System Design Evolution of The Prepared Partner: How a Labor and Childbirth Game Came to Term

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How do you help a woman in labor? The Prepared Partner is an educational video game about labor and childbirth, intended to teach mothers, birth partners, and everybody else about different natural ways to help a woman in labor. In the game, the player sees up to 50 non-pharmacological pain relief, comfort, and relaxation methods that he or she can suggest to the mother — and can help her have a satisfying birth. We present a partial taxonomy of childbirth in video games, and a discussion on skill selection and its effect on agency as motivation for the system. Through iterations of design decisions involving specialists across several vastly different fields, we present a simple way to model a woman in labor. We show that frequent interdisciplinary collaboration was key in making The Prepared Partner an educational game; that the review and re-assessment considered the system as a game, as an application, as a user interface, and as a mathematical model of a laboring woman. The overwhelming majority of positive survey responses speaks to the success of The Prepared Partner as an enjoyable learning aid. We attribute its success to the close ties we had to both the childbirth professionals and the usability and game design experts during all stages of design and development of The Prepared Partner.

The experience of childbirth is characterized by many highly subjective factors. It is impossible to determine in advance what one mother's birth experience will be like, as birth experiences vary from mother to mother and from birth to birth. Similarly, it is impossible to predict one technique or combination of interventions that will help all women through their labor experiences, or even one woman at different points in her labor (Brown, Douglas, & Flood, 2001). Preparing for childbirth through reading books and watching videos is difficult as these media are incomplete, static references to the dynamic event of labor and childbirth. Childbirth preparation classes are face-to-face sessions with one or more expectant parents and a childbirth educator. In these sessions, parents learn strategies to reduce stress and anxiety, to manage pain, and to increase self-confidence before and during labor and childbirth (Cheung, Ip, & Chan, 2007). The goals of The Prepared Partner as an educational game experience were to introduce natural coping mechanisms and their effects on labor, to introduce the mechanics of labor and childbirth, to train birth partners to help women in childbirth, to practice interacting with a woman in labor, and to simulate the stages of labor. The Prepared Partner targets anyone interested in childbirth, especially men intending to be birth partners. The Prepared Partner is free to play on one of the most influential resources for expectant parents: the Internet (Handfield, Turnbull, et al., 2006). The Prepared Partner is well-positioned to be an educational aid to traditional childbirth preparation classes, books, videos, and other non-interactive media for teaching about labor and childbirth.

We present The Prepared Partner as an example of user-centered game design, and describes the evolution of its design through several rounds of user feedback. We present a mechanic to model a woman in labor, and explain how this mechanic came into existence. We suggest a schedule for serious games design for learning, with entry points for expert feedback and user testing.

We acknowledge the five heuristic evaluators for their time and expert advice; Alaric Holloway for the designing and drawing all graphical assets; and Nicole Wilson for the sound contributions (voice acting). We wish to thank the Quarter to Three community for inspiration and suggestions about video games containing childbirth themes. We also thank DJ Capelis, Caitlin Sadowski, and Micah Carlin-Goldberg for their feedback on this manuscript.

Relevant Work

To establish a baseline or entry point for The Prepared Partner as a serious game, we investigated video games as a medium of representing labor and childbirth. The majority of obstetricians believe that popular media influences the rates of medical interventions in labor childbirth (Handfield et al., 2006) — that is, parents are more likely to elect medical interventions because of what they see in popular media. Men's perceptions of and beliefs about childbirth are negatively influenced by media (Ward, Merriwether, & Caruthers, 2006). Reality TV shows are another negative factor in portraying labor and childbirth, as they reiterate the incorrect belief that women's bodies are incapable of giving birth to a baby without medical intervention (Morris & McInerney, 2010). Unfortunately, video games historically misrepresent labor and childbirth.

A Partial Taxonomy of Childbirth in Video Games

Childbirth has been portrayed in video games for as long as games have existed. *Legend of the Red Dragon*[1], or LORD, a door game from the BBS era, allowed the player (if female) or the innkeeper's daughter Violet (if male) to conceive and birth a baby. The birth was not described, however; it was merely mentioned in a status message. The only reason for the child's existence was to save the player's character when he or she was about to die in combat. The child would be sacrificed so that the player's character could live. This minimalist and utilitarian approach to childbirth is common to many other games. When birth scenes do exist in games, the available actions, or affordances, to the player are minimal at best. Some video games that contain scenes of childbirth are as follows.

Simulations. Games in the class of people-simulators include *Second Life*[2] and *Sims 3*[3]. Each game affords the player to conceive, labor, and birth a child, but the labor process is not realistic, nor does it vary from labor to labor. *Second Life* is a simulation game in which the player role-plays her character in the virtual world. In *Second Life*, childbirth is shown as a natural, important life event. The character labors mainly on her back (which is one of the least comfortable positions for a laboring woman), but can be attended by other players (partners, midwives, friends), who provide moral support to the character. *Sims 3* is a simulation game in which the player can control several characters going about their daily routines. In *Sims 3*, the character in labor clutches her stomach and appears pained. Onlookers panic. Figure 1 shows the scene from *Sims 3* used as inspiration for the project. The scene depicts an example of inappropriate support for a woman in labor: the woman is experiencing contractions; the man standing beside her is confused and does not know how to help. The other woman character appears terrified and similarly does not help the woman in labor. When interacting with the woman in labor, the player has only one option: to take her to the hospital. The player is reminded of this necessity several times throughout the woman's labor, as the hospital is considered the only safe place to have a baby. However, failure to take her to a hospital still results in a healthy birth.

Action and role-playing games. In the beginning of *Fallout 3*[4], the player experiences his or her character's own birth, beginning with the blurry vision of a room full of doctors. In recent research, a mother does best when supported by those close to her, especially her partner and a doula (a woman in a role of professional childbirth support) (Klaus, Kennell, & Klaus, 2002). In *Final Fantasy X-2*[5], Lulu becomes pregnant and subsequently births a child. The interaction is via cut-scene only; the player has no control over the events in the childbirth. *King's Bounty: The Legend*[6] allows the character, the hero, to marry and impregnate his wife. However, when she gives birth to a child, the child immediately and permanently occupies one out of her four inventory slots, and is considered nearly worthless by the game mechanic.

The Flash Game. In the Flash game called *Birth Game*[7], the player controls a character lying flat on her back and receiving gas through a mask on her face. The player uses the keyboard to hurl newborns out of the character into passing prams, matching the baby's race with the race of the pram-pushing father. This game is completely unrealistic and inappropriate as a learning aid, as it does not take a serious position with respect to labor and childbirth.

Background Research

Before designing and developing The Prepared Partner, we conducted domain background research. Common themes in childbirth education books were information about the stages of labor, relaxation to reduce anxiety, natural coping mechanisms to deal with pain and discomfort associated with childbirth, and information about pharmacological options available to mothers in

[1] Legend of the Red Dragon (LORD) (1989), released by Robinson Technologies

[2] Second Life (2003), published by Linden Press

[3] The Sims 3 (2009), published by Electronic Arts

[4] Fallout 3 (2008), published by Bethesda Softworks

[5] Final Fantasy X-2 (2003), published by Square (now Square Enix)

[6] King's Bounty: The Legend (2008), published by 1C Company

[7] Big J's Birth Game (2008)

Figure 1. Confusion about assisting a woman in labor in *Sims 3*

a hospital or birth center (England & Horowitz, 1998; Gaskin, 2003; Goer, 1999; Simkin, 2008).

