Interactive Pedagogical Drama for Health Interventions

Stacy C. Marsella, W. Lewis Johnson & Catherine M. LaBore
Center for Advanced Research in Technology for Education (CARTE)
USC / Information Sciences Institute
4676 Admiralty Way, Marina del Rey, CA 90292 USA
marsella@isi.edu

Abstract. The goal of Interactive Pedagogical Drama (IPD) is to exploit the edifying power of story while promoting active learning. An IPD immerses the learner in an engaging, evocative story where she interacts with realistic characters. The learner makes decisions or takes actions on behalf of a character in the story, and sees the consequences of her decisions. The story's characters are realized by autonomous agents. We discuss IPD in the context of Carmen's Bright IDEAS (CBI), a multimedia title designed to teach problem solving skills to mother's of pediatric cancer patients. CBI was an exploratory arm of a clinical trial and here we discuss key creative and technical aspects of the design and results from that arm.

Topics: Pedagogical Drama; Virtual Learning Environments
SubTopics: Agent-based virtual characters; Health Interventions

The use of drama as a pedagogical tool is a constant across cultures and throughout history. In *Poetics*, Aristotle argued over two millennia ago that learning and drama are interwoven: that drama is an imitation of life and humans learn through enjoyment of that imitation. More recently, research in psychology has argued that narrative is central to how we understand the world and communicate that understanding [1]. And of course, the engrossing, motivational nature of story is unmistakable; the world now consumes stories in various media with a "ravenous hunger" [10].

Yet stories can also have a drawback from a learning perspective: they typically place the learner in the role of passive audience instead of active learner. The goal of Interactive Pedagogical Drama (IPD) is to exploit the edifying power of story while promoting active learning. An IPD immerses the learner in an engaging, evocative story where she interacts openly with realistic characters. The learner makes decisions or takes actions on behalf of a character in the story, and sees the consequences of her decisions. The learner identifies with and assumes responsibility for the characters in the story, while the control afforded to the learner enhances intrinsic motivation [7]. Since the IPD framework allows for stories with multiple interacting characters, learning can be embedded in a social context [17]. We take a very wide view of the potential applications of interactive story and IPD in particular. We envision interactive story as a means to teach social skills, to teach math and science, to further individual development, to provide health interventions, etc.

In creating an IPD, the demands of creating a good story, achieving pedagogical goals and allowing user control, while maintaining high artistic standards, must all be balanced. To ensure a good story, dramatic tension, pacing and the integrity of story and character must be maintained. Pedagogical goals require the design of a pedagogically-appropriate "gaming" space with appropriate consequences for learner choices, scaffolding to help the learner when necessary and a style of play appropriate to the learner's skill and age. To provide for learner control, an interaction framework must be developed to allow the learner's interactions to impact story and the pedagogical goals. These various demands can be in conflict, for example, pedagogically appropriate consequences can conflict with dramatic tension and learner control can impact pacing and story integrity.

We have developed an agent-based approach to interactive pedagogical drama. Our first IPD was *Carmen's Bright IDEAS* (*CBI*), an interactive, animated health intervention designed to improve the social problem-solving skills of mothers of pediatric cancer patients. Parents of children with chronic diseases are often poorly equipped to handle the multiple demands required by their ill child as well as the needs of their healthy children, spouse and work. Critical decisions must be made that affect family and work. To help train parents in the problem-solving skills required to address such challenges, *CBI* teaches a method for social problem-solving called Bright IDEAS [16]. Each letter of IDEAS refers to a separate step in the problem solving method: **I**dentify a solvable problem, **D**evelop possible solutions, **E**valuate options, **A**ct on plan and **S**ee if it worked. Prior to *CBI*, the Bright IDEAS method was taught in a series of one-on-one sessions with trained counselors, using worksheets that helped a mother detail her problems in terms of IDEAS steps. The purpose of *Carmen's Bright IDEAS* is to teach mothers how to apply the Bright IDEAS method in concrete situations. Mothers learn more on their own and at times of their own choosing, and rely less on face-to-face counseling sessions. An early version of the CBI system was first described in [12], and was subsequently further developed and tested.

Although the design of agent-based interactive drama systems is an increasingly active area of agent research [e.g., 4,9,15,18], it is also an open area of research with few fielded applications. Further, their use in pedagogical applications is far less common and raises additional challenges, especially in such a challenging application area as psychosocial intervention. *CBI* has been tested as an exploratory arm of a clinical trial of the Bright IDEAS method at seven cancer centres across the U.S. This paper describes design changes made in the course of preparing CBI for clinical trial, as well as results from its evaluation.

