ORIGINAL ARTICLES

Developing Online Learning Modules in a Family Medicine Residency

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BACKGROUND AND OBJECTIVES: Online modules offer an opportunity to overcome barriers to educational delivery. Such approaches can require significant investment dependent on the development model used. There is little in the literature on the formative assessment of design and development. Better understanding is needed to determine effective methods of training and supporting faculty authors.

METHODS: The purpose of this study was to examine the effectiveness of Web-based modules developed by a Department of Family Medicine in delivering instruction to resident learners and to examine perceptions of the design and development process. Participants included 49 resident learners and 28 faculty and staff members as the development team. Data collection involved use of Web-based surveys, participant observation focus groups, and pretesting/posttesting. Frequency distributions and mean comparisons were used to analyze quantitative data. Participant comments were thematically analyzed.

RESULTS: Residents felt that modules met their educational goals and contributed to understanding of core content. Pretest/posttest data showed statistical improvement for a majority of modules. The use of Web authoring software for Web-based learning and scheduling time to work on the modules posed the greatest challenges to module authors.

CONCLUSIONS: Formative assessment methods can provide important information to module developers and support staff to shape training, content development, and improve module ease of use, navigation, and content for resident learners.

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Online modules offer an opportunity to overcome barriers to educational delivery. Advantages include accessibility, economies of scale, flexible scheduling, ease in updating, individualized instruction, and incorporation of novel instructional methods.[1,2] Such approaches can lead to improved learner interest and control and may be particularly beneficial when limited availability challenges group teaching.[3-5] However, online modules can require a significant investment of time and resources to design, test, and manage.[6] Major changes become difficult and costly to implement following start-up,[7,8] which means that it is important to choose appropriate software tools and establish efficient and effective work processes during the early stages of module development.

Self-directed learners tend to scan rather than read Web-based content.[9] Module authors must attend to design considerations such as perceived applicability, content organization, ease of use, and the potential for engaging learner interest.[10] Research indicates that modules should remain free of distracting elements and align with learning objectives and time-to-completion goals.[11,12] Successful screen designs should present information in cognitively manageable "chunks" and focus attention on key elements so that learners can intuitively locate information, understand where they are within the module architecture, and easily access navigational aids.[13,14] Hyperlinks and other design elements must offer consistent labeling and formatting.[10,15,16] Developers also need to consider the extent to which modules assist users in task completion and determine the quality of users' experiences interacting with the Web application.[8,17,18]

During the development process, formative assessment can be used to identify needed changes in content and/or design.[15,19-21] Although formative assessment is a well-recognized element of basic Web site design and publication,[17,22,23] it has received limited attention in discussions of online learning module development.

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Our study addressed this gap by documenting and analyzing a module development process, and then evaluating the outcome of applying these practices in a family medicine residency setting.

Methods

Project Description

Based on resident feedback, the University of Michigan's Family Medicine Residency Program identified areas of curricular need for which there was insufficient opportunity within existing rotations and the didactic curriculum. A decision was made to develop online modules that would address specific curricular objectives by serving as required supplements to several rotations. We used a methodology recommended in the literature for the creation of effective Web-based learning materials.[8,15,17] This included evaluation of our technical capabilities, institutional support, and possible barriers to implementation. Web-authoring software allowed authors with little knowledge of HTML and Web-based programming to develop appropriate content. Module development was funded by an institutional grant to support residency education, and Institutional Review Board approval was secured for the curriculum improvement project.

The project work team consisted of a residency director, associate chair for educational programs, technology expert, education specialist, and two faculty members responsible for content oversight. Four residents and 12 faculty members served as module authors. The project team collaborated with faculty authors on developing content, objectives, and learning strategies. Authors created modules with approximately 10–12 hours of staff support (as opposed to direct management). An education specialist assisted with development of learning objectives, pretest/posttest questions, and refinement of text-based material for Web delivery. A technology specialist provided training on use of Web authoring software, module design and development, and copyright issues.