Because up to 80% of expectant parents attend childbirth preparation classes (Lumley & Brown, 1993), we attended a class intended to train doulas (women in a role of professional childbirth support) for their work of supporting women throughout labor, birth, and breastfeeding initiation. This class was a thorough introduction to the mechanics of labor, the emotional implications, the options available to the parents, and involved hands-on practice of dozens of natural coping mechanisms.

Selecting Skills

The Prepared Partner introduces the player to a number of various natural ways to help a woman in labor. In choosing the best way to present these natural ways to help a woman to the player, we investigated different ways that other games present skills.

Sims 3. In *Sims 3*, the player's skills are shown when clicking on avatars and objects. When an object or character is capable of interaction, a menu is displayed on the object or character, and the player can select from the list of affordances. We considered using this sort of interaction. In *Sims 3*, when the player selects (by mouse-click) different elements in the room, a menu with the possible affordances is displayed over the room element.

Figure 2. The skill-bar in *World of Warcraft*

The main benefit to this is that all skills are one menu-level deep in the interface. The main drawback is that the screen needs to be cluttered with different objects that have a potential of helping a woman in labor.

World of Warcraft. In the massively multiplayer online role-playing game *World of Warcraft*[8], the player becomes a character in the virtual world. The character levels up (by gaining enough experience points to progress to the next level) while completing quests. At certain levels, the character can choose to purchase new skills, or make existing skills stronger. For each skill, the player may place the skill on the skill-bar at any point in the game. A higher-level player will have many more skills than the skill-bar can hold. Two ways to deal with this problem have been used. First, modules and game modifications exist to allow the use of additional skills slots. Second, the player prioritizes the skills for prime skill-bar real-estate. The skills more frequently used, or most necessary, are placed on the skill-bar, while less necessary skills are left out. Figure 2 shows a snapshot of the skill-bar in *World of Warcraft*. The 10 leftmost action slots, of which only seven are occupied, are mapped by the user. That is, the player can assign these to be any of the character's actions. The actions are available from the spell book, a comprehensive list of spells and skills, arranged by category in a menu. The middle (small) set of icons are in-game options and menus. The five slots on the far right are spaces for containers for the character's inventory. We considered using this kind of skill-bar: the player's actions on the far left, in-game options in the middle, and inventory (if any) on the far right. The main benefit is that the *World of Warcraft* style of skill-bar is an industry standard, as *World of Warcraft* has 11.5 million subscribers worldwide (Blizzard Entertainment, 2008). The main drawback is that to incorporate the *World of Warcraft* style of skill selection, we need to also implement a skill book, complete with all available affordances to the player, and allow the player to select from these and customize the skill-bar. This requires some skills to be more than one menu-level deep, as we cannot fit all of the anticipated skills on one menu page.

Defense of the Ancients. *Defense of the Ancients (DotA)*[9] is a mod, or custom scenario, of Warcraft 3:

[8] World of Warcraft (2004), published by Blizzard Entertainment

[9] Defense of the Ancients (DotA) (2005), created by IceFrog as a custom scenario for Warcraft 3: The Frozen Throne

The Frozen Throne[10]. DotA is a multi-player real-time strategy game; the player selects or is assigned a hero character with four abilities. The object of the game is to cooperate with teammates to destroy the opponent's team base. Figure 3 shows a snapshot of the skill-bar in DotA. On the left-hand side of the skill-bar, the player has six inventory slots for items and potions. On the right-hand side, the player has four generic actions (move, stop, hold position, and attack) on the top line; the patrol action, and a stats modifier (purchased as a skill) on the second line; and the four character-specific actions on the third line. The player's character is a hero with several abilities, which are unlocked one at a time as the character gains levels. At each of the character's level-ups, the player can choose whether to make an existing skill stronger or whether to unlock one of the new skills. Each hero in the game has four abilities, one of which cannot be unlocked until the character reaches level 6. At the first level, the player selects one of the four abilities as the starting ability. When the character levels up, the player receives a skill point that can be spent on one of the abilities already unlocked, to make the ability more effective, up to a cap associated with the character's level. Alternately, the skill point can be used to unlock a new skill. The main benefit to using the *DotA*-style skill-bar is that it is minimal. The main drawback is that it encourages specialization. The player is forced to choose a few favorite skills and bring them to a level of expertise. This is contrary to the goals of The Prepared Partner, which include exposing the player to as many different skills as possible. For this reason, the *DotA*-style skill selection was not incorporated.

Figure 3. The skill-bar in *Defense of the Ancients (DotA)*

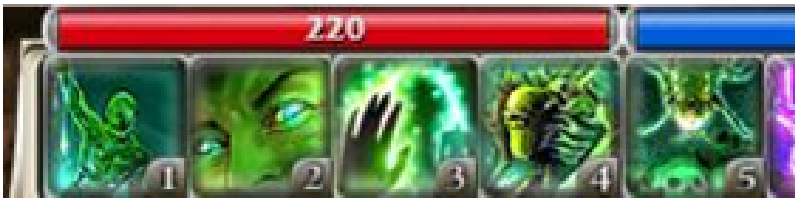

Figure 4. The skill-bar in *Guild Wars*

Guild Wars. *Guild Wars*[11] is a massively multiplayer online game, similar to *World of Warcraft* in theme. The player's character levels up by completing quests and engaging in player-versus-player combat. At the start of each mission, the player can choose up to eight skills from a list of all available skills. The chosen skills are placed on the skill-bar at the bottom of the screen. There is some strategy in choosing the subset of skills from the entire skill set: the player must think ahead about the mission and make educated guesses about which skills will prove useful both to herself and to her teammates. Figure 4 shows a snapshot of the skill-bar in *Guild Wars*. Seven of the eight skill slots are occupied by skills. Above the skill-bar, the player's health (red) and mana (blue) are shown. The main benefit to the *Guild Wars* style of skill selection is it forces the player to consider the available skills and options, recognize their effects, and make a prediction about what will work in the future. However, one of the goals of The Prepared Partner is to emphasize that labor is a highly variable and unpredictable process. It is difficult to predict which skills and actions will be helpful. Moreover, as with the *World of Warcraft* style of skill-bar, it is tempting to the player to continue reusing the same skills which worked well once, and hope for positive results again and again, thus restricting exposure to different actions.

First Prototype and Initial Feedback

The Prepared Partner was developed in Macromedia Flash — it requires Macromedia Flash Player 9 or higher to play. Flash was chosen for ease of distribution over the Internet.

