Comparison of methods for teaching developmental milestones to pediatric residents

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Background: Interactive media are effective tools in teaching and allow for self-directed study, which develops skills for life-long learning among health professionals. With this type of study, the learner can review material at his/her own pace and target areas that require emphasis. Pediatric residents require an accurate understanding of developmental milestones in children of various ages and their normal variations. The best representation of developmental milestones requires video recordings of children demonstrating appropriate skills. However, such recordings are not always available, so printed materials are most often used. In this realm, a computer-based interactive learning tool using animated cartoons gives flexibility for presentation using drawings. We compared pediatric residents' knowledge of developmental milestones in neonates to 5-year-olds before and after study with either an interactive DVD or paper-based materials.

Methods: A team of physicians and educational specialists in Texas Tech University Health Sciences Center produced an interactive DVD containing animated cartoons and questions. Residents were divided into an intervention group that used the DVD and a control group that used traditional paper-based materials. Each group's improvement [or increase] in knowledge was measured.

Results: Compared with the 17 residents in the control group, the 37 in the intervention group tended to acquire more knowledge about developmental milestones. The mean scores at T1, T2, and T3 doubled from the initial scores in the intervention group, while no difference was observed in the control group.

Conclusion: An interactive educational DVD can be an effective supplement to improve residents' knowledge of developmental milestones.

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Introduction

Interactive media are valuable and effective tools in teaching.[1-3] They promote independent self-study and skills for life-long learning among health professionals.[4] Interactive methods of teaching in the medical field, such as small-group instruction and discussion, seem to provide considerable support to traditional lectures or practice learning.[5] The advantages of such interactive methods have been demonstrated in teaching medical concepts,[6-9] case studies,[10,11] and clinical skills.[12,13] Different types of resources, such as computer- and web-based interactive tools, have distinctive advantages, including versatility in (a) the method of presentation, to accommodate different learning styles;[10,11] (b) the pace of presentation; and (c) the content, to accommodate for personal learning objectives.[14] Further, these materials are cost-effective because they can be used in self-study,[6,8] without faculty supervision.

During their residency, pediatricians are trained to identify possible developmental delays in children by knowing developmental milestones, listening to parents' concerns, and using proper screening.[15,16] General pediatricians often do not detect developmental delays early enough to make a meaningful difference through early intervention.[17-20] This suggests that training and continuing education in developmental milestones may be inadequate.

Currently, pediatric residents are taught several aspects of child development, including gross and fine motor skills, language acquisition, and intellectual ability. The teaching is mostly provided by traditional

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lectures and self learning using paper-based information and this is strengthened by assessing patients in continuity clinics. Interactive learning can provide an important complement to these traditional educational experiences.[21] In addition, learning developmental milestones is based on identifying skills that involve movement. Therefore, studying these milestones would be most effective with video recordings of children performing each developmental skill. However, obtaining such recordings at different ages can be complicated, expensive, and require an uncertain time investment. Different examples of the same skill may be required to produce an effective educational recording, and some skills cannot be elicited by the experimenter, so that one must wait for the recorded child to spontaneously perform the skill. An effective way to address these challenges is through computer animations based on drawings. Computer-generated stimuli offer complete control over movement that may not be captured readily on live video.[22]

While some studies have considered the advantages of interactive education using animated cartoons for younger students, there is a lack of comparative studies of the use of such materials in higher education. To the best of our knowledge, there is no computer-based interactive learning tool using animated cartoons to provide pediatric residents knowledge of developmental milestones. In order to determine the advantages of such a tool, we used the principles of interactive learning to produce an interactive DVD presenting developmental milestones in children from birth through 5 years. The DVD presents material through animated cartoons with different compositions and layouts outlining the developing abilities at different ages.

Methods

Study design
This was a quasi-experimental study with repeated-measures, using one intervention group and one control group. The intervention group used a developmental milestones interactive DVD and the control group used printed material (PM).