Table 1: Characteristics of Authors Involved in Module Development (n=16)

	NUMBER/PERCENT		
	Faculty (n=12)	Residents (n=4)	Total
Gender			
Male	5 (41.7)	1 (25.0)	6 (37.5)
Female	7 (58.3)	3 (75.0)	10 (62.5)
Computer and Internet expertise			
Beginning	0 (00.0)	0 (00.0)	0 (00.0)
Intermediate	8 (66.7)	4 (100.0)	12 (75.0)
Advanced	4 (33.3)	0 (00.0)	4 (25.0)
Average experience level–online module use or course participation			
None	3 (25.0)	1 (25.0)	4 (25.0)
One module	4 (33.3)	1 (25.0)	5 (31.3)
Two or more modules	5 (41.7)	2 (50.0)	7 (43.8)*
Average experience level–online module development			
None	6 (50.0)	4 (100.0)	10 (62.5)
Very little	2 (16.7)	0 (00.0)	2 (12.5)
Moderate amount	4 (33.3)	0 (00.0)	4 (25.0)
Extensive amount	0 (00.0)	0 (00.0)	0 (00.0)

* Totals to greater than 100 due to rounding.

The resulting modules contained between 12 and 25 Web pages of content, requiring between 10 to 60 minutes to complete. The modules addressed learning objectives related to musculoskeletal examination, common procedures, integrative approaches to disease, and mind-body medicine. Each module was designed to operate in an asynchronous fashion, without direct faculty supervision or participation. Several modules contained audio files and/or case vignettes, and all of the musculoskeletal modules featured embedded instructional videos. Pretests/posttests were included to assess content understanding and to document module completion.

Module Evaluation

Author Surveys and Expert Reviews. Authors completed a 14-item survey containing 30 evaluative statements regarding satisfaction with the development process, training provided, and the Web authoring software. Six additional statements related to author self-competence and motivation to develop additional modules in the future. Respondents rated each evaluative statement using a Likert-type scale ranging from 1=strongly disagree to 5=strongly agree. Nine additional statements captured information about the level of difficulty authors faced during the development process, with responses scaled from 1=very difficult to 4=very easy. We also captured information regarding the authors' prior experience with Web-based curriculum development and suggestions for improvement.

Sixteen faculty/staff experts participated in the review process of the modules for quality, relevance, clarity of presentation, content appropriateness, and alignment with learning objectives. They also identified strengths/weaknesses in navigation and overall usability.

Resident Usability Testing. We evaluated modules for technical difficulties, ease of navigation and use,

appropriateness of educational content, and learner satisfaction. We conducted two rounds of usability testing with residents. In the first phase, we used traditional methods such as "think alouds" and videotaping of keystroke action.[24] Two researchers took notes and recorded observations. Focus group discussion allowed residents to share their impressions of the modules and make suggestions. In the second phase, we conducted field tests, and each module was evaluated as part of the residents' required curricular rotations.

Both testing phases involved resident completion of the module pretests/posttests and an 18-item evaluative survey. Pretests/post-tests included three to 30 multiple choice questions, some written as clinical case scenarios, with posttest scores of at least 80% required for demonstrating competency. The evaluative survey contained 10 statements that explored ease of navigation, organization and flow, appropriateness of Web format, and usefulness of the Web tools. Additional statements were included to evaluate content relevance and clinical utility and the alignment between content, learning objectives, and pretest/posttest questions. Response scales ranged from 1=strongly disagree to 5=strongly agree. The survey also included demographic items and two open-ended questions.

Analysis

Frequency distributions and mean comparisons were used to analyze the survey data. Pretest/posttest results were analyzed using paired *t* tests and Cohen's *d* statistics calculated as an additional measure of effect size (.20 small, .50 moderate, .80 large).[25] We performed quantitative analyses using SPSS 17.0 statistical software (SPSS Inc, Chicago).

Open-ended survey items and expert reviewer comments were independently reviewed and thematically analyzed. We combined observational data with focus group input to explore trends in the residents' navigation paths and verbal "think aloud" processes as they moved through the module content, which allowed us to identify issues that might pose challenges to future users.

Results

Forty-nine residents and 28 faculty and staff participated in the module development process between March 2007 and July 2009. At least five residents and three expert reviewers assessed each of 16 modules included in the study.

Author Surveys

All 16 module authors completed the satisfaction survey. Demographic characteristics of respondents are shown in Table 1. Seventy-five percent rated their computing and Internet skills as "intermediate" and reported at least some prior experience with online course or module participation. While half of the faculty reported past engagement with module development, none of the residents reported such involvement. Resident authors appeared slightly more satisfied than faculty with various aspects of the module design and development process, but we detected no statistically significant differences in response patterns across the two groups (Table 2).

