Reaching Beyond the Invisible Barriers: Serving a Community of Users with Multiple Needs

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Abstract. This paper discusses a four-phase model for evaluating multi-media learning materials that emphasizes the diversity of learners and variations in instructional needs and user characteristics. The authors begin with an overview of the model, supporting evidence for its use, and key characteristics of users supported by each of the phases. They then focus on results of a current use that emphasized stage four, real-time usability, and show how they were able to document that the models under review met the needs of diverse learners and varied instructional strategies.

Keywords: Human-computer interactions; user characteristics, effect of use; collaborative learning.

1 Introduction

The role of the student in technology-supported learning is no longer viewed as that of a passive recipient, but instead, is perceived to be the key that unlocks the process of development and use [1,2]. Earlier technology transfer practices based the development of computer assisted instruction and technology supported learning on the assumption that "technology is better" and assumed that we only needed a few research studies to find clear evidence of technology's impact [3]. Most of the studies that were conducted as part of this development were based on elementary information processing theories and compared alternate modes of delivery (e.g., computer vs. in-person) or alternative sequencing and/or degrees of use [4]. The emphasis of both development and research was on how to use technology to transfer or deliver new technology and the development of best practices in design and development. Results of these studies did not meet expectations of those who were designing and developing technology supported curriculum and instruction; in most cases, there was little, if any, clear evidence that instruction with technology resulted in greater cognitive outcomes than did other forms of in-class or distance education [5,6]. What did become clear, however, was that the individual learner played an important role in the process. Even when assuming an objectivist, teacher-centered approach to learning, it became clear that human- computer interactions and subsequent learning were in some way related to key learner characteristics such as learning style, gender, familiarity with content, technology anxiety, and motivation to learn. In sum, good design, that is "making technology use better," required attention to learner variations. At the same time that technology-supported curriculum was

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expanding to include the dynamics of the user, the role of the learner in the overall process also was expanding. Constructivism and student-centered learning, coupled with social cognitive psychology, was identified as supporting the acquisition of many of the expected outcomes of technology-supported transfer of knowledge [7,8]. Using the assumptions of Vygotsky, Bruner, and other social psychologists [9], it was believed that not only did different learners bring their own characteristics to the process but that good technology-supported models would allow for instant scaffolding of materials that would assist in developing individual patterns of learning. As a result, designers and developers had to create technology-supported materials that would be adaptable to different styles of learners as well as different levels within a particular style. This broader definition of human computer interactions is now an important part of both design and use.

2 Purpose of the Study

The purpose of this paper is to present an evaluation model that is effective in documenting a constructivist, student-centered approach to technology-supported curriculum and instruction design and key user variables that should be considered as part of the process. Using examples of multi-media materials developed and piloted for pre and initial engineering classrooms, the paper discusses why we need to expand our boundaries of human computer interactions to include the needs of multiple users as well as some of the ways we can document the utility of the technology supported materials for varying types of users. A focal point of the presentation is findings related to stage four of the model, "real time usability" and key user variables that have been documented as being important at that stage.