For initial design decisions, members of the childbirth community, including doulas, midwives, and childbirth educators, were contacted for their comments. These childbirth professionals provided preliminary feedback on the theme of the system and suggested references for birth-related affordances, or actions that the player should be allowed during game-play. A list of around 50 affordances and their effects on labor was compiled from various sources (Simkin, 2008; Simkin & Ancheta, 2005;

[10] Warcraft 3: The Frozen Throne (2003), published in North America by Blizzard Entertainment

[11] Guild Wars (2005), published by NCsoft

Simkin & Bolding, 2004). Two pharmacological pain relief methods were included: narcotics and the epidural.

A low-fidelity prototype was created and presented to a panel of three video game experts. All three panelists were male members of a nationally-ranked video game team. In the first variant, there was one woman in a hospital room in labor. The player interacted with both the character and the environment around her to help her through her labor. Each centimeter of the character's dilation, up to ten, was one level in the game. The *Guild Wars* style of skill selection was introduced, in which the player selected a set of skills from a menu of around 50 actions. Figure 5 shows the initial concept for the game, and Figure 6 shows the skill selection prototype for the birth trainer video game. Possible actions in the skill selection menu included "Put on CD," "Ask for drugs," "Offer Gatorade," and "Toggle blinds."

The panelists provided feedback related to game mechanics: the main concerns were about user involvement and about the game's challenge. It is likely that labor, especially early labor, progresses slowly; watching one woman in labor is boring for a player, and increases the chance of negatively impacting the progress of in-game labor by offering to help when no help is necessary. The panel proposed to increase the number of women. The panelists agreed that the skill selection method guarantees that the players finds an action or a set of actions that works well for one stage of labor, and continues to select that action for subsequent stages. This mechanic limits the exposure to non-pharmacological methods to help the woman. Because one of the goals of the game was to introduce the player to as many ways as possible to help a woman in labor, the panel proposed to change the way the actions were presented to the user. We altered the design based on the panel's suggested changes.

Refinement of Concept

The next iteration of the concept involved five more women in labor (bringing the total to six), and a more abstract view of the labor process. In this refined prototype, there were six women characters in labor. One of the game's goals as a teaching aid is to expose the player to many different labor scenarios. We thought that seeing six different labors unfolding simultaneously was beneficial to the player, both in terms of challenge and interest. We discuss in a later section the problem with portraying multiple spontaneous laboring women, and how we resolved the issue in a later prototype. Figure 7 shows the concept art for the game prototype. Each character's overall well-being, or hit points, were visible overhead; the cervical dilation was shown as a number in the center of the character; the feet moved to indicate a sense of rhythm and well-being; when an action was applied to the character, the effect of the action was displayed as a buff or debuff below the hit-point bar. The player's avatar

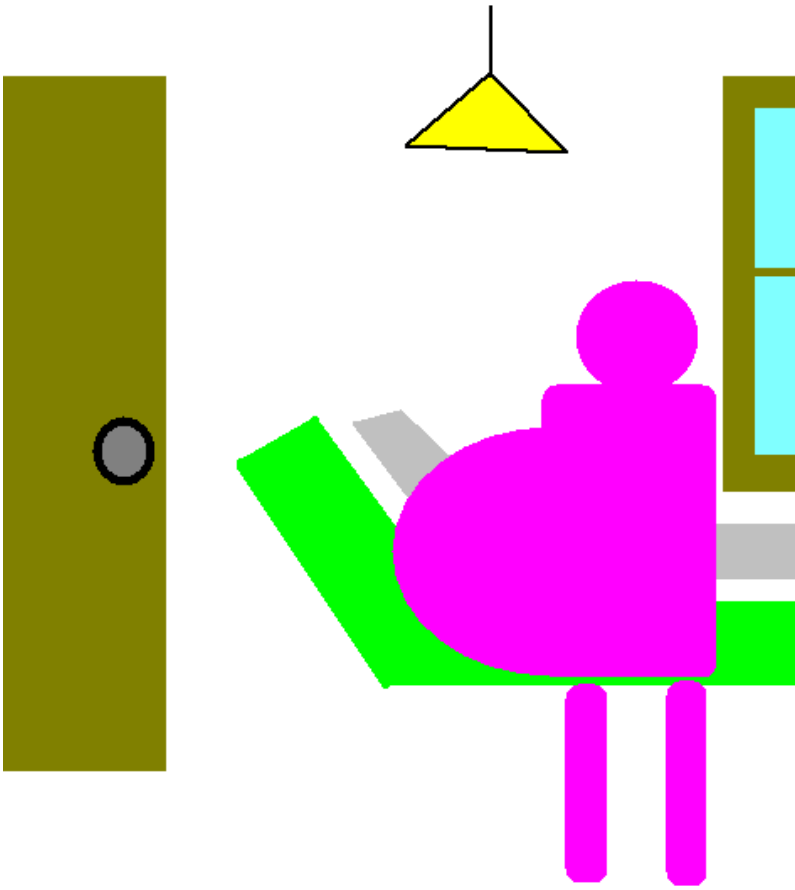

Figure 5. Initial concept

had to run between the characters to provide support as needed. The skill-bar was changed to a deck-of-actions mechanic. Action cards, dealt at random, fill each of the slots of the action deck, and the deck is re-shuffled when empty. Once an action is used, it is discarded and a new action is dealt. This deck-of-actions mechanic forces the player to see and use many different actions. The player is unable to rely on a single fix-all action or a rule of thumb; instead, improvisation and trial and error are needed to be successful in the game. In-game improvisation is supported by our focus of rapidly introducing many different ways to help a woman in labor.

Model of a Laboring Woman. A key component of The Prepared Partner design was characterizing a woman in labor using a simple model. The model was designed through conversations with mothers who had delivered babies, then simplified and condensed through several iterations of user testing.

As far as we know, no mathematical model nor video game has ever attempted to simulate a woman through

Figure 6. *Guild Wars* style skill selection prototype

the stages of labor. Thus, we created a simple model as a starting point for our work. Rounds of user testing showed that the model was simple yet effective, so modification from its original design was needed.

What characterizes a woman in labor? Is it a delicate hormonal balance between endorphins, oxytocin, and adrenaline? Oxytocin, the "love hormone," has been known to elicit pleasurable responses in women in labor (Buckley, 2002). A woman in labor may experience fear, anxiety, and pain, but given the right circumstances, can feel relief, satisfaction, calmness, and energy (Abbasi, Ghazi, Barlow-Harrison, Sheikhvatan, & Mohammadyari, 2009).

We decided to take a basic approach, and defined the woman as being governed by three axes: the amount of energy she has, her physical comfort, and her mental well-being. We translated the three axes into the following game mechanics.

Energy. This mechanic refers to the character's physical energy. It is influenced positively by food, drink, and rest, and negatively by physical activity, such as moving around. The player can directly affect the character's hit points by suggesting she perform these actions.

Physical Support. The character's physical support characteristic is directly affected by physical actions. Physical support refers to support of her body needs. The player can directly affect the character's hit points by making her feel physically supported. Examples of actions that have influence on physical support are massage, touch, and hydrotherapy (e.g., shower or bath tub).

