An Online Simulation in Pediatric Asthma Management

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Introduction

The Centers for Disease Control (CDC) estimates that nearly 20 million Americans suffer from asthma, 6.3 million of which are children(Centers for Disease Control and Prevention, 2004). It is not merely an annoyance disease, as is commonly believed. Asthma kills. It takes more than 5,000 American lives each year(Asthma Statistics in America, 2004). Asthma is the most common chronic disease of childhood, and it is the number one cause of hospitalization and absence from school. African Americans suffer asthma at three times the national rate, and are four times as likely to die from asthma as whites. Asthma in Atlanta's inner city children has increased to alarming levels in both morbidity and mortality, especially in black and Hispanic populations. Incidence and severity of asthma is inversely related to socioeconomic status. It is a dangerous pulmonary disease, which not only spoils quality of life for asthmatic children and their families, but results in many deaths. An important social hazard of childhood asthma in children is increased school absenteeism. The CDC estimates that asthma caused fourteen million missed schools days in 2002. Loss in productivity by working parents caring for children missing school due to asthma is estimated at $1 billion per year(Asthma Statistics in America, 2004). Absenteeism from school directly contributes to increased drop-out rates, with lifelong repercussions in earning capacity, health, and quality of life. More important, physicians, nurses, respiratory therapists, asthma case managers, and school nurses know very well that beyond the startling statistics lies the personal suffering of many individual children.

For children with asthma, the key to survivability and day-to-day participation in a satisfying life is judicious, timely management of the disease. Children with asthma must learn to monitor their breathing condition, avoid and manage environmental asthma triggers, and take prompt, aggressive action when needed. Asthma management includes monitoring symptoms and status, home treatment with medications and therapy, identifying and minimizing environmental asthma triggers, and knowing when and how to seek medical attention. Teaching asthmatic children to monitor and manage their disease is a complex instructional goal that must be accomplished to a high standard. Sensible management reduces hospitalizations, improves the quality of lives for both asthmatic children and their families, saves enormous amounts of money, and saves lives. Preventing a single hospitalization involving need for mechanical ventilation saves many thousands of dollars, and possibly a life. But community education for asthmatics is often not uniform, not timely, and not readily available.

Branching-Logic Clinical Simulation

Certification of competence, and professional credentialing of practitioners in medical fields, especially physicians, has been a challenge for more than a century. Beginning in the 1960s, testing and measurement researchers attempted to devise workable clinical simulation techniques to measure skills and competencies beyond rote memorization of facts(McGuire, 1995). The intent is to reliably, realistically measure practitioner competencies. The University of Illinois developed branching patient management problems (PMPs), paper-based simulations describing patient complaints and presenting a choice of management options such as initiating therapy, gathering additional information, or discharging the patient. The clinical problems proceed through a customized pathway determined by patient management choices, and are termed branching-logic simulations.

The field of respiratory care, an innovator in technology integration in teaching among health care fields, has used branching-logic clinical simulations in the credentialing process for respiratory therapists since 1979(Hopper, 2004). Originally using a latent image paper-based technique, the National Board for Respiratory Care (NBRC) replaced paper technologies with computer-managed credentialing exams beginning in 2000. Designed to simulate clinical practice reality, NBRC exams are text-based, and provide brief descriptions of clinical scenarios, followed by multiple-choice questions. Simulation sections are of two basic types:

1. Information-gathering, wherein the user requests specific items of information such as patient temperature, heart rate, breath sounds, and lab values, and receives the requested data. Items include valid, neutral, and harmful selections, relevant to the medical case at hand.

2. Decision-making, wherein the user assimilates information from the clinical scenario and one or more information-gathering sections, and chooses a course of action. Choices made in decision-making sections determine the pathway through the remainder of the simulation, and the simulation is in this way customized for each user. This provides for alternative but equivalent treatment choices to accommodate regional differences in medical

care(Kernaghan, 1978), and allows opportunities to rectify decision-making errors. In this way, users can partially redeem their scores by recognizing the results of incorrect choices and taking remedial action.

In both section types, items are assigned a score between three and negative three, with a score of zero earned for neutral items (neither harmful nor helpful). For example, choosing to perform the Heimlich maneuver in a choking emergency would earn a score of three points, while choosing to wait for laboratory results in the same situation would earn a score reduction of three points. Requesting patient skin tone, in many situations neither helpful nor harmful, and which is done quickly and at no expense, is an example of an item typically scored as zero. The simulation compiles cumulative scores in both information-gathering and decision-making, and users must achieve a calculated cut score in both categories to pass the simulation. The intent of the clinical simulation exams is to test the user's knowledge base, clinical acumen, and critical thinking(Hill, 2002; Mishoe, 2002, 2003). Successful users gather appropriate information, without wasting time in an urgent situation, without causing unnecessary harm, and without incurring excessive expense. Based on this information, the user then selects a judicious course of action, and the simulation proceeds to another section, which would be a likely result in a real clinical arena. The branching-logic clinical methodology is widely held to be both challenging and instructional, despite criticisms that simple memorization of clinical protocols may falsely verify true critical thinking capacity(Hopper, 2002).