3 The User Centered Model

If learner characteristics are important factors in the development of technology-supported instruction, it is necessary that these characteristics be reflected in the design and evaluation of modules that support learning. The challenge for IT managers is to lead development teams in designing technology-supported systems of learning that will facilitate the acquisition of factual and structural knowledge and its meaningful integration into the cognitive frameworks for learners from different backgrounds and with different degrees of prior knowledge [10]. As a result, the optimal goal is to structure the external conditions in a manner that will facilitate internal learning and information processing within each learner's zone of proximal development or scaffolding level. To meet this need, Newman [11] developed a multi-stage process for team leaders to use in designing, validating, and documenting IT learning systems. Each stage of the model involves acknowledgment of users' characteristics, their prior levels of knowledge, skills and experiences, and the external, contextual variables that influence the formation of new learning systems. The model was used to develop and validate approximately 100 modules in multiple settings across multiple content domains for multiple types of users. Extensive notes on the process were developed for each stage and module. A meta-analysis of the process across these users resulted in the identification of four phases involving assessment and inclusion of user characteristics [See 12]. The first phase identified by the meta-analysis is related to *content review*. Designing modules for learning systems typically requires use of experts in the field who are extremely knowledgeable about the content being created. Thus, the first phase recognizes cultural and contextual variables consistent with the biases of the designer and developer; it consists of an external validation of the module content. In the user-centered model, the design team utilizes experts representing theory and practice. Content area faculty and field based professionals review the instructional content and the proposed use of the content in various applied settings. The second reoccurring phase found in the meta-analysis consists of the need for an *instructional technology review* by experts in information systems design. The critical factor in these reviews is whether or not the technical design of the learning system acknowledges learner variables. Initial reviewers who are part of the design team work with project staff on a regular basis, providing formative feedback on user-centered needs. In addition, external reviewers who are specialists in instructional design and technology review and rate each system and/or module, assessing the relevance and flexibility of the presentation mode for different types of learners, and the flow of instruction and learning. *Usability evaluation* (phase three) specifically assesses the modules for relevance across different learning styles, prior experience with content, and previous experience with the specific mode of technology-supported system that is being developed. At least four types of learners should be involved in this process, those who are novice or experts in the content area and those who are novice or expert in the technology mode. In addition to being observed in the use of the module, participants also should be encouraged to “think aloud” as they go through the module, that is, to verbalize freely what they are thinking throughout their experience. The goal is to ‘get inside the learners’ head’ and elicit what they were doing and why; this progression through the module along with the “think aloud” comments is videotaped and used to determine sequences and patterns of module use by different types of learners and the ability of the module to be effective for varied types of users. Where possible, variations in learning style also should be recorded. The fourth phase that consistently yields relevant information about users’ characteristics involves direct observation of module use in *“real-time” settings*. This phase provides project staff with formative feedback on the utility of the modules in varied learning settings and work contexts. Procedures include observation of the use of the module, surveys of users, interviews with randomly selected learners, and follow-up interviews with instructional staff and developers.

4 The Program Under Study

4.1 The Modules

A multi-year project[1] involving the design, development, and evaluation of student initiated, student-centered learning tools utilizing innovative web based curricula in the pre-engineering and engineering domain serve as the background for this

[1] For more information on this project see http://www.academy.rpi.edu

investigation. The goal was to develop modules that would assist in presenting or creating knowledge in a manner that would allow for immediate transfer to practice in applied settings while motivating and rewarding learners as they progressed through the modules. Factors that needed to be considered as part of the development included students' gender, English as a primary language, prior use of technology and modules in learning settings, and variations in prior knowledge and experience. The modules also had to meet the needs of differing instructional strategies and teaching settings. To facilitate the development of the modules, a team consisting of discipline-based faculty, professionals from the specific content field, and specialists in learning, instructional design and evaluation, and technical developers was created. A formative, cyclical process of development, assessment, and evaluation was established that allowed the team to share information on an on-going basis, use discussion and feedback to make decisions and refinements in the process and the products, and share findings of intermediate outcomes. Provided in Table 1 is a partial summary of the modules under review and their ultimate uses in the classroom.

Table 1. Models of Module Utilization

Observed Classroom	Mode of module utilization	Activities during module utilization	Duration of module utilization
	Amplifier Circuits		
Classroom 1	Embedded instruction	Guided inquiry	45 minutes
Classroom 2	**Summation**	Free exploration	25 minutes
Classroom 3	Summation	Demonstration	10 minutes
Classroom 4	Summation	Guided Inquiry	20 minutes
	Power Factor Correction		
Classroom 1	Summation	Free Exploration	10 minutes
Classroom 2	**Embedded**	Demonstration	20 minutes
Classroom 3	**Summation**	Demonstration	30 minutes
	AC Voltage Regulation and Efficiency		
Classroom 1	Embedded instruction	Guided inquiry	15 minutes
	Filters CAD		
Classroom 1	Summation	Guided Inquiry	30 minutes
	Nodal Analysis		
Classroom 2	Summation	Demonstration	10 minutes
Classroom 2	Summation	Free exploration	20 minutes
Classroom 3	Summation	Free Exploration	40 minutes
	Pole Zero		
Classroom 1	Embedded instruction	***0Guided inquiry***	10 minutes
Classroom 2	Summation	Demonstration	10 minutes
Classroom 3	Summation	Guided inquiry	30 minutes
Classroom 4	Summation	Guided inquiry	25 minutes
	2nd Order Systems		
Classroom 1	Summation	Demonstration	5-6 minutes
	DC Circuits		
Classroom 1	**Advanced Organizer**	Free exploration	20 minutes
	Exploring Connectivity K-12		
Classroom 1	Embedded instruction	Guided inquiry	30 minutes