Cognitive Support. This metric refers to the character's mental state. Social support such as conversation falls in this category, as do distraction and mental focus. When the player suggests the character visualize or chant, her hit points increase as long as she keeps her concentration.

Strength of Contractions. In labor, the strength of contractions is expected to increase as labor progresses. There are actions that modify the strength of the contractions. Getting up, walking, sitting on the birth ball, and smooching all strengthen the contractions and help the labor progress. The player can suggest these actions to the character.

Dilation. In the first stage of labor, the cervical dilation is expected to increase to 10cm, after which point the character enters the second, or pushing, stage of labor. Dilation is affected by strength of contractions: a certain strength is needed at each phase of labor in order for dilation to increase.

Hit Points. Overall well-being or emotional state is modeled as a combination of energy, physical support, cognitive support, and the strength of contractions. The maximum hit points for the character are when energy, physical support, and cognitive support are at a maximum, and the strength of contractions is at its minimum.

Pain. We modeled pain as a combination of negative physical support and negative cognitive support, as research suggests that pain is a subjective experience influenced by environment and mental state (Simkin & Bolding, 2004; Petrovic, Petersson, Ghatan, Stone-Elander, & Ingvar, 2000). Actions whose effects were to decrease the feelings of pain (e.g., immersion in a large tub) increased both physical support and cognitive support.

Prototyping and Early Feedback

A low-fidelity working (playable) prototype was created in Macromedia Flash and presented to a panel of graduate students in the game design program. Due to the medium selected, there was no need for an avatar; hence, the player's avatar was removed. A graphics artist was recruited to create art for the skills action cards. Figure 8 shows a screenshot of the first playable game prototype. As in the low-fidelity prototype, the six women characters were in labor, and their well-being meters

were seen overhead. Each woman character's cervical dilation was shown by an orange circle in the middle of their yellow avatars. Here, a the corresponding centimeter number was also shown for debugging. At the bottom of the screen, five action cards were shown, each action card representing one coping mechanism. Action cards had the following inherent properties.

Success rate The success rate, gleaned from literature on natural coping mechanisms during labor (Simkin & Bolding, 2004), was a percentage chance the action has an effect on the character.

Effect duration The effect duration determined how long the action will have an effect on the character. It was important to distinguish between effects that help for a long amount of time, such as immersion in a tub, and effects that help for only a brief amount of time, such as chewing on ice chips.

Effect rate The effect rate determined how quickly the action affects the character. For example, if one can fall asleep, the effects of sleeping are quick to replenish lost energy; on the other hand, sipping water may take a longer time to replenish the same amount of energy.

Cool down If an action is locked to the action bar (i.e., it cannot be discarded), a cool-down timer was be used to prevent the action from being re-used immediately.

Descriptives The action's name, description, and pros and cons were encoded, to be displayed as information to the player in a later iteration of the game prototype.

Effect matrix Each action had a matrix of effects. It was necessary to show that the actions could have different effects in different stages of labor. For example, immersion in a large tub late in labor is beneficial for reducing the experience of pain while speeding up labor (intensifying the contractions), yet early in labor it has the effect of slowing down and weakening contractions. Counting breaths late in labor is good for mental focus, yet too early in labor it may make a woman feel discouraged and tired.

In addition, a global cool-down was implemented for each action slot to prevent players from suggesting actions too quickly.

Characters that had successfully delivered a baby before the hit points reached zero were shown as blue circles; those that were unable to deliver a baby were removed from the screen. Dilation increased in random steps for each character.

The graduate student panel watched an iteration of the game and suggested changes related to the information displayed.

Feature Implementation and Intermediate Feedback

In the second design prototype (see Figure 9), we added a mechanic for discarding and locking. The trash can, seen at the right of the action cards, was a way to deal out up to five new action cards from the deck of actions. Sometimes the actions dealt do not correspond well with the women in labor, and it is therefore preferable to remove all of the actions and hope for more appropriate ones. The lock, seen below each action card, was a way to exempt up to two of the action cards from being discarded. In this way, if the player found that a particular action worked well for several of the characters in labor, the player can lock the action and re-apply it to each of the characters.

Each of the women characters was given a random name upon invocation of the game to increase affinity.

Tool tips were added for each action card, displaying on mouse-over the action name, description, pros of suggesting or using the action, and cons of using the action. Additional tool tips were added for each of the characters in labor. For example, for the action "massage shoulders," the following were the informational attributes.

Description Massage her shoulders gently.

Pros Massage can provide pain relief and psychological support.

Cons When more concentration is required, touch can be a distraction.

Debugging information about the hit point bar was added in the form of pie charts for each of the women characters' energy, physical support, cognitive support, and strength of contractions; corresponding arrows for each of the four mechanics were added beneath each action. An up-arrow signified that the mechanic increases over time as a result of suggesting or using the action; a down-arrow meant that the mechanic decreases. each character received a name plate beneath the avatar; a status bar was added for status messages, such as when an action is successful; a status window was added as a running log of all actions that had been used, successfully or otherwise. Figure 10 shows a snapshot of the game after these changes were made.

Visual Elements Study

We ran a small online study about the visual elements using the third prototype of the system, shown in Figure 10. The purpose of the study was to find the optimal visual element for displaying key information from the