1. The Design of Carmen's Bright IDEAS

In our basic design for interactive pedagogical drama, there are five main components: a cast of autonomous character agents, the 2D or 3D puppets which are the physical manifestations of those agents, a director agent, a cinematographer agent, and finally the learner/user who impacts the behavior of the characters. Animated agents in the drama choose their actions autonomously but also follow directions from the learner and/or a director agent. Director and cinematographer agents manage the interactive drama's onscreen action and its presentation, respectively, so as to maintain story structure, achieve pedagogical goals, and present the dynamic story so as to achieve best dramatic effect. The design of all these agents requires both general capabilities as well as knowledge specific to the interactive drama that is being created.

Figure 1: Gina & Carmen (right)

The story for Carmen' Bright IDEAS was developed via collaboration between the authors, clinical colleagues at two of the seven sites where the Carmen was to be tested and a professional scriptwriter (Jonathan Kaplan). The story and design features of the interactive experience went through a sequence of formative evaluations with mothers at one of these sites. The story is organized into three acts. The first act reveals the back story; various problems Carmen is facing, including her son's cancer, her daughter Diana's temper tantrums, work problems, etc. The second, main, act takes place in an office, where Carmen discusses her problems with a clinical counselor, Gina, who suggests she pick a solvable problem and use Bright IDEAS to help her find solutions. See Figure 1. With Gina's help, Carmen goes through the initial steps of Bright IDEAS, applying the steps to one of her problems and then completes the remaining steps on her own. The final act reveals the outcomes of Carmen's application of Bright IDEAS.

The design goal for the overall CBI experience was to mirror, but be distinct from, the kinds of problems the learner faces. The learner was supposed to be transported into the drama away from the stress of their own problems. Whereas the emotions evoked would be strong, the transportation would make them more manageable. To realize this goal, we chose a presentational, third person experience where learners influenced Carmen but were not immersed in the drama. Characters would not directly talk to the learner about their own problems, which might be insulting or too distressing. Presentational drama would allow for psychological distancing and the freedom to explore coping strategies through Carmen. Further, it reduced interactivity demands – stressed mothers did not need to control their character moment-to-moment since it had its own motivations. The interactivity would nevertheless allow active learning, promote identification with Carmen and ideally lead to belief in the efficacy of the skills being taught. To the extent the learner explored unproductive coping strategies with Carmen, we wanted those strategies projected back into the drama where they would be dealt with.

1.1. Interaction Model

The interaction model we designed for CBI is what we call a rubber-band model. See Figure 2. Both Gina and the learner exert influence over Carmen. It is Gina's job to keep the social problem solving on track so that the story proceeds to a successful outcome by effectively responding to Carmen's cognitive and emotional state, at

Figure 2: Rubber Band Model

times motivating her through dialog to work through the steps of IDEAS on some problem or alternatively calming or reassuring her. The human mother interacts with the drama by making choices for Carmen such as what problem to work on and how she should cope with the stresses she is facing. The learner can choose alternative internal thoughts for Carmen, such as "I hope this helps with Diana." These were presented as thought balloons (see Figure 3). Both Gina's dialog moves and the learner's choices influence the cognitive and emotional state of the agent playing Carmen, which in turn impacts her behavior and dialog, perhaps in conflicting ways. In this interaction model, the Gina agent is both on-screen character and the drama's director. The Carmen agent has her own cognitive and emotional dynamics (hence rubber-band metaphor) that ensure her behavior is believable, regardless of how Gina and the learner influence her.

The combination of Gina's motivation of Carmen through dialog and the learner's emotional impact on Carmen creates tension, a tug-of-war between Gina's attempts to motivate Carmen and the initial, possibly less positive, attitudes of the Carmen/learner pair. As the learner plays a role in determining Carmen's attitudes, she assumes a relationship in this tug-of-war, including, ideally, an empathy for Carmen and her difficulties, a responsibility for the onscreen action and perhaps empathy for Gina. If

Figure 3: Thought Balloons

Gina gets Carmen to actively engage in applying the IDEAS technique with a positive attitude, then she potentially wins over the learner, giving her a positive attitude. Regardless, the learner gets a vivid demonstration of how to apply the technique.
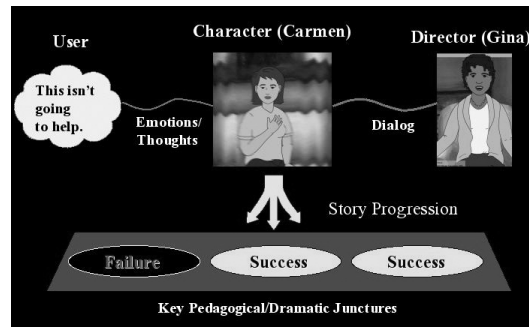
2. Agent Models

The interactivity in CBI largely centers on the main act in Gina's office, where there is a discussion of serious and disturbing problems confronting Carmen. In building agents for these characters, a central challenge was to faithfully model the emotions and coping behaviors associated with these issues and reflect them in the agent's behaviors. In addition, it was necessary to model the inherent structure of this act, the discourse strategies Gina and Carmen might use in their discussion of how to apply Bright IDEAS to those problems.