4.2 Data Sources and Methodology

A series of *content reviews* was conducted for each module by team members who were experts in the material and by potential faculty users and advanced graduate students. The team conducted an initial review at the time of design (e.g., while "storyboarding") and later by independent faculty users and advanced students. The final review was conducted during "real-time" use by students and faculty as part of the final evaluation effort. *Educational technology reviews* were conducted for 12 modules to assess their instructional principles by two experts in the area of learning cognition. The majority of the designed modules focused on the topics and materials covered at the beginning level of engineering undergraduate classes. *Controlled usability tests* (n=12) were conducted on three sample modules to determine their usability for students of differing content and computer ability levels. Each usability test consisted of participants working through a computerized module: one beginner computer user/beginner content, one beginner computer user/advanced content, one advanced computer user/beginner content, and one advanced computer user/advanced content. The purpose of the usability test was to demonstrate the level of computer ability and content knowledge required to successfully utilize the modules.

Multiple data sources and sub-studies were conducted to document *real-time usability*, the focal point of this paper. Paper-pencil surveys were distributed to and collected from undergraduate students who have been exposed to the computerized instructional modules (n=371). Survey respondents were enrolled in introductory Engineering undergraduate classes in 2005-2006. Surveys provided data concerning the level of utilization of the computerized instructional modules, and student perceptions of their affective and cognitive learning. Follow-up individual interviews were conducted with students (n=21) to determine perceptions of the availability, implementation, and utility of the computerized instructional modules. These interviews were conducted in-person at the conclusion of the class sessions. Observations (n=28) were conducted in classrooms to assess the setting and environment of module use, available technological support, and the participants' interaction with the instructional technology, instructors, and peers during module utilization. In addition to this naturalistic data collection, a series of causal comparative and quasi-experimental studies were conducted to test for relationships of module use and learner characteristics.

5 Findings

5.1 Phase 1 and 2: Validation of Content and Instructional Design Integrity

The modules exemplified many of the best practices in multi-media development that facilitate use by diverse learners with multiple needs. Content validation studies indicated the modules successfully presented information that could be used to provide supplemental or alternative content coverage as well as key concepts. Each module not only addressed the concept under study, but also provided examples of real world applications. A brief introduction summarized content and potential instructional applications including multiple ways in which instructors and learners could interact with the concepts. Both stand-alone use and integration-into-classroom instruction was facilitated by the sectioning of learning activities so that the material could be used in a continuous sequential manner or in a user/instructor selection approach. Modules also allowed for free exploration; students could take different paths with each that allowed them to explore some concepts more in depth than others. Many of the units also overtly supported constructivist learning by providing users with suggestions on how they could manage their own process through the modules. As can be seen in Table 1, this flexibility allowed the modules to be used in studio classrooms, for demonstrations/lecture, as part of laboratory projects, and to support distance learning and study outside the classroom.

All modules involved the student in a number of reflective thinking activities, ranging from periodic question-and-answer exercises to direct opportunities to manipulate objects on the screen. Multi-media were incorporated in the forms of graphs, charts, diagrams, pop-up windows, and manipulative (applets). In addition, real-world examples were included. In some cases, graphical organizers and/or concept maps provided alternative representations of the structure of the module and related materials. Each module could easily be used to engage students in open-ended complex problem solving allowing them to develop and provide solutions with the opportunity to comment on the process. In addition, interactive modules were 'playful,' encouraging students to revisit content from different perspectives, and to take responsibility for their own learning. The modules also provided multiple opportunities for students to assess their own strengths and weaknesses.

In addition to interacting with the content, the modules provided students with multiple explicit opportunities to interact meaningfully with each other and/or the instructor. The inter relationships between the illustrations, content material, applets, and practice materials provided settings that supported collaborative work and discovery learning. The modules also provided exploration exercises that could result in collaborative decision-making and promoted peer teaching activities.