Project Vision and Scope

Asthma management is a tightly defined instructional goal, which lends itself well to traditional methods of systematic instructional design(Dick & Carey, 2001), and to delivery via Internet technologies. Information on asthma and its management changes rapidly. A potential solution was envisioned as a high quality, engaging online simulation, which asthmatic children could access from any school, home, church, or business with a rudimentary personal computer (PC) and an Internet connection. The child would take charge of the management of a virtual, online asthmatic child, and make virtual decisions about environmental triggers, drug administration, self assessment, and other basic issues. The simulation would follow a branching-logic format, similar to the NBRC credentialing exam for respiratory therapists, and with multiple pathways, so that the learner would encounter situations and information customized for his or her knowledge and skills. The simulation could adapt to a variety of user ages and circumstances, and print certificates of achievement. Above all, virtual asthmatic children and their homes and environments in the simulation should be representative of the users' circumstances and experience. It is essential that target learners relate to the simulation content and images.

Although there are abundant informational resources on asthma available on the Internet, and sophisticated high bandwidth multimedia products published on compact disk (CD), an online simulation on asthma management could not be found. An Internet mediated branching-logic simulation in pediatric asthma management, based on the NBRC credentialing examination for respiratory therapists, was adjudged worthy of development and investigation. Such a project would sidestep the technical disadvantages of production and distribution on CD. Most notably, the rapid evolution of content related to asthma management makes CD production a dubious distribution choice. It is not workable to recall thousands of CDs when the subject content in asthma management changes; however, an online asthma simulation website may be modified and updated quickly, cheaply, and from a single production and access point. Additionally, it was anticipated that the branching-logic simulation approach, delivered online, would be challenging and engaging for young learners.

The simulation was envisioned as targeting those in the community most challenged in managing the disease. The simulation must be constrained by the lowest hardware standards of potential users, but offer the advantages of being universally, instantly available, and modified as asthma management evolves. Such a project has the potential to affect an audience beyond the greater Atlanta area. It is not the intent of the simulation to provide comprehensive and complete information on asthma management. Rather, the project was envisioned to provide an important supplementary role to traditional training, as would be delivered in the physician's office, by the school nurse, by information documents provided by various organizations such as the American Lung Association, and by asthma case workers. This is in keeping with the findings of some researchers that online instruction may be best suited to a supplementary role(Harmon & Jones, 1999; Hopper, 2001). Rather than attempting to teach everything about asthma, the simulation covers the most important and most common content areas affecting asthma management.

Learner and Context Analysis

The primary learner population targeted for this project is inner city asthmatic children in the metro Atlanta area (Atlanta Empowerment Zone), but also comprises parents and families of asthmatic children, school nurses, coaches, physicians in general practice, medical clinic personnel, nursing and allied health students, and other adults in contact with asthmatic children. Asthma case workers from Atlanta's Zap Asthma organization (http://www.sph.emory.edu/zapasthma/Default.htm) were visited and interviewed to determine target learner characteristics, and technology access. These SMEs reported that the majority of asthmatic children in this target group had at least limited access to PCs and the Internet. Some of the children have access to home PC equipment. Most have limited access to technology in school libraries and classrooms, and from community libraries and churches. The Zap Asthma SMEs believed that hardware and software standards were dated, as is their own computer technology. The SMEs reported that they perceived the target population of children to be enthusiastic about computer technology, but with undetermined PC skill levels.

Design and Development

Prior to selection of technologies, instructional analysis, and user interface design, project specifications were developed:

- Simplicity—intuitive, robust, and user friendly.
- Technology soft—technology structure Spartan. To make the simulation available and useable on the widest possible range of hardware, the technology structure must be kept minimal. Technologies requiring high Internet bandwidth, plug-ins, or Flash are excluded.
- Content accurate. This is the point of the simulation—accurate, current information.
- Learner centered—language and operation matched to the target audience.
- Scalability—to accommodate content and operational updates, and to facilitate development for other learner groups.
- Aesthetics—visually appealing, interesting, and perceived as a positive experience.
- Flexibility—choices and alternate pathways to accommodate users of various ages and genders, and multiple accesses by the same users.
- Feedback—the simulation must provide liberal informational and attitudinal feedback, and provide remedial feedback skillfully and constructively. Feedback should be provided throughout the simulation experience, and a final summary of performance should be provided.

Specifications of simplicity and reliability require a minimalist approach to technology selection. The basic online platform consists of HTML and Javascript, usable by virtually all current and recent PC workstations.

The instructional analysis (see figure 3) was performed by two professional instructional designers from the corporate arena (Home Depot and Cingular Wireless), under the direction of a faculty instructional designer (project lead) who is a registered respiratory therapist (RRT), as an independent study project toward a master's degree in technical communication. The design team conducted subject matter expert (SME) content sessions to extract and refine the skills and specific knowledges of pediatric asthma home management. SME sessions included hospital health educators, pulmonary rehabilitation specialists, case managers, pulmonologists, and health professions faculty.

The instructional design team first developed and refined the project's instructional goal:

Asthmatic children in the greater metropolitan Atlanta area will improve asthma self-management by applying preventative, monitoring, and treatment tools and techniques to significantly reduce emergency room visits, school absences, and hospitalizations.

The simulation storyboard was developed in Microsoft PowerPoint (see Figures 5 and 6), in consultation with project SMEs. A Southern Polytechnic faculty member in graphics design was contracted to develop customized images for the various simulation sections, rendered as smallest possible GIF files (see Figure 1). Southern Polytechnic students and faculty in technical communication voluntarily performed much of the technical and development work, including technical writing and editing, technical development, and usability testing. The website was constructed in HTML and Javascript (see figure 7), using the following development tools:

Dreamweaver MX	Macromedia	website design and management
CourseBuilder	Macromedia	Javascript interactions
PowerPoint	Microsoft	storyboard
Javascript	Microsoft	custom event tracking and scoring
Photoshop	Adobe	photographic images
Illustrator	Adobe	graphics
Fireworks	Macromedia	selected graphics—including animated GIF movies

Premiere	Adobe	digitized video
WMA Workshop	Litex Media	sound file editing and conversion
Project	Microsoft	project planning and management

The project was completed in three phases:

Phase 1	2001	instructional analysis choose technologies
Phase 2	2002	storyboard SMEs review and refine develop prototype
Phase 3	2003-04	code graphics and sounds usability testing deploy (November 1, 2004)

Major grant funding was provided by GlaxoSmithKline on completion of phase 2.