The study did not include a control group presented with no instructional materials, but the repeated measure design allowed the groups to serve as their own controls.[23]

Measurement
The primary measurement was the total score on a 24-item self-report test about developmental milestones in children from newborn to 5 years old. The test was used on three occasions: prior to the interventions (time 1; T1); immediately after 2.5 hours of use of either the DVD

or PM (time 2; T2); and 3 months after the last use of material (time 3; T3). A period of 3 months was considered reasonable to control for the recall at T3 of the questions used in the test. Furthermore, tests used at T2 and T3 had the same questions as at T1, but their order was changed.

Data source measurements
The 24-item test was developed by experts including three pediatric professors following the format of the pediatric board test in the USA, which is a formal assessment of a resident's knowledge. Each professor prepared a set of 10 questions and responses to discuss as a group. Each professor responded to the 30 questions, and responses were matched to indentify discrepancies. Six questions were eliminated for different reasons, including language complexity, being unrelated to developmental milestones, and being formatted inconsistently from questions on the pediatric board exam. Questions had a case-based design, where the response required a synthesis of information and selection from four choices. The following is an example of a sample question: "In your developmental rotation, you are observing a group of preschoolers drawing pictures, identifying several colors, talking to each other while playing with blocks, and explaining what color block goes on top or below each block. Most likely they are: 1) 5 years old, 2) 4 years old, 3) 3 years old, or 4) 6 years old." A pilot study was conducted to observe possible problems in understanding the questions. The test was adjusted accordingly to avoid confusing items. The test was scored by awarding one point for each correct response and no points for incorrect responses. Two independent evaluators scored the response sheets, and the final results were determined. The evaluators did not have access to the names of residents but instead to each resident's username.

Study participants
Candidates for inclusion in the study were all residents in the Department of Pediatrics at Texas Tech University Health Sciences Center, during their first, second, or third years in the 2006-2007 academic year (intervention group) and first year residents in the 2007-2008 academic year (PM group). Participants were not admitted to the study if they were (1) unwilling to participate in or their (2) time for participation in the study was less than 2.5 hours in 4 weeks.

Study intervention
While participating in this intervention, residents were participating in clinical rotations. Sessions of 2.5 hours were scheduled every Wednesday after lunch for 4 weeks, and each resident participated in one of the four sessions, spending a total of 2.5 hours reviewing the

materials.

Residents could opt not to participate in this study (only one resident decided not to participate in). During these sessions, they had access to either the PM (*n*=17) or DVD (*n*=37) and a computer with sound and video capability. All residents selected for the intervention group corresponded to residents available at the time of the intervention. Because of the small sample size and logistics including the desire of residents to use the DVD, the intervention group was formed by all residents, for the control group residents were selected from all accepted residents in the next academic period. Residents were allowed to attend three or four sessions to use of the DVD or PM. The total time for use of either was set at 2.5 hours and monitored by a study coordinator. Faculty members were not present in the sessions. Most of the residents completed the required time in two sessions.

The interactive DVD and PM were available only during study sessions. However, alternative PM could be obtained from diverse sources, such as the library or clinics. Residents on some clinical rotations may also have received independent printed material from the faculty. During the study, residents from both groups attended lectures, conferences, or could access information about the subject at their own discretion. The results of the tests were not discussed with participants until the end of the study.

Description of materials

The DVD presentation was organized in five sections on social, intellectual, language, and gross and fine motor skills; a total of 242 different skills were presented using computer animation. The materials included the following ages: birth, 1, 2, 4, 6, 9, 12, 15, 18, 24, 36, 48, and 60 months. The DVD allowed the user to view images, listen to an audio track, read text, and identify developmental milestones. Different styles of presentation were used, including animated cartoon segments, printed charts, and navigation. A large portion of the material was presented in short segments using animated cartoons with a background that included narration, music, and sound effects. Material for the DVD was prepared by a group of physicians, educators, graphic designers, researchers, and health communication specialists.

Technical material was extracted from books currently used by all pediatric residents in the USA to learn developmental milestones, including the Bright Futures Guidelines for Health Supervision.[17] The production team included an educator/health communicator with many years of experience and awards in producing educational material in the health field including animated cartoons for parents and children. Table 1 contains an overview of the content of the interactive DVD with samples of the dialogue presented. A snapshot of the menu listing the component sections included on the DVD is presented in Fig. 1.