Each onscreen character is realized by an agent architecture that has goals, (discourse) strategies to realize those goals and dialog tactics that flexibly interpret those strategies allowing the agent to react in goal-directed fashion to the unexpected. The architecture is realized by a collection of modules: problem solving and dialog model how to use dialog to achieve goals, emotional appraisal models how the agent emotionally evaluates events and behavior generation arbitrates the agent's nonverbal behavior. The full details of this architecture are beyond the scope of this paper (see [11,12] and authors for more details).

The agent models and learner interaction are grounded in the research that influenced the Bright IDEAS pedagogy: cognitive appraisal models of human emotion. In appraisal models, emotions and coping responses stem from appraisal of events in terms of their significance to the individual. Appraisal leads to a characterization of a stressful event along several dimensions, including *ego-involvement*, *expectancy*, *accountability* and *coping potential*. Ego involvement concerns how an event impacts the collection of commitments, goals, concerns or values that comprise a person's ego-identity, such as self- and social-esteem. Expectancy concerns whether the situation will likely get better. Accountability is an evaluation of who is at fault. Coping potential is an evaluation of how a situation can be coped with, leading to a wide range of possible coping behaviors such as taking action to change the world, avoidance of stressful situations, trying to focus on the positive, or denial. The key to the pedagogy is to teach how to choose and carry out the right strategy for a given situation and to maintain a realistic belief in one's own efficacy.

For example, at one point Gina asks Carmen why her daughter is having tantrums. Carmen feels anxious about being judged a bad mother (ego-involvement) and the learner may choose a thought that reinforces the anxiety (e.g., by reducing expectancy). Carmen copes (problem solving) by dismissing the significance of the tantrums (dialog model): "She is just being babyish, she wants attention." Based on Carmen's dialog and emotional state, behavior generation selects relevant behaviors (e.g., fidgeting with her hands). Her dialog also feeds back to emotional appraisal. She may now feel guilty for "de-humanizing" her child and display that feeling (physical focus) and then go on to openly blame herself. Carmen can go through this sequence of interactions solely based on the flux in her emotional reaction to her own behavior. Gina, meanwhile, will emotionally appraise Carmen's seeming callousness and briefly reveal shock (e.g., by raised eyebrows), but that behavior is quickly overridden if her dialog model decides to project sympathy.

2.1. Dialog Module

The dialog module uses high-level strategies to drive the discourse through a scene. For example, the main act in CBI is Gina's goal of getting Carmen to apply IDEAS to one of her problems. Gina has an abstract strategy to do this (reassure Carmen, suggest they use IDEAS, ask her to choose a problem and guide her through the steps of IDEAS). Gina also has alternative sub-strategies that can be used to solve these steps, e.g., she can help Carmen **develop** solutions by prompting her to enumerate them, or she can help Carmen **identify** features of a problem by asking a sequence of questions.

These strategies both recapitulate the original script as well as variablize it at multiple levels, both in terms of the alternative strategies and sub-strategies that can be selected as

well as by how the strategies are interpreted. The agent realizes dialog turn-by-turn by flexibly executing the high-level strategies using a state machine built out of 12 types of dialog acts. The machine allows the agent to adapt to twists and turns in the dialog caused by the autonomy of the agents and the learner's interactions. For example, if Carmen doesn't answer a question properly, Gina may try an alternative path in the state machine to get the answer, such as reassuring Carmen and re-asking the question. In addition to acts like Ask and Answer, there are ones that are tightly coupled to emotional state and pedagogy: Reassure, Praise, Agree/Sympathize, Resign (Give-up) and Summarize.