Basic tenets of development also were met: modules were carefully screened to eliminate culturally or gender biased language that could offend learners; the screens were simple, balanced, and easy to us; and text was visible, legible, and formatted for meaning. Finally, the differing kinds of content and activities were distinguished from each other in a consistent fashion with graphs, charts, and diagrams emphasizing important themes.

5.2 Phase 3: Controlled Usability

Controlled usability studies also documented that the modules met the needs of diverse users. Each type of user accessed information in a different pattern but was able to accomplish the expected tasks. Participants with high levels of technical skills and content knowledge could easily navigate within looking at both content and sequence; because they were familiar with the content, they attached meaning to the module structure and looked for their own pattern of information. Novice users, on the other hand, used the module in a very sequential pattern, going through each stage as presented and not moving forward until that phase was mastered. Content expert-novice module users spent more time looking at the layout of the module content and developing a cognitive structure for use; they then moved to those sections that provided them with the content they wanted to access and skipped over uses that were not of interest or were areas where they already understood what would happen. Module expert-content novices reviewed the layout of the module first, tried a few sample experiments to make sure they understood the command structure, and then began to sequentially go through the content. Participants, who were experts only at content but not module use, found that they could increase their knowledge base, but did initially experience difficulties navigating within some specific modules. Overall, use indicated that if allowed to work through the module in a self-selected manner, all could complete the tasks and develop their own knowledge base.

5.3 Phase 4: Real Life Usability

As noted in Table 1, faculty utilized the modules in different ways: as an advanced organizer, embedded into particular class activities, or for the purposes of summation and review. In the advanced organizer mode of module utilization, the module was typically introduced at the beginning of the class to provide a framework for the session that followed. In the embedded instruction mode, the instructor would usually embed the module into the lecture to illustrate particular concepts or into activities as a problem-solving tool. In the summation mode of module utilization, the module was usually introduced at the conclusion of the class to provide another application of the material covered in class, or as a means to assist students in their homework assignments. In a typical session, the faculty would introduce the module as a supplementary material, which would reinforce the material covered in class. Instructions of how to navigate the module were thoroughly provided, and numerous applications of the modules were examined through examples. Students were expected to engage in a variety of activities in the process of module utilization; these included free exploration, guided exploration, or use of the module to complete an assigned activity. In many of the instances, students were given an opportunity to freely explore the module capabilities and draw conclusions of the modules specific applications. The modules also supported more traditional instructor–centered modes of teaching when use was restricted to instructor demonstration only. The module also supported variations in time of use; the duration of module exposure ranged from 10 to 45 minutes depending on the instructional messages that were conveyed. More complex modules incorporating multiple concepts required significant investment of class time and were used throughout consecutive sessions.

The majority of the students rated the different modules utilized in instruction favorably in terms of relevance, usefulness and organization of the information, and opportunities provided to practice course content; however, there were variations in the students' ratings based on key user characteristics. As indicated in Table 2, 95% of the students reported that the information presented in the module was relevant to the course content; 86% of students indicated that the modules provide opportunity to practice the course content, and 85% percent of them noted that the information presented was useful with regard to the real practice. Some variations by student characteristics were evident. Males tended to find the modules to be more useful in regard to practice than did females; autonomous users also noted them to be easier to understand and more related to course content. Collaborative learners, however, found the information to be more relevant; this latter response may be related to gender of subjects and should be investigated further. These findings were supported during interviews; several students indicated that most of the modules were easy to understand and self-explanatory. Students also pointed out that the modules served as a good reinforcement of content that had been taught and helped them to review the course material for exam purposes. Many indicated that the effective use of the modules was facilitated by the quality of the instructor-student interactions and the opportunities provided to students to interact with peers. These factors also increased their interest and motivation. The observational data gathered confirmed that the use of the module increased student interest and tended to increase their motivation to stay on task. Additionally, observers noted that the use of the modules tended to add to the class dynamic and facilitated the effective use of group work. In interviews and on surveys, students indicated that the use of the modules facilitated collaborative group work; 67% of the students indicated that module utilization facilitated the process of collaboration with peers. Working with fellow students in solving problems was perceived as not only increasing the level of interactivity in the session but also as enhancing students' understanding and comfort with the material covered in class.

