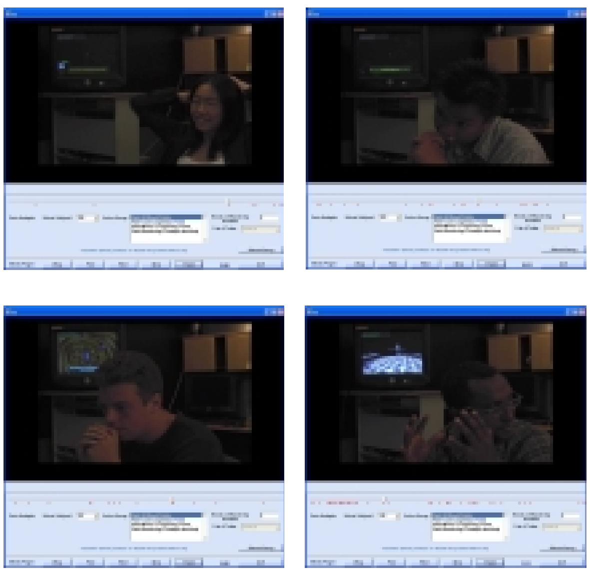

Figure 4. Breaks and wandering points captured using ISIS. Clockwise from top left: (a) user doesn’t know what to do next (b) frustration caused by problematic design (c) contemplating the educational content of the game (d) user offers advice on how to improve the game

3.2.4 Wandering Point

A similar query to breaks is wandering points that identifies the period when the user-player is moving but does not make any events (e.g. selection or placement of objects) for a specific period of time. Evaluators can use this query to analyze user-player behavior to identify any difficulty user-players may have encountered and identify potential design problems. In study sessions, one user-player was identified as roaming around for quite some time and said that she was “not sure what to do next”. Following further analysis of the circumstances surrounding this and then comparing this with the behavior of other user-players using ISIS, we were able to reason that the problem was not with design as we had first suspected but a lack of experience on behalf of the user.

The implementation of break and wandering queries in ISIS provides evaluators and developers with an efficient way to select and analyze video clips associated with these breaks and wandering points to determine the cause of break/wandering. For example, Figure 4(a) illustrates the point at which a user-player in a study session stopped playing the game following a period of wandering around aimlessly because she was not sure what to do next after correctly placing the three organs: *pancreas, liver & muscle* (refer to the goal listed in the HABS for the serious game as and shown in Figure 2). This suggests a lack of instruction after finishing the first task and further analysis confirmed this to be the case. Figure 4(b) after wandering around for a while, this shows the moment when a user-player is frustrated by problematic design of the activated wormholes and so stopped playing. Figures 4(c) identified when a user stopped play to appropriately contemplate the educational subject content of the game and 4(d) identifies when a user stopped play to offer advice about how improvements to the game could be made.

4 Informing Game Development

Using ISIS in conjunction with HABS enabled us to effectively identify many problematic design features and elements, for example:

- detected that subjects were becoming disoriented after losing track of where they were inside organs of the human body. To overcome this problem, a map of the human body indicating their location on the display screen at all times was implemented.
- identified that subjects became forgetful or would lose sight of their tasks/goals. To overcome this problem, following periods of no interaction or wandering around, a sliding instruction box appears for a short duration as a gentle reminder to subjects of their goals.

5 Conclusion

While research in human-computer interaction (HCI) issues in computer games has recently attracted considerable attention, HCI has been slow in addressing the lack of serious approaches and methodologies for serious games, as well as for other game environments. This paper addresses some of the challenges facing HCI in computer games. It describes two approaches, HABS and ISIS, that used in conjunction can help in game development for user-players staying there. The application of these approaches to inform the processes of design, evaluation and development of an educational serious game was then described. Future research aims to extend the hierarchical activity-based scenario (HABS) approach and functionality of ISIS so that aspects of scenario and design can be more accurately linked to experience. Finally, we will work towards applying the approaches described herein to other digital game genres, especially those for entertainment.