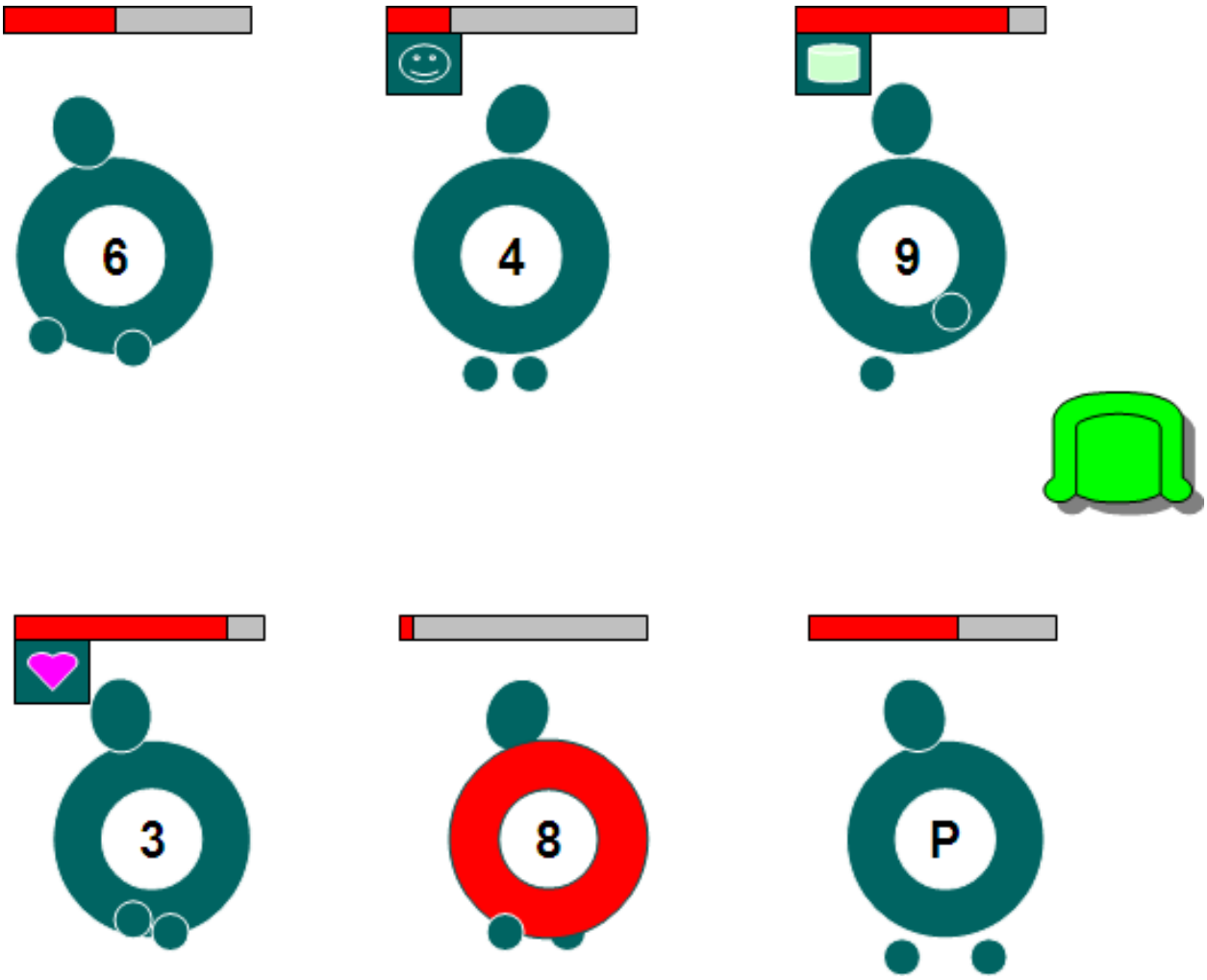

Figure 7. Concept (low-fidelity art) for the game prototype

game. The visual elements under test were the tool tip, status bar, status window, and pop-up window. Although the survey gave significant results, the real benefit to the survey was in analysis of the write-in comments. Of the 12 participants, nine provided insightful comments about the game mechanic. Seven were confused about the pie charts left in for debugging. Two suggested a tutorial. Two mentioned that the lock was never used. Two said the game went too fast.

We redesigned the game based on the survey results. Five of the six women were removed from the game, the game was slowed down, and the focus turned back to one woman. The pie charts, which were used just for debugging in the third prototype, were expanded to be functional units in the game mechanic. To make the game more challenging, the number of action cards dealt was reduced to three. Three choices are known to be as good as, if not better than, two or four choices (Straton & Catts, 1980). Figure 11 shows a snapshot of the redesigned game.

Final Prototype

For the final prototype, we consulted a number of resources about learning games to formalize the game mechanics for The Prepared Partner.

Garris, et al., present the input-process-outcome game model (Garris, Ahlers, & Driskell, 2002). In this model, the input is the instructional content together with the game characteristics. The process or game cycle involves the player's judgements and behavior interacting with the system. Finally, after a post-game debriefing, learning outcomes can be measured. In the ideal circumstances, the game cycle is self-propelling: the player is sufficiently interested in the game that repetitive play occurs. The debriefing was missing from the game, and was

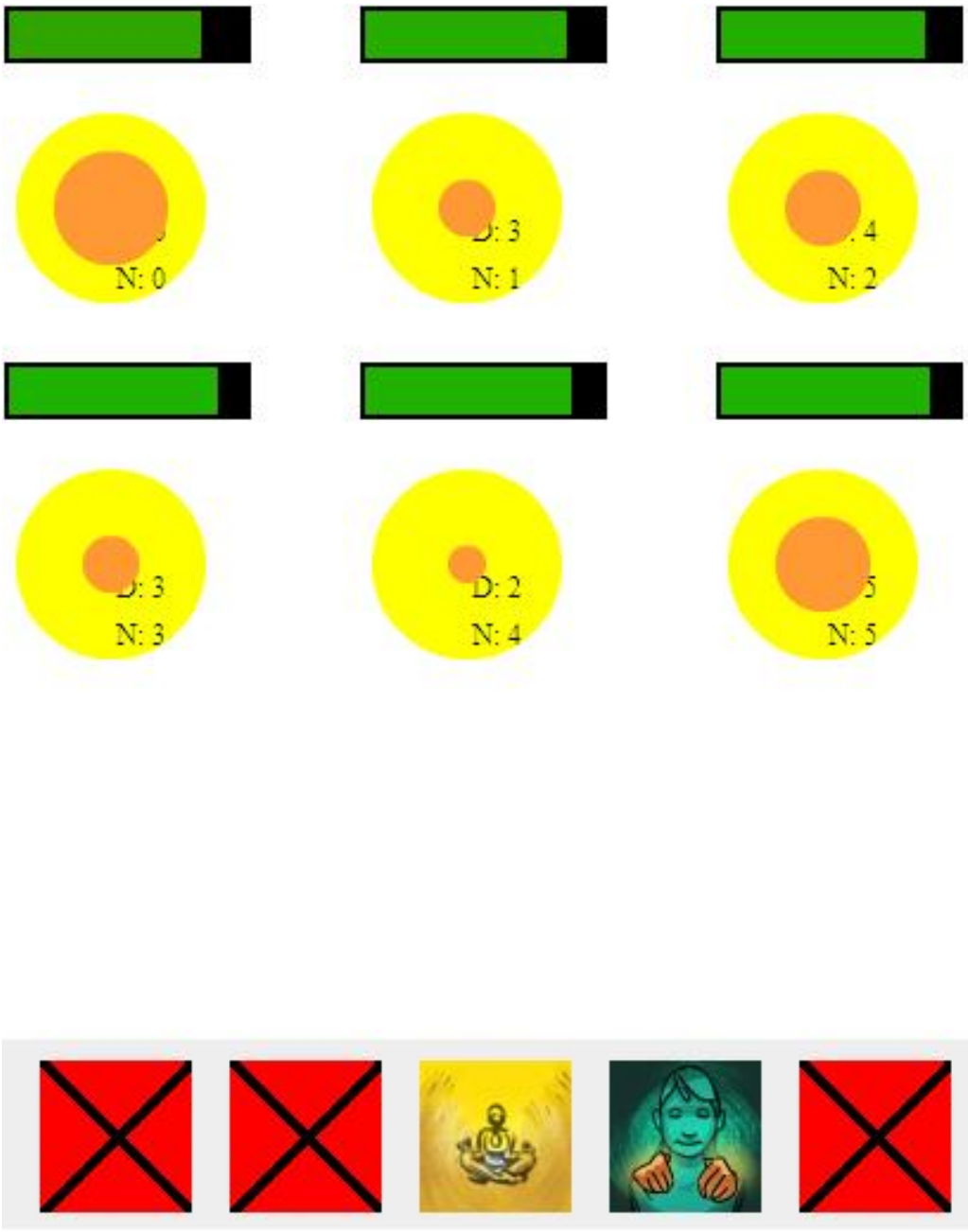

Figure 8. Initial snapshot from first game prototype

added after expert evaluations (described in a later section). Learning outcomes include skill-based outcomes, cognitive outcomes, and affective outcomes. Skill-based outcomes were not applicable to The Prepared Partner as no skill was involved in game-play. Cognitive outcomes include declarative, procedural, and strategic learning. Declarative knowledge is a recitation of facts; procedural knowledge involves an application of rules; with strategic knowledge, inferences and applications to the real world are produced. Finally, affective learning outcomes include feelings of confidence, self-efficacy, and changes in attitude and preferences. For The Prepared Partner, we were measuring cognitive learning by pre- and post-test and affective changes by survey.