Table 2. Perceptions of Relevance By Student Characteristics Percent of Agreement

Type of Use	Gender		English Primary		Prior Use		Current Use		Total
	Male	Female	Yes	No	Yes	No	Auto	Co	
The information presented is relevant to the course content.	96	92	97	89	95	98	**93**	**98***	95
The information presented is useful with regard to course content.	92	88	91	96	91	94	**89**	**84***	91
The module provides opportunity to practice the content.	**88***	**75**	87	83	85	87	85	88	86
The information presented is easy to understand.	84	82	84	81	84	83	**88**	**81***	84
The information is well organized.	86	84	86	85	86	89	87	85	86
The information presented is useful with regard to real practice.	**86***	**76**	84	87	84	87	83	86	85

% agreement on 6 point scale (responses to three levels); * more than one standard error of measurement difference.

Data also indicated that diverse user needs were met, but differentially, when specific module and course goals were targeted. The modules were perceived as having helped the students to visualize problems, develop problem-solving skills, apply course content to new problems, and recall course content. Students indicated also that they would like to receive more explanations and guidelines on the appropriate use of the modules. As noted in Table 3, the majority of the student participants positively perceived the use of several modules with regard to specific learning outcomes. Specifically, 85% of the participant students perceived that the modules helped them to think about problems both in graphical and pictorial ways. On further query via interviews, a majority of the students commented on the graphic/visual component of the module, indicating that it was an aid to learning. Some of the students noted that the ability to see the layouts of the circuit, and the capability of changing the layout graphically, helped them to compare and understand concepts better. When queried as to the direct relevance to course content, 79% agreed that the modules helped them to better recall course content; during interviews, students reported that the modules reinforced the material covered in the classroom even if used before content presentation. Additionally, 72% of the students noted that use of the modules helped them to develop skills in solving problems with regard to the specific aspects of course content. Although both groups were positive about module use, those who used it in a collaborative setting had greater perceptions of its ability to help construct or reinforce specific content. Evaluator observations indicated that students in these settings not only used the module but also verbalized the findings in order to work with a partner. This additional reinforcement and extension of learning may be a facilitator to long-term learning that is not available with autonomous learning.

Table 3. Perceptions of Effect on Specific Learning Outcomes by Student Characteristics Percent of Agreement

Type of Use	Gender		English Primary		Prior Use		Current Use		Total
	Male	Female	Yes	No	Yes	No	Auto	Co	
Helped me think about problems in graphical or pictorial ways	85	82	84	87	85	86	**79**	**89***	85
Recall course content	79	80	79	78	79	78	**75**	**84***	79
Develop my skills in solving problems in the course content	72	73	71	73	72	73	72	72	72

% agreement on 6 point scale (responses to three levels); * more than one standard error of measurement difference.

As noted in Table 4, effect of module use on general learning or course-wide goals are less emphatic. Between one-half and three fourths of students perceived positive outcomes in this domain but degrees of support were noted by student gender, English as their primary language and their use in autonomous or collaborative settings. Overall, 76% of the students perceived that they were better to apply course content to new problems, and more than two thirds of the students (68%) stated that the use of the module helped them to develop different approaches of solving problems and transfer knowledge and skills to problems outside of the course. During interviews, many students reported that the module helped them to understand course material; a few students indicated that the module had the potential of going beyond the course content. One of the features that students indicated they liked was the ability to input any number and observe the output immediately. This allowed them to try out different inputs thereby providing opportunities to practice content. Observations of classroom usage of the computerized instructional modules showed that the modules engaged students in problem solving tasks, encouraged students to revisit content from different perspectives, and helped them to take responsibility for their own learning.