Expert Reviews

Of the 16 experts who provided assessment data, they all agreed (80.0% strongly agreed, 20.0% agreed) that selected content was at an appropriate level for the residents and that learning objectives were aligned with content. They also agreed (70.0% strongly agreed, 30.0% agreed) that module content was substantive, either equivalent to or surpassing traditional lecture material, and that the material was presented in a straightforward and comprehensive manner (60.0% strongly agreed, 40.0% agreed). Suggested changes included adding examples and explanatory text, reducing content density, moving less important text off the central navigation path, and eliminating unnecessary redundancies. The expert reviewers made various suggestions for pretest/posttest revisions (eg, wording clarifications, removal of irrelevant distracters, narrowing the range of clinical issues embedded in case-based scenarios).

Resident Usability Testing

The 45 residents who participated in usability testing submitted a total of 143 evaluation surveys. Most were first-year residents (46.2%), and most (83.2%) rated their level of computing expertise as "intermediate" (Table 3). Most (76.1%) had prior experience using two or more online modules or courses. Almost all (94.5%) reported previous exposure to the content material, but few (27.3%) had "a moderate" to "great deal" of such experience.

Almost all residents (91.6%) agreed that learning objectives were consistent with featured content (Figure 1). More than 80.0% credited module activities for contributing to their understanding of content, key concepts, and procedures. A similar percentage agreed the modules were well organized and had a logical flow, the Web-based format was an effective way of presenting the material, and the content was relevant to their educational goals. Most (77.8%) found the modules easy to navigate. Half (50.7%) thought that links to external Web sites were helpful and only a third (34.7%) encountered technical problems.

Survey comments indicated that residents valued the use of consistent terminology, access to definitions, and repetition of key concepts through summary statements or exercises. Residents also valued the use of embedded case presentations and video demonstrations. With regard to design, residents expressed interest in having more pictures and images but reported that scrollbars and pop-ups diverted attention from key content material if not carefully placed within the module architecture. They cautioned authors to restrict text density, provide clear navigation cues, and limit use of external links. Module content was regarded

Table 2: Module Author Feedback Ratings (n=16)

	Faculty (n=12)		Residents (n=4)		
	Mean/Median	SD/Range	Mean/Median	SD/Range	*P* Value*
Satisfaction or Dissatisfaction (5-Point Scale)†					
Training for creating learning objectives	4.3 (4.5)	0.87 (3–5)	4.5 (4.5)	0.58 (4–5)	.77
Training for design of pretest/posttest questions	4.3 (4.0)	0.79 (3–5)	4.3 (4.5)	0.96 (3–5)	1.00
Orientation to the project/unit development	4.3 (4.0)	0.62 (3–5)	4.0 (4.0)	0.82 (3–5)	.60
Developing pretest/posttest questions	4.1 (4.0)	0.67 (3–5)	4.5 (4.5)	0.58 (4–5)	.38
Peer review process	4.0 (4.0)	0.63 (3–5)	4.0 (4.0)	0.82 (3–5)	1.00
Training for determining and planning content	3.9 (4.0)	1.00 (2–4)	4.0 (4.0)	0.82 (3–5)	.95
Proposal forms, author checklist, timelines	3.9 (4.0)	0.79 (2–5)	4.0 (4.0)	0.82 (3–5)	.95
Piloting process	3.8 (4.0)	0.87 (2–5)	4.0 (4.0)	0.82 (3–5)	.85
Development of text materials	3.6 (4.0)	0.90 (2–5)	4.3 (4.0)	0.50 (4–5)	.26
Training for storyboarding	3.6 (3.5)	0.90 (2–5)	3.8 (4.0)	0.50 (3–4)	.68
Designing for the Web-based format	3.5 (4.0)	0.91 (2–5)	4.3 (4.0)	0.50 (4–5)	.17
Ease or Difficulty With… (5-Point Scale)‡					
Creating learning objectives	4.1 (4.0)	0.90 (2–5)	3.3 (3.0)	1.53 (2–5)	.45
Developing content material	3.8 (4.0)	0.58 (3–5)	3.3 (4.0)	1.16 (2–4)	.63
Designing pretest/posttest quiz questions	3.6 (4.0)	0.79 (2–5)	3.0 (3.0)	1.00 (2–4)	.37
Organizing and structuring online content	3.0 (3.0)	1.21 (1–5)	2.7 (2.0)	1.16 (2–4)	.73
Meeting recommended timeline check points	2.4 (2.0)	1.24 (1–5)	3.3 (4.0)	1.16 (2–4)	.30
Software use	2.4 (2.0)	1.00 (1–5)	2.0 (2.0)	0.00 (2–2)	.54
Scheduling time to work	2.3 (2.0)	0.89 (1–5)	2.3 (2.0)	1.53 (1–4)	.84

* Fisher's Exact Test, 2-tailed calculated at 95% confidence level

† Coded: 1=very dissatisfied to 5=very satisfied.