Acknowledgments

This research has been funded in part by NSF grants EEC-9529152 (IMSC ERC), IIS-0238560 (PECASE) and IIS-0307908, and unrestricted cash gifts from Microsoft. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. Thanks to members of the Serious Games Lab, USC.

References

CHRISTIANSEN, E. 1996. Tamed by a Rose: Computers as Tools in Human Activity. In: B. Nardi (ed.), *Context and Consciousness: Activity Theory and Human-Computer Interaction.* Cambridge, Massachusetts: MIT Press, pp. 175-198.

KAPTELININ, V., Nardi B. and Macauley C. 1999. The Activity Checklist: A Tool for Representing the "Space" of Context, *Interactions,* July/August, 27-39.

KUUTTI, K. 1996. Activity Theory as a Potential Framework for Human-Computer Interaction Research. In: B. Nardi (ed.), *Context and Consciousness: Activity Theory and Human-Computer Interaction.* Cambridge, Massachusetts: MIT Press, pp. 17-44.

LEONT'EV, A. N. 1978. *Activity, Consciousness, and Personality*. Englewood Cliffs, NJ: Prentice-Hall.

LEONT'EV, A. N. 1981. *Problems of the Development of the Mind*. Moscow: Progress.

MARSH, T., WRIGHT, P., and SMITH, S. 2001. Evaluation for the Design of Experience in Virtual Environments: Modelling Breakdown of Interaction and Illusion, *Journal of CyberPsychology and Behavior 4,* 2, 225-238.

MARSH, T. 2002. *Towards Invisible Style of Computer-Mediated Activity: Transparency and Continuity*. Ph.D Thesis, University of York, UK.

MARSH, T. 2003a. Staying there: an activity-based approach to narrative design and evaluation as an antidote to virtual corpsing, In *Being There: Concepts, effects and measurements of user presence in synthetic environments.* G. Riva, F. Davide and W. A. IJsselsteijn, Ed., Amsterdam, The Netherlands: IOS Press, pp. 85-96.

MARSH, T. 2003b. Presence as Experience: film informing ways of staying there, *PRESENCE: Teleoperators and Virtual Environments 12*, 5, 538-549.

MARSH, T., YANG, K., SHAHABI, C., WONG, W.L., NOCERA, L., CARRIAZO, E., VARMA, A., YOON, H., and KYRIAKAKIS, C. 2005a. Automating the detection of breaks in continuous user experience with computer games. In *Proceedings of ACM CHI '05: extended abstracts on Human factors in Computing Systems,* ACM Press, New York, 1629–1632.

MARSH, T., WONG, W.L., CARRIAZO, E., NOCERA, L., YANG, K., VARMA, A., YOON, H., LUN HUANG, Y., KYRIAKAKIS, C. and SHAHABI, C. 2005b. User experiences and lessons learned from developing and implementing an immersive game for the science classroom. In *Proceedings of the 11th International Conference on Human-Computer Interaction*.

MARSH, T., SMITH, S.P., YANG, K., and SHAHABI, C. 2006. Continuous and Unobtrusive Capture of User-Player Behavior and Experience to Assess and Inform Game Design and Development, In *Proceedings of the 1st World Conference for Fun 'n Games,* UK, Accepted.

SHAHABI, C., BARISH, G., ELLENBERGER, B., JIANG, N., KOLAHDOUZAN, M.R., NAM, A., and ZIMMERMAN, R. 1999. Immersidata management: Challenges in management of data generated within an immersive environment. In *Fifth International Workshop on Multimedia Information Systems (MIS99)*.

SHAHABI, C. 2003. AIMS: An immersidata management system. In *VLDB CIDR, January*.

YANG, K., MARSH, T., MUN, M, and SHAHABI, C. 2005. Continuous Archival and Analysis of User Data in Virtual and Immersive Game Environments. *In The 2nd ACM Workshop on Capture, Archival and Retrieval of Personal Experiences (CARPE'05),* Singapore, ACM Press. pp. 13–22.