Chung proposes game design variables for the game cycle and the learning outcomes described above. These

Figure 9. Snapshot from the second design prototype

variables are feedback, instruction, in-game assessment, core mechanics, and motivation, and outcome variables (Chung, 2009).

Feedback The feedback variables include timing and precision. These were not present in The Prepared Partner as the game is not a skill game.

Instruction and core mechanics The instruction variables include game mechanics, conceptual understanding of game contents, and procedural instruction. Because instructional content was, in effect, the game characteristics — that is, the game's theme was tied very closely with the educational content, rather than injecting the content into a sec-

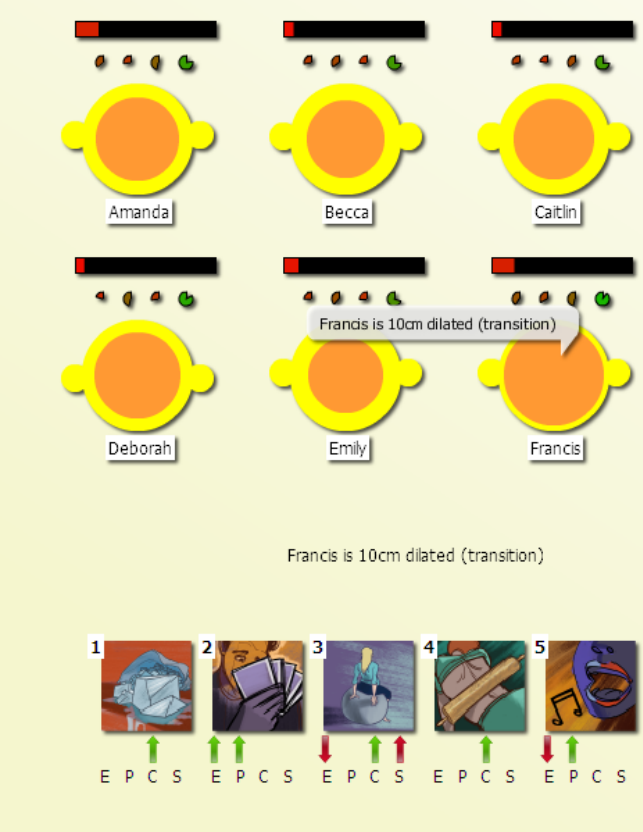

Figure 10. Snapshot of prototype used in visual elements study

ondary theme — the instructional mechanic and core mechanics of The Prepared Partner were the same set of variables. These included both cervical dilation and application of actions.

Motivation The motivation for playing is the "bling" — in the case of The Prepared Partner, it was the graphics. We added animation to indicate to the user when an action was affecting the energy, physical support, cognitive support, and strength of contractions; we also added a pair of scissors to cut the umbilical cord after the baby's arrival. However, this was later found to be insufficient motivation, and more effects were added.

In-game assessment The in-game assessment variables include scoring and performance sensing. The third prototype was missing this important component of game design. A scoring system (explained below) was added. Performance metrics were included to report the results from the game-play to the researcher.

Outcome variables The outcome variables help the researcher to verify if learning occurred as a result of playing the game. In The Prepared Partner, the outcome variables were skills, score, duration of play, and student perception of the game as a learning tool.

The new scoring system added points whenever the dilation of the character's cervix increased by any small fraction. This gave forward motivation to allow labor to progress. Additional points were awarded for successfully using skills, and points were added for each increase of the individual components of energy, physical support, cognitive support, and strength of contractions. Finally, a successful birth (the game's winning state) gave a score bonus, whereas if the character was taken by the doctor, no bonus was awarded. The health, or hit points, were the direct sum of the energy, physical support, cognitive support, and the inverse of the contraction strength. Finally, we added a short tutorial to help users start the game easily.

With the final prototype shown in Figure 11, we conducted a set of heuristic evaluations.

Heuristic Evaluation

A heuristic evaluation is an expert evaluation of the system under test. We recruited five usability experts to conduct heuristic evaluations. A set of heuristics specifically designed for games and their playability was used (Desurvire, Caplan, & Toth, 2004). The categories under evaluation were game play, game story, mechanics, and usability. Severity ratings were used as in Nielsen's heuristics method (Nielsen, 1994). The minimum rating was 0, and the maximum rating was 4. The heuristic evaluation found a total of 73 issues, of which 15 (20%) were major or critical. Several of the issues found were caused by one or more design flaws; hence, the number of issues does not correspond directly to the changes made in the system.

The types of issues found, and several examples from each category, are included below.

Game Play The guidelines governing the goals of the game, scoring and challenges, the conditions for winning the game, and initial experiences were in the game play category. First, evaluators found that there was no ability to customize the game experience nor power-ups in the game allowing the player's skill to increase in proportion to the game's increasing difficulty. We did not address this issue as we felt the player's skill, not the skill's power, should increase from exposure to different methods with which to help the character in labor. Next, evaluators found the game to be easy to learn, but also too easy to master. We later tuned the game variables to quicken game play later in

the game, yet leave the slow pace earlier in the game.

Game Story The player's involvement in the game is assessed in the game story category. First, a threat-to-reward imbalance was found, as evaluators were unclear what a winning condition was, and how well their progress throughout the game translated into final game statistics. To address this, we added warning messages, hinting about how to make progress in the game. These warning messages were only displayed after several seconds of cervical or health inactivity. Additionally, a congratulatory reward screen at the end of the game, listing the player's accomplishments, score, and in-game contributions, was added. We considered this part of an in-game debriefing, with the post-test making up the other part. A lack of immersion was cited; to address this, we recruited a voice actress and added in-game sounds, as sounds make a game more immersive (Garris et al., 2002). For the sounds, the name of the action was read aloud upon mouse-over. Additionally, a vocalized response to an application of each action was added We added a chance of failure of applying or suggesting each action to the character in labor based on real-world failure rates of non-pharmacological techniques for labor (Simkin & Bolding, 2004). Unsuccessful actions produced one type of sound effect (e.g., "I do not want that"), a decrease in score, and a lack of positive feedback. Successful actions, however, produced positive vocal feedback (e.g., "Oooh, that feels nice"), and increased the score. Several new visual effects were included, such as filling the screen with water when the character entered in the bath tub or shower, and darkening the screen when the *dim lights* action was used. Next, evaluators said the strategy was difficult to determine, as initially, experimentation with the different actions is required until the underlying mechanic was gleaned from system feedback. We did not address this issue because we felt it to be more realistic. It is impossible to determine in advance which actions will help a woman in labor, and which will have a negative effect. The evaluators' response to this heuristic indicates we succeeded in incorporateing uncertainty into the game.