‡ Coded: 1=very difficult to 5=very easy.

as relevant if it clearly linked to clinically useful information. Residents preferred linear presentation formats and content language that was succinct and presented from a clinical care perspective. They requested immediate and specific feedback on their test responses.

Table 4 summarizes the pretest/posttest results for each module. *T* test results (2-tailed, 95% confidence level) indicate significant pretest/posttest knowledge increases for 13 of the 16 piloted modules with effect sizes ranging from moderate to large (0.49 to 6.48). Log files reveal that the majority of residents (153/157, 97.5%) completed the testing immediately prior to/after module completion. *T* tests were calculated both including and excluding the four delayed test takers as noted in Table 4.

By observing residents during the first phase of usability testing, we were also able to document instances where the content material required extensive time to complete or created confusion. During focus group discussions, residents expressed satisfaction with the pace and scope of the material and identified module resources that they regarded as particularly valuable (eg, patient consent forms, checklists).

Discussion

This study examines an approach to developing online learning modules for family medicine residents. We followed guidelines identified in the literature and obtained evaluative input at several stages in the process, which allowed us to troubleshoot navigation errors and points of confusion. Our results highlight the importance of establishing a protocol for monitoring module development and contribute to an understanding

of the opportunities and limitations involved in developing online curriculum for a residency.

Our findings support the feasibility of using a formal online module development process for creating and delivering content to resident learners. Our team approach to preparing, developing, and presenting educational material represented a paradigm shift away from traditional work methods, and the creation of online teaching methods was itself a new experience for many. Limited faculty development was required to make effective use of Web authoring software and to reorient module authors' conceptualizations of educational flow for the online environment. Despite their ability to successfully develop Web-based modules, author feedback indicated that learning to conceptualize the design of Web-based instructional material and using Web authoring software posed the greatest challenges. They also cited scheduling time to work on the module as a significant challenge.

This methodology may be particularly useful to programs that face geographical challenges to ensuring that residents can attend didactics or those that wish to assign required content to specific rotations. Modules were developed for several different educational applications, including creating a structured didactic experience for a "night float" rotation, as required preparatory material before certain clinical experiences, and to expand the didactic curriculum relative to specific rotations. As residency programs increasingly utilize shifts rather then call schedules in response to work hours requirements, this learning strategy may have expanded applications. Online modules allow residents to receive didactics at a time and place convenient to them, work at their own pace, interact with content tailored to their clinical and educational needs, and review familiar material when needed clinically.[1,2]

Online materials were generally well accepted by residents in this study. Residents perceived that the modules met their educational goals and contributed to understanding of core content. They found the modules user-friendly and regarded clinical relevance as an important consideration in reviewing content. When asked about suggestions for improvement, residents most frequently recommended expanding the use of graphics/videos, case studies, and review materials. They also recommended reducing text density whenever possible.

Resident pretest/posttest scores showed statistical improvement for the majority of modules. During the development process, an emphasis was placed on the alignment of goals and objectives with module content and test questions. If material was well aligned and appropriate for the intended learners, we considered whether modules with lower improvement scores contained design challenges and required revision in the technical delivery, educational format, or the content density. The vast majority of modules were completed by residents in one session with the pretest/posttest scores therefore reflecting knowledge gains acquired through exposure to module content.

Modules were utilized in the curriculum in several different methodologies, which may have an impact on their educational utility. Some modules were intended as core didactics, similar to traditional lectures, to ensure that all residents have exposure to content not found

Table 3: Characteristics of Residents Involved in Module Evaluation and Pretest-Posttest Testing