In order to maximize expressive effect, recorded dialog of voice actors was used instead of speech synthesis. A significant amount of variability in the generated dialog is supported by breaking the recordings into meaningful individual phrases and fragments and by recording multiple variations (in content and emotional expression). Additionally, different expressive behaviors could be associated with a phrase (discussed below). There are 480 dialog fragments in the clinical trial version of CBI. The agents compose their dialog on the fly, using annotations attached to the fragments to understand each other and decide how to respond. The agents experience each fragment's annotation in order, so their internal state and appearance can be in flux over the dialog segment. Annotations include:

- Dialog content: Dialog Act, Speaker and Addressee
- Emotional content: Coping Act (e.g. denial)
- Propositional content: Main referent (e.g. Diana) & Topic (e.g., temper tantrums)

2.2. Emotional Appraisal and Behavior Generation

The emotion model in CBI has several unique features required to realize psychosocial drama that set it apart from most models of emotions used in agent systems. Emotions can stem from appraisals of the other agent's dialog; but an agent can also react emotionally to its own dialog. The expression of emotion also stems from two sources, appraisals [3] as well as the intention to communicate emotions [8,13] derived from the dialog act. Thus an agent can communicate emotions that they do not feel. The expression of emotion and nonverbal behavior is sequenced by the behavior generation module over the course of an agent's dialog fragments, beginning with an emotional expression based on the appraisal of previous dialog, followed by other nonverbal behavior (e.g., gestures) selected based on current dialog fragment and emotional state and ending with the appraisal of that fragment.

As the above tantrum example revealed, a key aspect of the emotion modeling is the agent's ego identity. Carmen's ego ideal of being a good mother, and desire to be perceived as one (social esteem) leads to her anxiety about discussing Diana's tantrums with Gina. Ego identity is modeled as a collection of role ideals (Carmen wants to be a good mother), concerns (good mothers want their children to be happy and healthy) and responsibilities (good mothers are responsible for their child's behavior). The system also models relations (Gina is a parental-surrogate for Carmen). Appraisal rules derive emotions from these various representations (e.g., an event is negative if it violates a concern; if talking about negative event which agent feels responsibility for then increase guilt).

3. Clinical Trials

The overall clinical study of Bright IDEAS, of which CBI was a smaller exploratory arm, was designed to validate the Bright IDEAS technique for teaching social problem solving skills. This larger study involved each learner interacting with a clinical research assistant (RA) once a week over the course of an 8-week intervention. This intervention involved face-to-face discussion of the mother's problems and guided instruction on how to use the Bright IDEAS technique in general and its worksheets in particular. Evaluations were done using a standard social problem solving skills instrument. In the CBI arm, the system was to

replace the standard interaction with the RA on 3 sessions, with the other 5 being the standard RA intervention. Each of these 3 sessions was supposed to involve a separate problem-solving vignette, for example, Carmen's difficulties with Diana's temper tantrums, understanding the medical treatment, and work-related issues. RAs at the various sites instructed subjects on how to use CBI, and were available to answer the subjects' questions.

System development had to accommodate the clinical trial's coordinated recruitment of mothers across the USA. Due to the tight constraints, there was insufficient content created in time to detail Carmen working through solutions to three separate problems. Only one full vignette was completed, the Diana tantrum problem. To compensate, two other modified vignettes were done, a task that was facilitated by the flexibility of the agent infrastructure. A reduced content vignette was created concerning Carmen's problems at work in which the system would at key junctures ask the learner how she would address Carmen's problems ("Can you help Carmen DEFINE solutions?") and write down these answers on Bright IDEAS worksheets. This reduced the need for more voice recording and animation, while providing more concrete experience in using Bright IDEAS. In addition, a third vignette was created, a variant of the Diana problem but with text windows popping up at key pedagogical junctures with commentary on the on-screen events in terms of Bright IDEAS concepts. For example, at a moment in which Carmen was despondent, a window would pop up, stating "Carmen CAN solve some of her problems. She needs to be more optimistic." Both of these techniques tended to break the "fourth wall" of the drama and thus opened up additional concerns and evaluation issues.

Being part of a larger study also led to other changes. Most significantly, recruitment of mothers for other arms of the larger study was behind schedule. To compensate, sites had to shift recruitment away from the Carmen arm and some sites did not run any subjects at all. For example the Children's Hospital LA (CHLA) site played a key role in the design of the system, but was then redirected to another arm of the study. This led to distributional differences between the other arms of the study and the CBI study, which made direct comparison difficult. The populations tested at each site differ along several dimensions, such as what type of cancer, the family's social-economic status, computer expertise, marital status, ethnicity and whether the mother is a native English speaker.