Table 4. Perception of Effect on General Learning Outcomes by Student Characteristics Percent of Agreement

Type of Use	Gender		English Primary		Prior Use		Current Use		Total
	Male	Female	Yes	No	Yes	No	Auto	Co	
Apply course content to new problems	**78***	**67**	**74**	**84***	75	82	**73**	**80***	76
Develop different ways of solving problems	**66***	**77**	67	73	66	77	**63**	**71***	68
Transfer knowledge/ skills to problems outside of the course	67	63	**65**	**73***	66	69	**64**	**68***	66
Improves grades	58	57	59	55	59	51	**61***	**55**	58

% agreement on 6 point scale (responses to three levels); * more than one standard error of measurement difference.

The majority of students perceived module usage as increasing their knowledge base and understanding in the specific content area. Additionally, students were more active and engaged during module usage than during the lecture portion of the class, and students' confidence of using computerized instructional modules increased as a result of module usage. As noted in Table 5, students agreed that the modules met their learning needs (77%), assisted in increasing their knowledge (73%), enhanced their confidence in the content area (67%), and motivation (64%). Important variations were noted by student gender, English as primary language, prior use with modules and autonomous/collaborative uses. Classroom observations noted that when students used the modules working in teams they were highly engaged and motivated. During interviews, those students for whom English was not their primary language reported that they preferred the hands-on experience more than classroom teaching, as did students with no prior experience. During the interviews, some students voluntarily suggested that the modules be used as advanced organizers, noting that if they had been introduced in the class prior to going through all the content material, they would have grounded later learning of theoretical content. Amount of time was noted to be important; classroom observations showed that some students had a difficult time completing the module activities during the allotted time; many wanted more time to free-explore the concepts and develop their own pattern of interactions.

The modules also were reported to have a positive impact on the students' learning affect (See Table 6.) Overall, students reported that use of the modules positively affected their confidence in their knowledge of the content (81%); their interest and motivation (66% and 68%, respectively) and attitudes related to their ability to

Table 5. Perception of Cognitive Benefits by Student Characteristics Percent of Agreement

Type of Use	Gender		English Primary		Prior Use		Current Use		Total
	Male	Female	Yes	No	Yes	No	Auto	Co	
The module suits my learning needs.	79*	63	76	80	78	76	78	78	77
My knowledge has increases as a result of the module	**74***	**65**	**71**	**83***	**71**	**81***	**70**	**76***	73
My confidence in the content area has increased because of the module	67	67	**66**	**85***	**65**	**76***	66	67	67
The module content is motivating.	64	66	**63**	**74***	63	68	**62**	**67***	64

% agreement on 6 point scale (responses to three levels); * more than one standard error of measurement difference.

Table 6. Perception of Effect on Learning Affect by Student Characteristics Percent of Agreement

Type of Use	Gender		English Primary		Prior Use		Current Use		Total
	Male	Female	Yes	No	Yes	No	Auto	Co	
Developed confidence in content area	**81***	**73**	78	84	79	84	**79**	**83***	80
Developed interest in content area	66	67	63	82*	66	64	**63**	**68***	66
Developed attitudes of self-direction and self-responsibility	62	61	**60**	**71***	62	59	**59**	**64***	62
Became motivated to learn course content	68	73	67	78*	67	73	**65**	**70***	68

% agreement on 6 point scale (responses to three levels); * more than one standard error of measurement difference.

self-direct and become responsible for their own learning (62%). An important common student use was noted for this set of variables. Student who used the material in a collaborative manner reported greater affect development than did those who were involved in autonomous learning settings.

6 Conclusion

Overall, the students reported that the modules provided supplemental or alternative methods of instruction that could assist them in learning the core concepts presented in the introductory courses of Electrical Engineering. The majority of students also noted signs of individual outcomes pertaining to learning affect. Specifically, they perceived module usage as increasing their knowledge base and understanding in the specific content area, helping them to visualize problems, develop problem-solving skills, apply course content to new problems, and recall course content. Additionally, students were observed more active and engaged during module usage than during the lecture portion of the class.

Key variations were noted that support the acknowledgement of user characteristics and the need to ensure that the modules meet the needs of these users. Although both groups had overall positive perceptions of module use, male students had higher perceptions on several dependent constructs including the modules' relevance toward practice in the classroom, practice with real variables, their ability to tie content to new problems, and general problem solving. Male students also reported that the use of the modules better met their learning styles than did the female students and self-reported greater increases in knowledge and in confidence in their own ability. Female students, however, reported gains in knowledge on developing different patterns of problem solving than did male users.