	Number/Percent	
	Evaluations (143 submissions)*	**Pretests-Posttests (157 submissions)***
Gender		
Male (n=13)	36 (25.2)	35 (22.3)
Female (n=32)	107 (74.8)	122 (77.7)
Year		
HOI	66 (46.2)	76 (48.4)
HOII	58 (40.6)	58 (36.9)
HOIII	19 (13.3)†	23 (14.6)†
Computer and Internet Expertise		
Beginning	1 (1.0)	0 (00.0)
Intermediate	119 (83.2)	129 (87.8)
Advanced	23 (16.1)†	18 (12.2)
Previous Experience–Online Module Use		
None	4 (2.8)	6 (4.1)
One module	30 (21.1)	25 (17.1)
Two or more modules	108 (76.1)	115 (78.8)
Previous Exposure–Module Content		
None	8 (5.5)	6 (4.1)
Very little	33 (23.1)	29 (19.7)
Some	63 (44.1)	72 (49.0)
Moderate amount	35 (24.5)	36 (24.5)
Great deal	4 (2.8)	4 (1.4)

* *n*=aggregated response totals

† Total ± 100 due to rounding

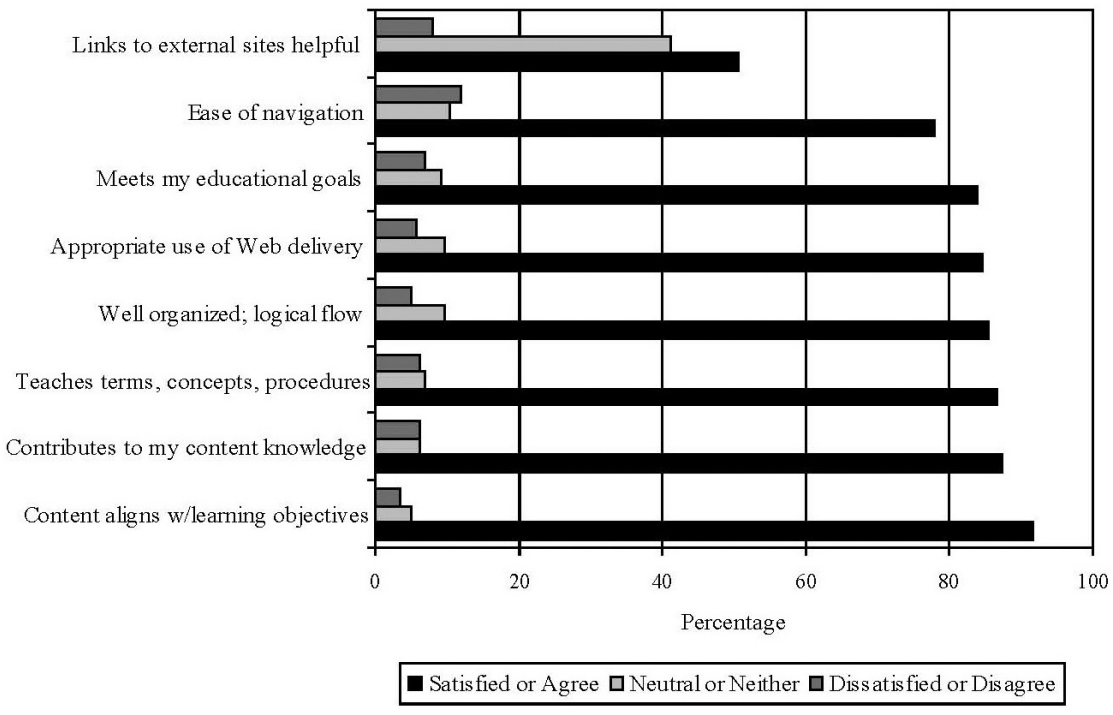
elsewhere in the didactic curriculum. Other modules were intended as preparatory for a rotational experience (ie, neonatal circumcision), with completion expected prior to the intended clinical work. The short-term knowledge gains demonstrated in this study are likely relevant in this latter application as the information was needed shortly after completing the module. The ability for residents to maintain and access learned information at later times when clinically necessary warrants further investigation.

We found that modules with overly dense content were difficult for residents to complete within a reasonable timeframe (20–25 minutes). About half of the residents also reported dissatisfaction with use of external hyperlinks but regarded internal hyperlinks as useful for transitioning in and out of core material and facilitating return to areas of interest. The potential for distractions in online education is high, so maintaining focus on core objectives remained a key concern. Video clips allowed a unique presentation style for teaching musculoskeletal examination skills. Research indicates that visually enhanced learning improves long-term retention[26,27] and that moving scenes are better retained than single static images or still pictures.[28,29] Despite a positive response to video usage in our study, residents offered considerable comment on the importance of keeping the length of video clips short. Residents found video most effective when used to demonstrate specific exam skills or key procedural points.