Twenty-six subjects started the Carmen arm, sixteen of which used CBI and completed the subsequent training sessions and post-test evaluations. The main instrument for the evaluation of CBI was a questionnaire designed by the authors that used 5-point scale items (1-5; e.g., from strong disagreement to strong agreement with "somewhat" in the middle). Key issues addressed included :

- Helpfulness in remembering the steps of Bright IDEAS (BI)
- Helpfulness in understanding how to apply BI to the learner's own problems
- Relative difficulty of Carmen's problems and her ability to cope
- Clarity, interestingness, believability of the story
- Assessment of the interactivity via thought balloons
- Assessment of interface features that were outside the drama:
    - First vignette's showing Carmen's worksheets being filled out by Carmen
    - Second vignette's stopping the story so learner could fill out worksheets
    - Third vignette 's commentary on the unfolding drama

Table 1 presents results for key questions. The mothers felt that Carmen's Bright IDEAS helped them remember the steps of Bright IDEAS and understand how to apply them to their own problems. Anecdotally, one mother commented that CBI made Bright IDEAS more concrete. They also assessed the story as believable, interesting and convincing. We believe this to be a remarkable achievement; it should not be forgotten that the learner is interacting with 2-D cartoon-like animated characters about deeply distressing problems and

the possibility of a negative reaction was *a priori* a deep concern of the developers. The mothers also tended to find the amount of interaction about right. To our surprise, they also found the elements that break the fourth wall helpful. Overall, the results were positive. Although there are a small number of subjects and the assessment is subjective, many of the results are significantly above mean. We believe this argues for the potential effectiveness of interactive drama.

Category/Question	Range	Mean	95% Confidence Level
Interactive Story			
Story Believable	2-5	4.5	.47
Conflict w/Diana Convincing	3-5	4.4	.43
3rd Vignette's commentary useful	2-5	4.0	.51
Interaction (1-too little, 3-about right, 5-too much)	2-4	3.0	.19
Pedagogical effectiveness			
CBI helped understand how to apply BI	3-5	4.3	.45
CBI helped recall of BI steps	2-5	4.1	.49
Self-Motivated (1-not, 3-somewhat, 5-very)	2-5	3.4	.58

Table 1: Results

Additionally, nine mothers said they would prefer to interact with Carmen as opposed to seeing a video (5) or reading a story (1). In an open-ended question on what they liked, mothers often stated or suggested they identified with Carmen, liked her "real" problems and said CBI helped them with their problems. We also asked for criticisms, but these tended to be muted (system "a bit slow", "lack of options in dealing with problems"). And under suggestions, mothers stated that there should be more problems for Carmen to address, often giving specific examples, and wanted an increased ability to interact on the problem solving. The RAs also filled out a questionnaire on each mother's experience. In open comments, they noted that several mothers reported identifying with Carmen or her problems, although one mother reported that Carmen should stop feeling sorry for her self. One RA commented that identification led to a more positive interaction with CBI. Thus, both instruments indicate a definite need for more tailoring. RAs also identified technical glitches. Finally, subjects were given the same instrument of the larger study designed to evaluate problem-solving skills. Analysis of this final outcome measure is still underway. We conjecture that effectiveness will depend on site and perhaps RA supervising the intervention.

4. Related Work

This work complements, but is distinct from, the work of Schank, Klein, and others on the edifying narratives of personal experience ("war stories") [14,5]. Such narratives are fundamentally non-interactive, unlike IPD. Some story-oriented learning methods (e.g., Jasper series [2]) promote active discussing and problem solving in the context of stories, but do not provide learners a way of seeing the consequences of their decisions. The goal-based scenarios of Schank [14] are closer in spirit, however IPD takes into account both the dramatic and pedagogical decisions that must be made in managing an interactive story.

There is also related work in the areas of managing interactive drama [4,9,15,18]. For example, Weyhrauch[18] structures the space of all possible stories in terms of possible permutations of plot points or important moments and a preference function on which orderings of those points it prefers. When an important plot transition is recognized then the manager does a forward projection of all possible extensions of the current story, chooses one that it prefers and proceeds to try to manipulate the world so that story occurs. In contrast, CBI's emphasis is on flexibly managing the dialog interactions to motivate the characters to achieve the story's goals.

5. Conclusion

The results of the exploratory evaluation are promising for the use of IPD in health interventions. Although the expectation that a system like CBI could substitute for time spent with a trained clinical researcher teaching Bright IDEAS is bold, the reality is that the current alternative of repeated one-on-one sessions with RAs is not economically feasible for reaching a larger audience. Similarly, discussion groups or role-playing games also require specially trained facilitators and would be difficult for these busy mothers to participate in. On the other hand, passive presentation methods are not likely to promote active learning. Interactive Pedagogical Drama could fill a void in making effective health-intervention training available to the larger public at their convenience. The training task for Carmen's Bright IDEAS was a difficult one, fraught with many potential pitfalls. The fact that it was so well received by the mothers was remarkable, and bodes well for applying IPD to other training and learning tasks.

Acknowledgements

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