The website is designed for access using a Windows PC with Microsoft Internet Explorer 5.0 or later. It does not work properly using Macintosh platform or Netscape Navigator browser. This is compatible with technology access of the learner population, revealed in learner analysis. Narration sound files were converted to smallest workable file size for rapid download. Similarly, motion video was restricted to two simulation sections only, and rendered in animated GIF format. Graphics, sound, and motion video files are preloaded in all simulation sections to achieve a smoother operational flow for the user.

Virtual subjects for the simulation were recruited from learners in the target population (see figure 2) and are children from metro Atlanta who have asthma. The narrator is a Zap Asthma case worker whose voice and language are representative of the cultural environment of the target population. It is recognized that language decisions in the project may make the simulation challenging outside the target population, but the specific needs of the project's learners prevailed. Language throughout the simulation project was carefully edited to achieve a Flesch-Kincaid grade level average score of about grade five.

Unlike the NBRC branching-logic simulation format, this project does not compile separate information-gathering and decision-making scores, but calculates a single combined score. Users completing the simulation in testing mode earn one of three performance ratings (see figure 8):

- Asthma Zapper First Class
- Asthma Zapper Second Class
- Asthma Zapper in Training

Final score is reported and users are invited to try for a higher score.

Field Testing and Usability Testing

The project was field tested at Atlanta's Zap Asthma headquarters, with twelve metro Atlanta asthmatic children, as part of a one week asthma camp conducted by Zap Asthma case workers. Children were assigned to work individually on computer stations with color monitors, external speakers, and DSL Internet connections. PCs at this site are surplus and donated units from various federal and state agencies. Average PC age is about five years (processor speed and memory undetermined), and all use Microsoft Internet Explorer 5.0. Users ranged in age from seven to fourteen years, and most were female. The field test was conducted by the project lead and three volunteer graduate students (Southern Polytechnic Technical Communications Program). Major findings from the field test included:

- Users in most cases demonstrated significant computer skills (mousing, typing, browsing, etc.), and navigated the simulation website with apparent ease.
- Instructed to access the review option of the simulation for as long as they wanted, then attempt the testing option, users averaged about ten minutes in review mode followed by about thirty minutes to complete the exam. The majority of users earned an "Asthma Zapper First Class" rating on first attempt, attesting to the rigor of content of the Zap Asthma camp preparation.

- Users experienced no major technical malfunctions, revealing the simulation to be robust and reliable. Download time, even in simulation sections with motion video files (animated GIF) and many sound files, did not appear to be a factor in user satisfaction.
- Voice narration in review mode was clearly an important factor in user satisfaction. Users tended to avoid reading remedial text, but listened carefully to audible narration. This is in keeping with current research on the use of audio in multimedia learning(Barron & Calandra, 2004).

User comments were uniformly positive, and in many cases enthusiastic. Asthma case workers monitoring the exercise expressed similar positive responses.

- Some users as young as seven years successfully used the simulation, although the minimum recommended age based on field testing is eight years.

Usability testing was conducted in the Southern Polytechnic usability lab as a culminating exercise for an undergraduate course in usability testing. Three learners representing the target population, two parents of asthmatic children, and other volunteers accessed the simulation website under controlled conditions. User actions, verbal comments and questions, and observer notes were recorded for each participant. Users completed a preliminary survey to gather demographic data, and information on the user's previous knowledge and experience in asthma management, and in PC skills. They were debriefed following the simulation to probe user attitudes regarding the instrument and the experience. Usability testing revealed many important positive and constructive aspects of the simulation, including:

- The fundamental premise of the simulation was easily grasped and applied by users.
- The navigational design and structure was confirmed—users successfully entered, participated in, and completed the simulation without undue difficulty.
- Some screen design elements were altered as a result of usability testing. For example, it was observed that the first round of participants rarely pushed a "Reveal correct answers" button to self evaluate performance. But this improved dramatically in the second round when the location of the button was moved to be near the "Go" button that exits each section.
- Several language problems were discovered and corrected. For example, few of the users understood the word "sputum" and this was subsequently defined within context. Similarly, words such as "assemble" and "disassemble" were replaced with "put together" and "take apart."
- Need for an on-screen switch to toggle sound one and off was apparent (see figure 7).
- Users expressed emphatic appreciation of voice narration rather than reading the same remedial text. This was the case with both children and adults.

Deployment

The simulation is scheduled for public release November 1, 2004. A working version of the project may be seen at the following URL:

http://www.spsu.edu/htc/Zasthma_sim_demo/ZapSimTempDemo.htm

Evaluation

Data that may be collected online from children is restricted, necessarily limiting the scope and detail of data that may be collected from the simulation. As the simulation completes, users are asked to indicate their age (eighteen and above or less than eighteen) and are directed to survey instruments developed for each age group. Attitudinal response to the simulation is queried, and recommendations for improvement are solicited. Additionally, the following data is collected for each visitor to the simulation website:

- First name entry
- Date and time entering website
- Access to review mode and cumulative review time
- Number of sections completed in testing mode, and pathway through the simulation
- Score in testing mode

This data will be analyzed to suggest refinements, and to ascertain average user time to complete the simulation.