The PM group had access to the PM that contained material used to produce the DVD, including printed sheets of the material used for review exercises on the DVD (cases and quizzes).

Variables

The dependent variables were the scores on the tests at T1, T2, and T3. The independent variable of interest

Fig. 1. Menu of learning child developmental milestones interactive DVD.

Table 1. Interactive DVD content

Categories
Overview – Animated segments of developmental milestones grouped by skills at specific ages.
Example: A 4-mon-old baby with narration that describes "a baby at this age can babble, coo, might say something like 'ah goo', can laugh out loud…"
Milestones – A summary of all milestones classified by age.
Example: Selection of "4 mon old" will present a baby at 4 months of age with appropriate social, intellectual, gross motor, fine motor and language skills.
Progressives – Progression of skills as children grow.
Example: Orientation to the sound of bell, gross motor progression.
Landmarks – Babies at different ages are presented, allowing the user to select the type of skill they want to review by clicking at specific regions of the child.
Printed developmental milestones – Age-appropriate children presented in a printed format and grouped by age and developmental skill.
Review: Questions related to developmental milestones.
Narrated developmental milestones are presented using an age-appropriate child produced in animated cartoons executing each developmental skill accompanied by voice, sound effects, and music.

was the group (DVD or PM). Covariates of interest were level (i.e., year) in the residency program (first [PL1], second [PL2], or third [PL3]) and sex.

To avoid the necessity of controlling for differences in developmental milestone knowledge at baseline, we used repeated-measures testing. Each participant served as a control with baseline data collected for each subject, reducing the error variance caused by intersubject differences. The researchers were blinded to the results by having residents use usernames; residents were blinded to the results of their test by not being given their scores. The usernames also helped to control for additional stress caused by the possible expectation that residents in later years of their program would score better than those in earlier years. In addition, this helped to protect the confidentiality of the results.

Sample size

A power analysis was performed to allow for detecting of a mean difference as small as 1.1 points with a common within-group standard deviation of 1.0 at an alpha level of 0.05 at over 80% power. To detect this minimum effect, 15 participants were needed in each group. The power analysis was performed with Power

Table 2. Mean test scores among pediatric residents studying developmental milestones with either an interactive DVD or printed material

Time period	Interactive DVD (n=37)	Printed material (n=17)	P
Pre-intervention*	10.35±2.56	9.47±1.77	0.210
Post-intervention†	19.49±4.43	8.71±2.23	<0.001
3-mon follow-up†	18.54±3.81	8.29±2.17	<0.001

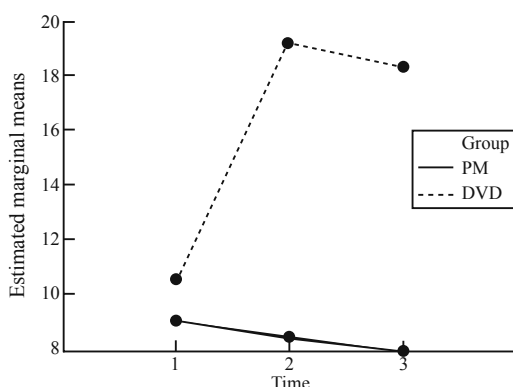Data are presented as mean ± standard deviation. *: non significant; †: significant.

Fig. 2. Estimated marginal means on test scores among pediatric residents studying developmental milestones. The tests, scored with 0-24 points, were administered prior to (time 1), shortly after (time 2), and 3 months after residents completed 2.5 hours of study with either an interactive DVD (DVD) or a traditional paper-based material (PM). The estimated marginal means are adjusted for the covariate of level in the residency, which had a value of 1.67.

and Precision v.3 (SPSS Inc, Chicago, IL).

Statistical analysis

A 2-way mixed between-within-subjects analysis of variance (ANOVA) was performed with group (DVD, PM) as the between-subjects factor and time (T1, T2, and T3) as the within-subjects factor. Group level (PL1, PL2, PL3) was entered as a covariate. Sex was left out because independent t tests between males and females at each time point revealed no differences between the groups. All analyses were performed with SPSS v.17 (SPSS Inc, Chicago, IL).