Mechanics The physical controls of the game, the ease of use of the game, and the game's underlying mechanics were assessed in the mechanics category. The heuristic calling for appropriate feedback to the user scored highly; as above, we added sound and additional visual assets to the game.

Usability The player's experience was evaluated with respect to usability. Usability included any menus, help screens or manuals, system feedback, artistic elements, and general ease of use and interaction. Pause, game on, and game off capabilities were not implemented at the time of evaluation. The only way to stop the game was to close the Flash window; restarting the game was accomplished by reloading the Flash file. In response, we implemented a replay option, but did not add pausing capabilities because we wanted to mimic a real-life labor experience in which pausing is not an option. We added a splash screen with a large *Play* button to make the only available option very clear when starting the game. No other menus were implemented as there were no options in the game.

After the changes were made in response to the heuristic evaluations, formal user testing was conducted.

Final System

The final system had undergone several rounds of changes.

The Prepared Partner was developed in Macromedia Flash. The game had a fifteen- to thirty-minute target play duration, in which the player assisted a woman through the stages of labor by performing supportive actions, such as massage, visualization, and hydrotherapy. The actions were presented to the player in the form of three action cards at a time from a deck of approximately 50 single-use actions. When the deck was exhausted, it was re-shuffled and dealing resumed.

Figure 11 shows a snapshot of the final version of the game which was tested by users. In the snapshot, Amanda's cervix is 4cm dilated. The player has just used the *aromatherapy* action; as it was successful, it appears to the right of Amanda. Amanda's positive emotional reaction to the aromatherapy is seen as an increase in cognitive support; aromatherapy is known to increase the contraction strength, which is modeled in the game. Finally, Amanda's physical support is decreasing, probably because of an aversion to smells in active labor (Simkin & Bolding, 2004).

Later in the game, during transition, the most intense but the shortest part of labor, the player helps Amanda immerse in a bath tub, as shown in Figure 12.

Amanda's health is displayed as a green number. The health represents her overall well-being. The player's cumulative score is shown to Amanda's right. On the far right of the screen, a running log of actions and their effects is shown. Although the log is unlikely to be referenced during game-play, it can be valuable as a "birth story" reference for the player after the game is over. The three single-use action cards, each representing a way to help Amanda through her labor experience, are shown below Amanda. As before, the winning condition

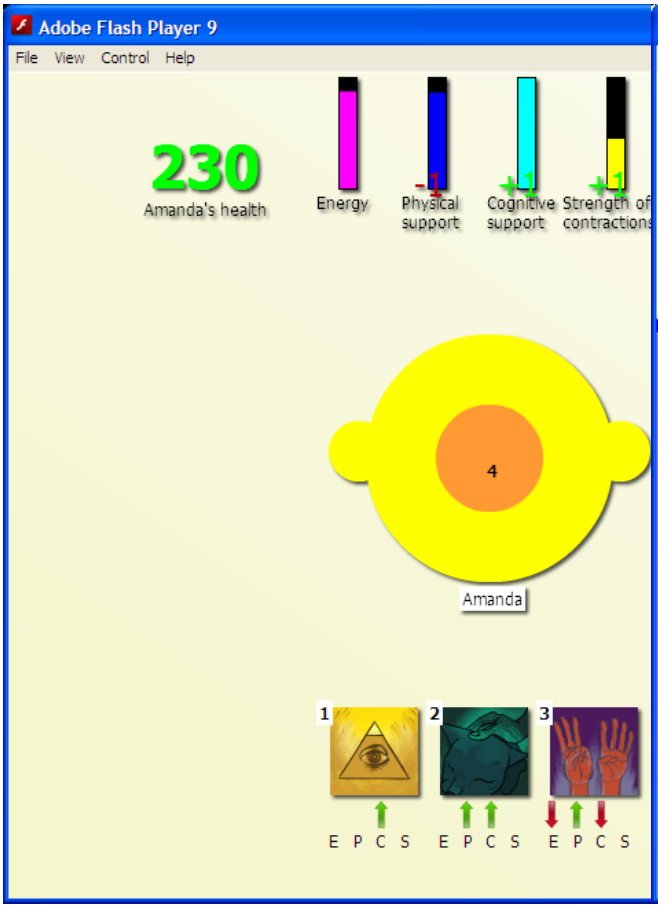

Figure 11. The Prepared Partner snapshot: Amanda is experiencing aromatherapy during active labor

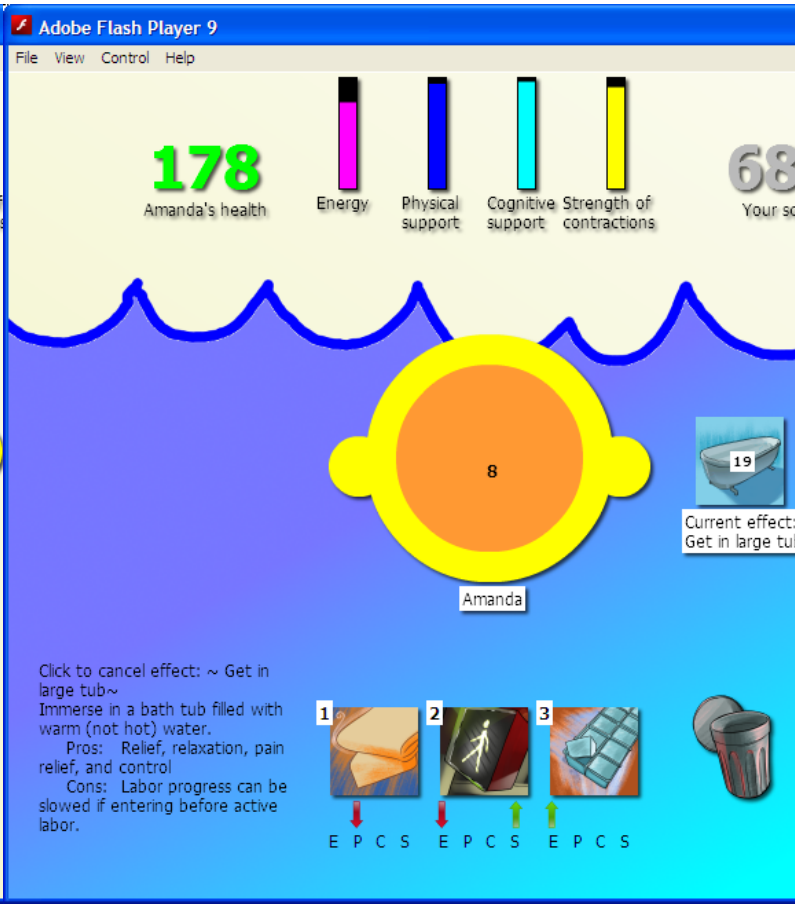

Figure 12. The Prepared Partner snapshot: Amanda is immersed in the bath tub during transition

is when Amanda has delivered her baby naturally or by c-section; this condition triggers post-game debriefing, including the number of successful and unsuccessful actions, score, time spent in each stage of labor, and other game metrics.