Lessons Learned

Perhaps the most important, and surprising, lesson from this project is that computer skills and access in the Atlanta inner city environment for children is greater than anticipated by the project designers. Target learners in this population were manifestly skilled in PC and Internet fundamentals, generally more so than their own parents, and adapt quickly and competently to the online simulation approach.

Second, the branching-logic clinical simulation methodology appears to be a good match for this instructional goal and these learners. Representative learners related well to the virtual subjects and the content, and were able to effectively navigate through complex simulation sections, remediate errors, and earn respectable final scores. An unanticipated aspect of the simulation is the competitiveness that it generated among users, both children and adults. It may be preferable to report a general score category rather than exact numerical scores(McGuire, 1973).

The Future

Metro Atlanta comprises a large population of adult asthmatics, and as in the case of children with asthma, adult blacks experience an incidence of the disease disproportionate to general population. Asthma management in adults is similar to that of children but treatment varies somewhat in drugs and dosages, and in lifestyle and environment factors. Anatomically, the small airway caliber of children increases the severity of asthma symptoms as the effects of airway inflammation and constriction are magnified(Farzan & Farzan, 1997). These factors cause an instructional program on asthma management for children to be relevant to adult asthmatics, but not a good fit. Therefore, a simulation targeting adult asthmatics in the same population is contemplated, with content and simulation approach and flow aligned with adult learner characteristics. For example, the role of smoking avoidance/cessation is more important in teaching adult asthmatics to manage the disease. Similarly, workplace triggers and stress are issues that should be emphasized in a simulation targeting adults.

The growing Hispanic population in the U.S. presents another important learner population that would benefit from an online asthma simulation. Prevalence of asthma in Hispanic children is alarming and increasing(Centers for Disease Control and Prevention, 2004). A simulation for these learners will require careful attention to language, to accommodate various dialects of Spanish, and a selection of online characters that Hispanic children can relate to. There are important cultural differences in practices and attitudes toward medical intervention, especially in a disease with many myths and folk remedies, as is the case with asthma.

Since inception of this project, Flash has become ubiquitous and available to most Internet users, and CourseBuilder/Javascript may be replaced with Flash to construct successive iterations of the simulation.

Conclusion

The simulation downloads and runs quickly even on older PC systems. It provides an engaging way to teach and practice asthma self management. We expect user data to confirm developer perceptions that the simulation website is effectively designed, and engaging and satisfying for target users. The website will be evaluated and refined in response to evaluation data and user comments, and as the subject content of asthma management evolves. This project will continue to serve a project-based learning role for Southern Polytechnic students.

References

Asthma Statistics in America. (2004). Asthma in America. Asthma statistics. Retrieved 10/4/2004 from http://www.asthmainamerica.com/statistics.htm

Barron, A. E., & Calandra, B. D. (2004). The use of audio in multimedia learning: Theory and practice. *Journal of Interactive Instruction Development*, in press.

Centers for Disease Control and Prevention. (2004). Morbidity & mortality weekly reports: Asthma prevalence and control characteristics by race/ethnicity--United States, 2002. Retrieved 10/4/2004, 2004, from http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5307a1.htm

Centers for Disease Control and Prevention. (2004). Morbidity & mortality weekly reports: Surveillance for asthma--United States, 1980-1999. Retrieved 10/4/2004 from http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5101a1.htm

Dick, W., & Carey, L. (2001). *The systematic design of instruction* (Fifth ed.). New York: Addison-Wesley Educational Publishers, Inc.

Farzan, S., & Farzan, D. A. (1997). *A concise handbook of respiratory diseases* (4th ed.). Stamford, Conn.: Appleton & Lange.

Harmon, S. W., & Jones, M. G. (1999). The five levels of web use in education: Factors to consider in planning online courses. *Educational Technology, 39*(6), 28-32.

Hill, T. V. (2002). The relationship between critical thinking and decision-making in respiratory care students. *Respiratory Care, 47*(5), 571-577.
Hopper, K. B. (2001). Is the internet a classroom? *TechTrends*, *45*(5), 35-43,25.
Hopper, K. B. (2002). Is critical thinking a luxury? (letter). *Respiratory Care*, *47*(9), 1018-1021.
Hopper, K. B. (2004). Education, teleconferencing, and distance learning in respiratory care. *Respiratory Care, 49*(4), 410-420.
Kernaghan, S. G. (1978). Clinical simulation: The profession's new tool for registry evaluation. *Respiratory Care, 23*(6), 570-576.
McGuire, C. H. (1973). Diagnostic examinations in medical education. *Public Health Papers, 1973*(52), 59-69.
McGuire, C. H. (1995). Reflections of a maverick measurement maven. *JAMA, 274*(9), 735-740.
Mishoe, S. C. (2002). Educating respiratory care professionals: An emphasis on critical thinking (letter). *Respiratory Care, 47*(5), 568-569.
Mishoe, S. C. (2003). Critical thinking in respiratory care practice: A qualitative research study. *Respiratory Care, 48*(5), 500-516.