Variations also were noted for perceptions based on whether learning took place in required autonomous or group settings. Those who did participate in group or collaborative use reported greater relevance to the course, greater gains in pictorial and visualizing skill, more direct recall, better application to new problem settings, and greater transference of learning. These students also reported more gains in knowledge, more motivation, confidence in mastery of material, greater interest in learning related topics, and greater gains in self-direction and control of learning than did those who worked alone. Students who worked alone found the module, itself, more useful and easier to understand, and reported that use improved their grades.

Students with no prior experience also reported positive outcomes. They perceived higher levels of transfer and problem solving skills than did those students with prior experience and reported greater gains of knowledge and confidence.

Overall, these data support the use of web-based learning modules for all types of learners but provide extra support for those that are constructivist in nature. Modules that require students to interact, develop their own cognitive framework, and present or share that knowledge with others appears to be especially useful. Further research is needed on the interaction of key student variables and how they moderate the impact of each for the five constructs under study. In addition, instructor/user characteristics also should be examined to determine if key modes of use might influence use. For instance, does the use of embedded module use impact outcomes for selected types of students differently than does rehearsal or demonstration use? As designers, developers, evaluators, and users commit greater teaching roles to on-line or web-based tools answers to these questions must be found. The use of user centered approaches to module development and documentation will assist in this process and should be encouraged.

References

1. Lambropoulos, N.: User-Centered Design of Online Learning Communities. In: Lambropoulos, N., Zaphiris, P. (eds.) User-Centered Design of Online Learning Communities. Hershey, PA, IDEA Group, Inc. pp. 1–28 (2007)
2. Papastergiou, M.: Attitude as Predictor of Success in Online Learning. International Journal on E-Learning 5, 593–622 (2006)
3. Akhras, F.N., Self, J.A.: Modeling the Process, Not the Product, of Learning. In: Lajoie, S.P. (ed.) Computers as Cognitive Tools: No More Walls, vol. II, pp. 3–28. Lawrence Erlbaum Associates, Mahwah, NJ (2000)
4. Newman, D.L.: Taking Learner Characteristics into Consideration: Improving Development and Use of Technology Supported Learning. In: A paper presented at Human Computers Interaction (HCI) International Conference, Las Vegas, NV (2005)
5. Pierson, M.: NTLS VII: Key Research Questions for Technology and Core Content Disciplines. Journal of Computing in Teacher Education 22, 47–48 (2006)
6. Thompson, A.D.: Scientifically Based Research: Establishing a Research Agenda for the Technology in Teacher Education Community. Journal of Research on Technology in Education 37, 331–338 (2005)
7. Cheng, Y.C.: New Paradigm of Learning and Teaching in a Networked Environment: Implications for ICT Literacy. In: Wee Han, L.T., Subramaniam, R.(eds.) Handbook of Research on Literacy in Technology at the K-12 Level. Hershey, PA, IDEA Group, Inc. pp. 1–20 (2006)
8. Sugrue, B.: Cognitive Approaches to Web-Based Instruction. In: Lajoie, S.P. (ed.) Computers as Cognitive Tools: No More Walls, vol. II, pp. 133–162. Lawrence Erlbaum Associates, Mahwah, NJ (2000)
9. Law, E.L.C., Havannberg, E.T.: Quality Models of Online Learning Community Systems: Exploration, Evaluation, and Exploitation. In: Lambropoulos, N., Zaphiris, P. (eds.) User-Centered Design of Online Learning Communities. Hershey, PA, IDEA Group, Inc, pp. 71–100 (2007)
10. Nemeth, C.P.: Human factors methods for design: Making systems human-centered. CRC Press, Boca Raton, FL (2004)
11. Newman, D.L.: Rensselaer Polytechnic Institute Project Links: Mathematics and Its Applications Across the Curriculum. A technical report, Evaluation Consortium, University at Albany/SUNY (1998)
12. Newman, D.L., Passa, K.: The role of user characteristics in the development and evaluation of E-learning systems. In: Law, W.K.(ed.) Information resources management: Global challenges. Hershey, PA: Idea Group Publishing (in press)