Results

This study included 37 residents in the DVD group and 17 residents in the PM group. The DVD group consisted of 13 (35.1%) residents in their first year, 12 (32.4%) in their second year, and 12 (32.4%) in their third year. The members of the PM group were all in their first year. In the DVD group there were 10 (27%) males and 27 (73%) females, and in the PM group, 7 (41.2%) males and 10 (58.8%) females.

Table 2 presents means and standard deviations of test scores for each group at each time of measurement. There was a main effect of group (P<0.001), meaning that the scores for the DVD and PM groups were significantly different from each other when collapsing across time. This indicated a difference in the effectiveness of the two teaching approaches, with the DVD group displaying higher scores. There was a main effect of time (P<0.05) such that the scores improved across time even when collapsing across the type of intervention. Finally, there was a significant time × group interaction (P<0.001), indicating that the DVD group showed a significant improvement after the intervention but the PM group did not. There was no significant time × residency level interaction (P>0.05), meaning that students at different residency levels did not show any different level of improvement over time.

Fig. 2 displays the estimated marginal means of test scores for the DVD and PM groups at each time point. Estimated marginal means were adjusted for the covariate of level in the residency. This covariate had a value of 1.67.

Discussion

Interactive computer- and web-based tools have been used to successfully teach medical concepts,[8-11] review clinical case scenarios,[10,11] and teach surgical skills.[13] Studies using progressive media have shown that for a new generation of physicians these educational tools

might be more appealing and enjoyable than traditional tools.[24,25] Without a doubt, materials that are colorful and have sound and interactivity are more appealing to almost everyone. However, the question from an academic standpoint is whether such materials are better educational tools than traditional written materials and lectures. Some studies indicate that this depends on how the material is constructed, indicating a difference when illustrations are added only as decoration but not when they are substantially used to communicate and teach.[26]

The impact of multimedia in education is promising, and reported effects can be very valuable and seminal.[27-30] Some authors have argued that media-use does not affect learning under any conditions, but others have clearly demonstrated an effect on students' cognitive processes and memory.[26,31] Clark[32] stated the importance of distinguishing how different media are used to deliver a message, as well as the corresponding cognitive processes involved. For example, books allow the reader to go back and forth to review the information and may include pictures, but do not have sound. The symbolic processes that the viewer develops to remember the material in a book are limited. In the case of multimedia, symbolic processes and the corresponding processing capabilities are presented together in a single instructional environment. The use of computer animation in this DVD permitted the display of 242 skills, providing breadth and flexibility to this educational tool. The combination of digital tools, including interactive multimedia, graphic software, and interactive video games, has become promising in education.

In this study we showed that the group that used the DVD recalled more information, with a score difference of at least 10 points which was observed both at short term and 3 months after using this educational tool, than did the group that used traditional PM. This result was independent of the level (i.e., postgraduate year) in the residency program. The mean scores on the knowledge test improved significantly from the baseline in the DVD group, but not in the PM group.

Limitations in the design of this study included a lack of random assignment to groups. Randomization was not possible due to the small number of residents in the program and the difficulty of having residents use the PM instead of the DVD sessions if their peers were using the latter. We did not measure clinical behavior changes after the use of the material because of the multifactor complexity involved.

In addition, residents who used the PM could not use the DVD but those who used the DVD could access other printed materials in the library, in clinics, etc. This additional access to material could have given an additional advantage in test performance to the DVD group.

Additionally, this study did not allow us to determine an optimum number of hours of use. It became necessary to use a 2.5 hour period due to the educational obligations of residents that made it difficult for them to dedicate more time to this study. Furthermore, the better recall of information on a test does not necessarily translate into the application of that knowledge to produce better clinical outcomes. Finally, several of these limitations were partially compensated for by the use of repeated measurements that allowed for each participant to serve as his/her own control in certain analyses.

In conclusion, the DVD was more effective than traditional PM at teaching pediatric residents developmental milestones. The DVD has certain other advantages that were not measured in the current study. For example, the use and production of this type material can help educators improve their teaching abilities. Such media are also more appealing to residents than traditional PM, as evidenced by our residents' strong preference towards the DVD group rather than the PM group. The interactive DVD serves as an example of the potential benefits that multimedia applications can offer to health education and practice.

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