Appendix

Figure 1 Sample graphic (watching for asthma triggers)

Figure 2 Simulation cast, left to right: Jalesa (Michelle), Trellaine (Vanessa), Jamal (Jamal) and Bonita (narrator)

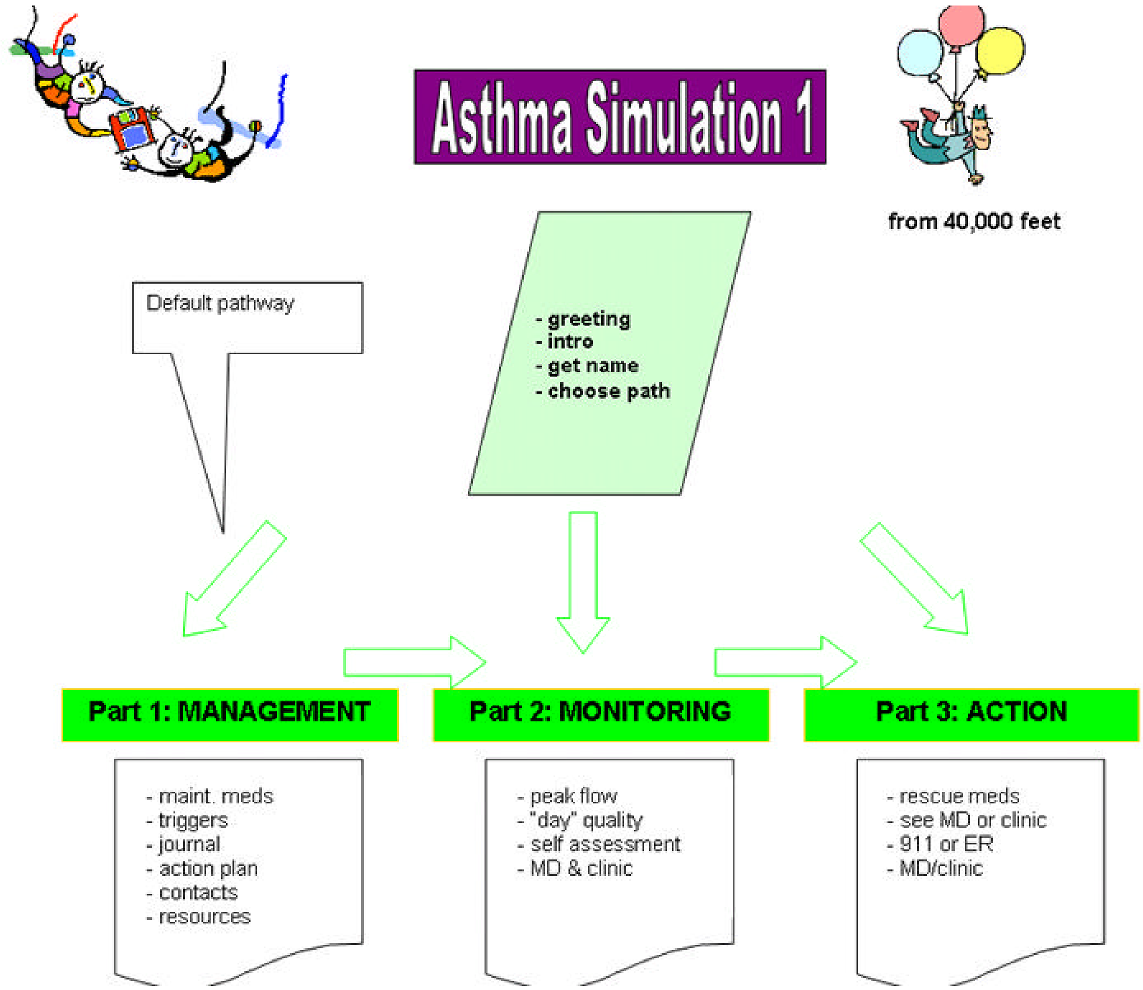

Figure 3 Simulation design overview