Research on learning preferences suggests there may be a benefit to dividing module pages into discrete components (text, images, utilities, etc) to provide navigational options to the learner.[12] Results of our research support these findings in that residents expressed satisfaction with modules that contained Web pages with divided interfaces. Such formats added dimension to the learning experience and allowed residents to explore topics in greater depth without disrupting the intended flow of information.

This research has several limitations. Our sample size is small, and not every resident completed each module. We focused on module development in a single medical school-based residency program, and content was customized to the needs of that program. Generalizability to other programs has not yet been demonstrated. Further, resident and faculty evaluations were based on self-reports, which can be limited in accuracy.[30] For example, their reporting of previous experience in creating Web-based instructional material may have been overrepresented due to our faculty experience in posting PowerPoint™ presentations online. Also, the relatively small number of

Figure 1: Resident Usability Testing—Evaluation Survey Results (143 Evaluations Submitted)*



* *n* = aggregated response totals.

Table 4: Results of Resident Pretest/Posttest Knowledge Assessments

Module	n =		# Quiz Items	Mean Score	SD	t =	*P* =*	Effect Size
Elbow	9	Pre-Module	6	59.1	31.64	3.88	.005	1.83
		Post-Module		100.0	0.00			
Endometrial biopsy	5	Pre-Module	18	83.3	4.27	2.02	.113	-
		Post-Module		91.4	8.83			
Foot/ankle	10	Pre-Module	11	33.9	28.29	4.01	.003	2.08
		Post-Module		87.4	22.81			
GERD	5	Pre-Module	11	77.2	3.01	5.90	.004	3.18
		Post-Module		92.3	5.99			
Guided imagery	6	Pre-Module	30	78.4	20.87	0.88	.419	-
		Post-Module		87.9	11.86			
Hip	7	Pre-Module	11	53.2	24.19	2.85	.029†	1.59
		Post-Module		86.3	17.49			
IUD	6	Pre-Module	26	63.0	13.23	2.61	.048	1.71
		Post-Module		80.3	5.54			
Joint injection	17	Pre-Module	9	77.9	16.37	3.18	.006	1.26
		Post-Module		94.8	9.44			
Knee	14	Pre-Module	5	70.8	30.91	3.53	.004	1.21
		Post-Module		97.6	4.68			
Mind-Body	24	Pre-Module	13	75.4	18.33	2.99	.007	0.49
		Post-Module		85.1	21.63			
Neonatal circumcision	11	Pre-Module	25	49.9	11.65	2.10	.062‡	-
		Post-Module		63.9	17.43			
Obesity	7	Pre-Module	9	39.2	8.95	17.00	.000	6.48
		Post-Module		94.0	8.01			
Osteoporosis	5	Pre-Module	24	71.3	12.39	5.21	.006	2.03
		Post-Module		90.2	4.51			
Skin surgery	10	Pre-Module	18	72.7	17.26	2.97	.016	1.11
		Post-Module		88.5	10.34			
URI	13	Pre-Module	3	46.2	21.71	5.20	.000	2.49
		Post-Module		92.3	14.60			
Vasectomy	8	Pre-Module	12	50.9	20.04	7.95	.000§	2.76
		Post-Module		93.8	9.16			

* 2-tailed, paired *t* test calculated at 95% confidence level

† *P*=.073 with delayed resident excluded

‡ *P*= .106 with the 2 delayed residents excluded

§ *P*=.000 with delayed resident excluded

GERD—gastroesophageal reflux disease

IUD—intrauterine device

URI—upper respiratory infection

questions on some module quizzes limits our ability to fully assess resident learning outcomes, and the improvement in knowledge scores only assessed short-term learning gains. Additional research will be needed to more fully measure the educational impact of module use on residents.

Our results suggest that resident users have little patience for even minor technical or navigational difficulties. Therefore, programs utilizing online modules should be prepared to support ongoing technology changes given that system or

software upgrades may affect functionality. In this study, links to external Web sites did not extend the usability of the learning modules to any great degree. Usage of such features has not been well studied and, while many educators assume that the addition of supplementary resources represents an improvement, our results provide limited evidence favoring the utility of investing the additional time, effort, and resources required to create a unified learning path.[12] Additional research into optimal educational flow will be welcomed as educators consider the expanded use of technology in their curricula.

Conclusions

Online modules can assist in the distribution of learning opportunities in a residency training program. Multiple methods of data collection can be used to provide important information to module developers and support staff to address training issues, support authors, and improve module ease of use, navigation, and content.

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