Pilot Study

In order to assess the refined system, we recruited seven participants from a liberal-arts college for a pilot study. All participants were females between the ages of 19 and 26 years old. The results of the pilot study were positive: on average, participants scored higher on a post-test than on a pre-test about labor and childbirth. Additionally, the participants answered positively to survey questions about feelings of learning, enjoyability, engagement, and fun. Quantitative data (scores on the pre-test and post-test) supported the qualitative data (survey answer about learning). Because of the positive outcome of the pilot study, a full study was conducted.

Full Study

The full study was conducted remotely, over the Internet. In the full study, participants filled out a demographics questionnaire, completed a pre-test, played The Prepared Partner, completed a post-test, and filled out a survey about their experiences. Participants were recruited for the study by e-mail announcement, through social networking sites, with online communication aids, and through a video game online community. Estimated time from beginning to end of the study was 30 to 45 minutes. Although 88 of the self-selected participants began the survey, only 51 completed the pre-test, played the game, and completed the post-test and exit survey. Because of the nature of the advertisement for the study, 80% of the participants were males with a mean age of 30. Most (51%) of the participants said they played video games daily for at least an hour each day. The large sample of male participants was not a problem because The Prepared Partner has a target audience of future birth partners, of which most are male. Moreover, we felt the

prevalence of video gamers added a more critical participant set of our video game.

The Prepared Partner as a game. A total of 122 games were played in the full study of the learning assessment. Of the 122 games, the players used an average of 20 actions per game to help the character in labor. Actions included massage, hydrotherapy (immersion in the tub or shower), distraction, visualization, and position change. The game afforded around 50 unique actions. The average game score was over 11000. Only five game births (less than 5%) were by c-section, whereas the average c-section rate in the US is over 30% (Hamilton, Martin, Ventura, et al., 2007). This may indicate one of the following. Either the game was perceived as too easy, and the game metrics need fine-tuning to increase the difficulty of delivering a baby normally, or the game shows that helping a woman through the stages of labor greatly decreases her risk of c-section. The latter explanation is corroborated by research; Klaus, et al. found that having a doula, or a woman in a role of professional support for the woman in labor, can decrease the c-section rate by up to 50% (Klaus et al., 2002).

Did The Prepared Partner teach about labor and childbirth?. To investigate whether The Prepared Partner was effective as a learning aid, we compared participants' pre-test and post-test scores. The pre-test and post-test questions were either identical, or of similar difficulty and subject matter. Paired samples t-test was used to analyze the difference in pre- and post-test scores. Across 52 subjects, mean test scores rose 28 to 29 points — the equivalent to 5 or 6 correct answers — after playing The Prepared Partner ($p < 0.01$). The change in scores is a result of playing The Prepared Partner. We investigated the participants' subjective (perceived) learning experience with survey questions presented after the post-test. We analyzed the results with chi-square; the following significant results were observed.

Learning experience

- 85% agreed: I had a positive overall learning experience. ($p < 0.001$)
- 68% agreed: I feel more prepared for childbirth than before participating in this study. ($p < 0.05$)
- 88% agreed: I feel I learned about labor and childbirth by participating in this study. ($p < 0.001$)
- 78% agreed: I feel I learned five natural ways to help a woman in labor. ($p = 0.001$)

Learning was supported in both quantitative (test results) and qualitative (survey answers) data. In particular, participants answered at least 5 more questions correctly on the post-test than the pre-test, and also answered that they felt they learned 5 more different ways to help a woman in labor, in addition to feeling generally more prepared for labor.

Was The Prepared Partner fun?. We investigated the participants' playing experience with survey questions presented after the post-test. Analysis with chi-square showed how the majority of participants rated the following phrases.

Playing experience

- 83% agreed: I had a positive overall playing experience. ($p < 0.001$)
- 43% disagreed: The game went too fast. ($p < 0.01$)
- 76% agreed: The goals of the game were clear. ($p = 0.001$)
- 83% agreed: I found The Prepared Partner interesting. ($p < 0.001$)
- 71% agreed: The Prepared Partner is enjoyable to replay. ($p < 0.01$)
- 85% agreed: I was engaged in playing The Prepared Partner. ($p < 0.001$)
- 80% agreed: I found The Prepared Partner enjoyable and fun. ($p < 0.001$)
- 78% agreed: I would recommend this game to my friends, if they were expecting a baby. ($p < 0.001$)

As a playing experience, the game was seen as interesting, replayable, and engaging. An overwhelming majority of participants said they had fun playing The Prepared Partner, and most would recommend the game to friends.

Analysis of variance showed an overwhelming number of positive responses to all survey items by participants of either gender ($p < 0.001$).

Conclusion

We presented the evolution of the system design of The Prepared Partner, an educational video game about labor and childbirth. In the game, we implemented a novel approach to modeling a woman in labor, and a game model for actions taken to help her through her labor. The Prepared Partner is the first game of its kind. Although the models The Prepared Partner uses to simulate a woman through the stages of labor are simple, our learning assessment and other studies show the methods are effective in teaching players about the stages of labor and natural ways to help a woman in labor. The game presents about 50 natural ways to help a woman in labor, and allows the player to explore these different options by trying them on the simulated woman in labor.

Designers of educational games should be aware that the design-development cycle needs to accommodate ample time and opportunity for interdisciplinary collaboration. Initial prototyping, refinement of the concept, continued prototyping, feature implementation, the final prototype, and the final system are parts of the design process, but they are incomplete without intermediate feedback from all disciplines at all stages. Domain literature search, background research, and intermediate feedback, both formal and informal, are critical in mak-

ing an educational game. We showed the evolution of the user-centered game design of The Prepared Partner. Numerous studies contributed to the final version of the system, including a visual elements study, heuristic evaluation with expert usability evaluators, a pilot study, and an assessment for learning.

When designing serious games, it is critical to iteratively re-evaluate and re-design the system to suit user demands, even if it means the underlying game must be re-designed at several points in the design-development cycle.

The overwhelming majority of positive survey responses spoke to the success of The Prepared Partner as an interesting, enjoyable, replayable, and fun learning aid for those interested in labor and childbirth. The Prepared Partner encourages learning through an engaging, interactive interface designed through tight, interdisciplinary collaboration. We attribute its success to the close ties we had to childbirth professionals and usability and game design experts during all stages of design and development of The Prepared Partner.

Future Work

Future work on The Prepared Partner includes further improving the game, including modifying the game mechanics for more realistic pacing, and changing the user interface to present the player with a greater ability to select actions. We plan to conduct another study with these changes. We are recruiting more men to play The Prepared Partner, because literature indicates that birth partners and expectant fathers require more support in labor and childbirth than was previously assumed (Hallgren, Kilhgren, Forslin, & Norberg, 1999).

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