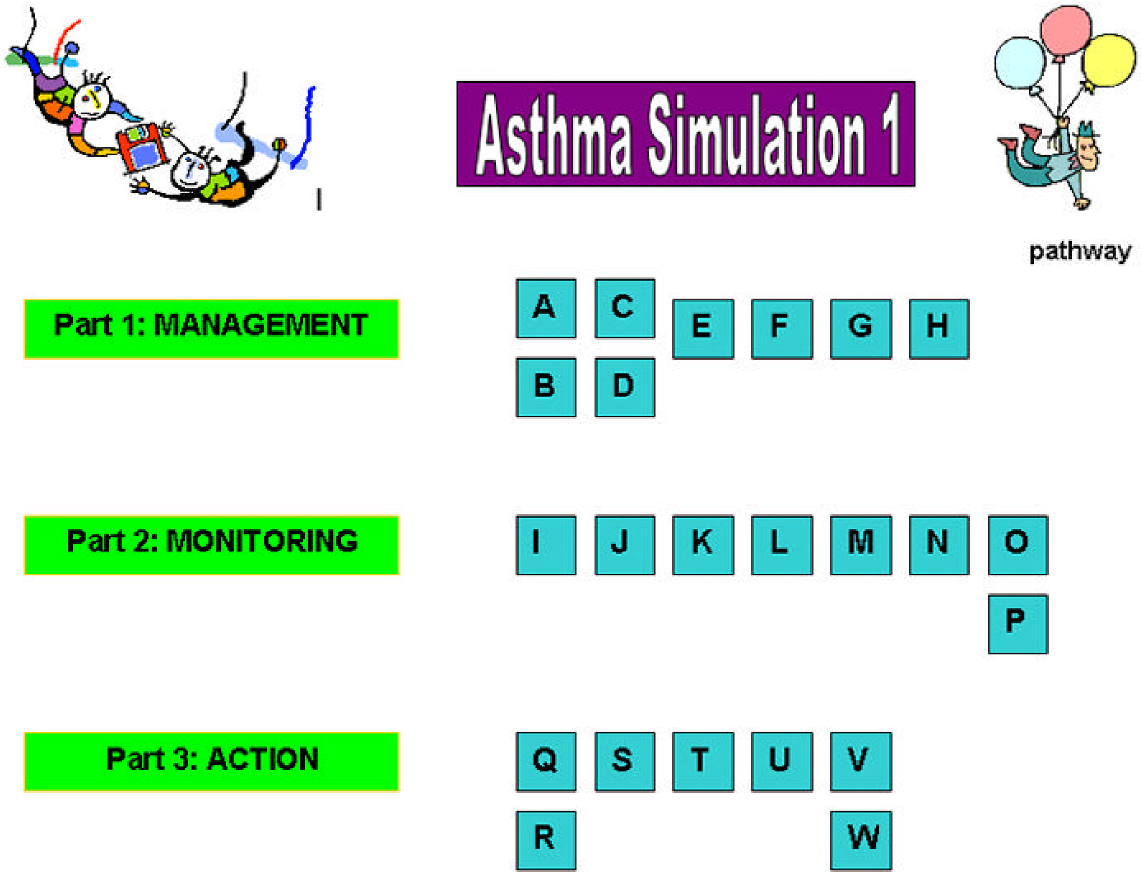

Figure 4 Simulation pathway (parallel sections assigned randomly, or are alternative/remedial sections)

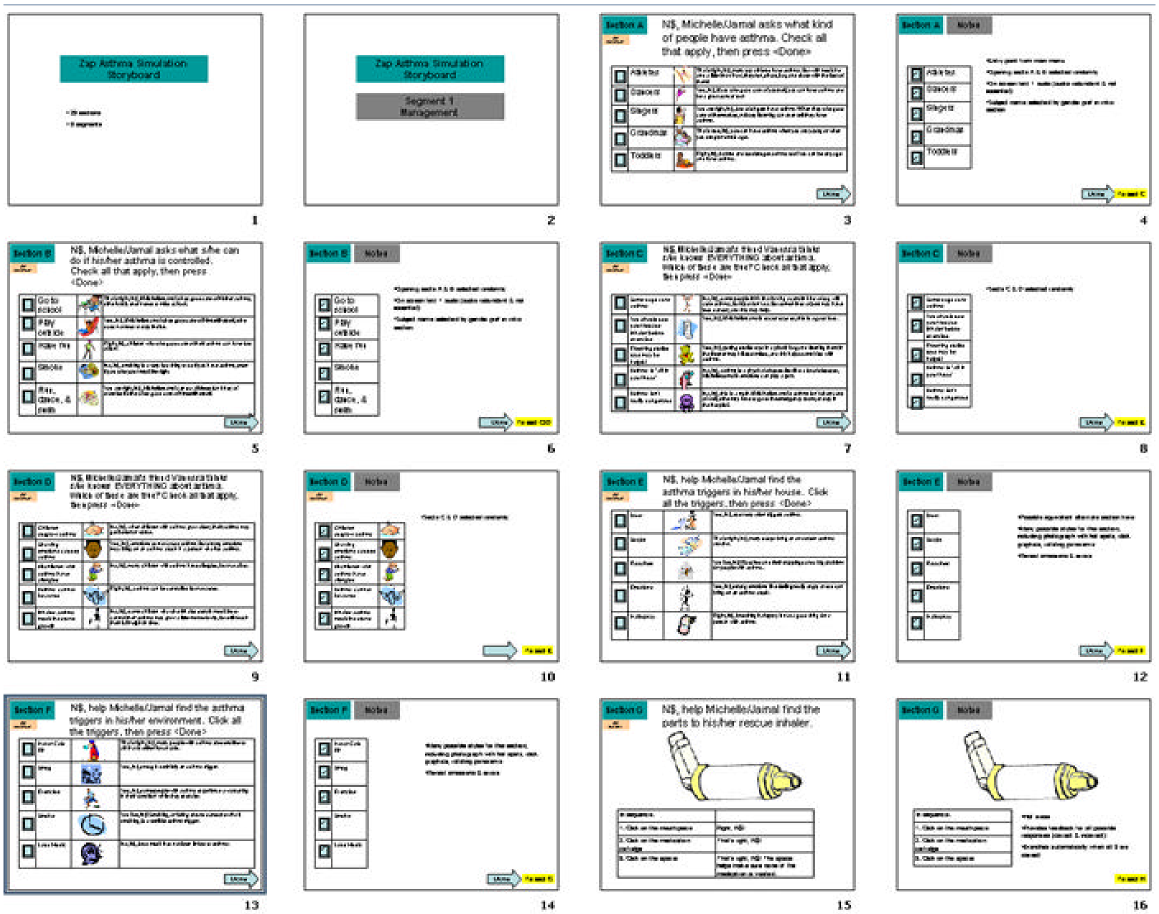

Figure 5 Simulation storyboard (partial; PowerPoint)

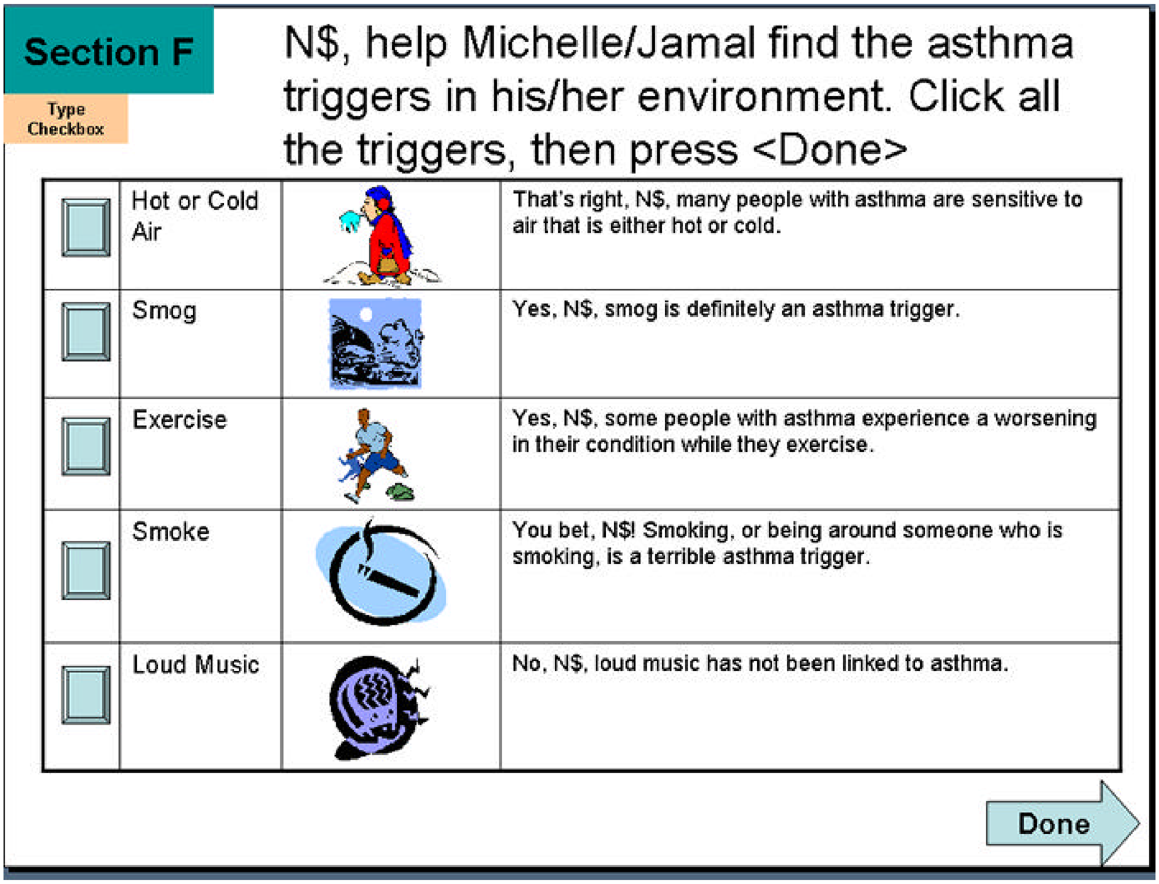

Figure 6 Simulation section from storyboard (PowerPoint)

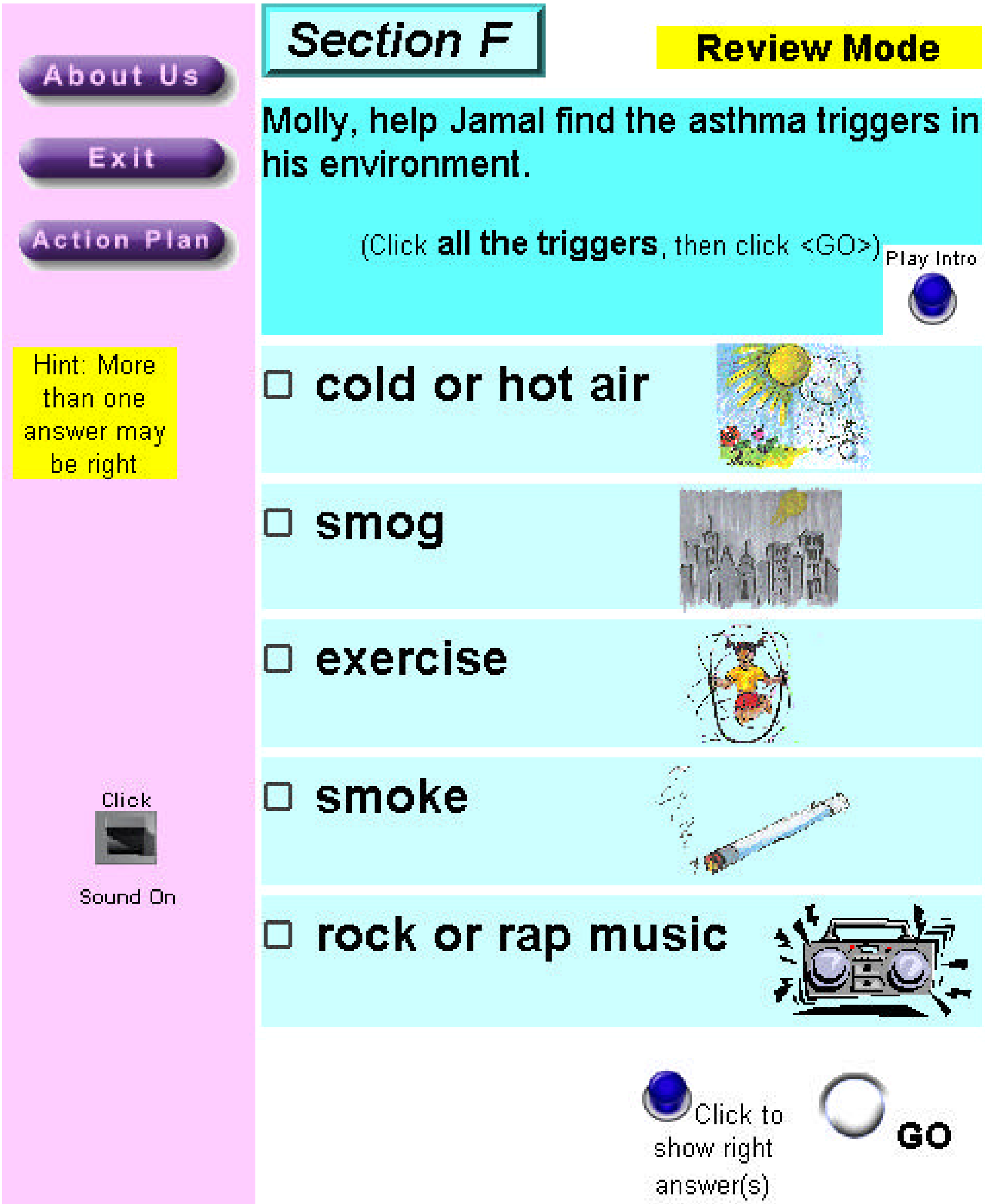

Figure 7 Simulation section in distributed form

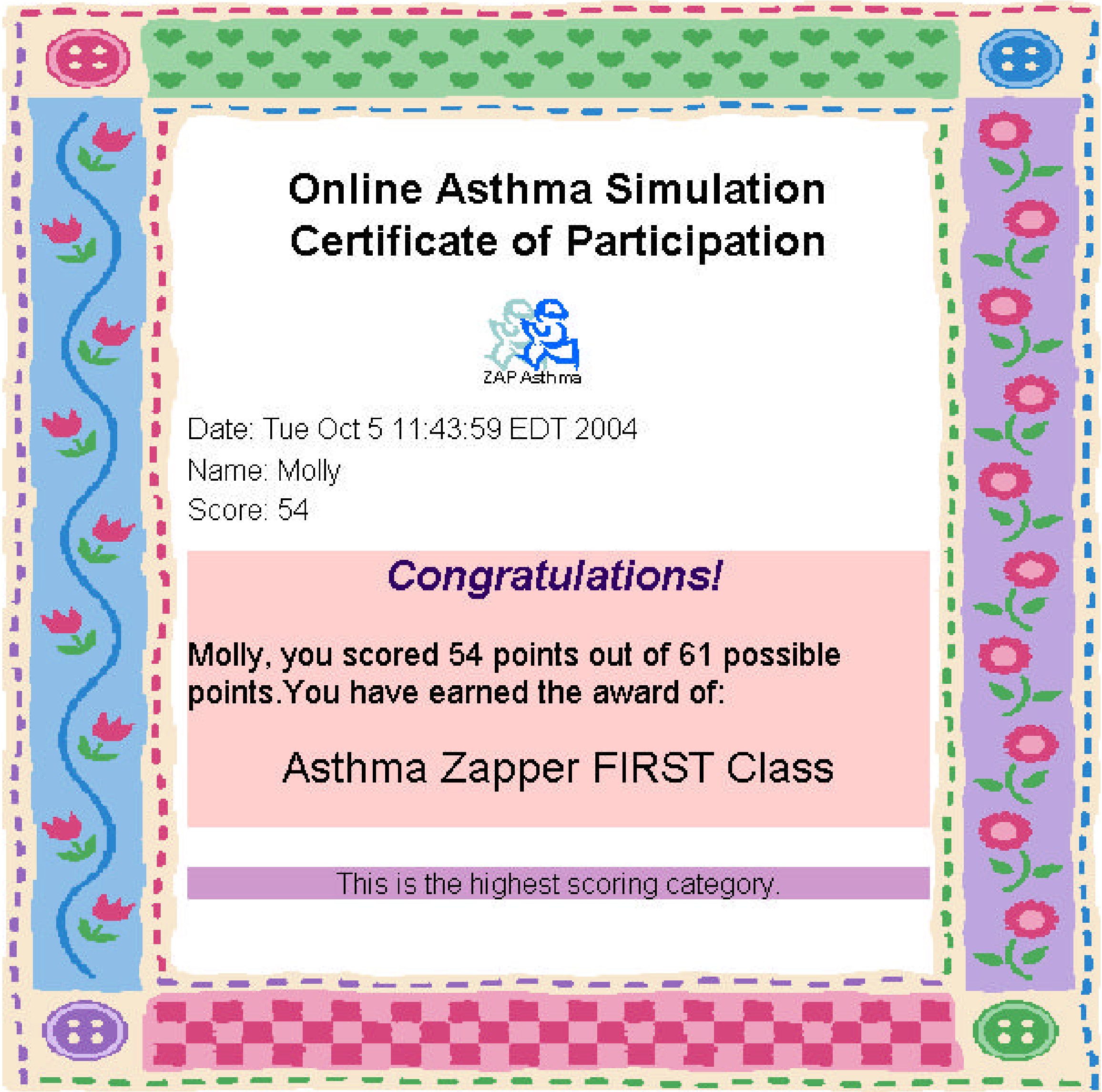

Figure 8 Printable certificate of achievement