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Interactivity and interactive functions in web-based learning systems: a technical framework for designers

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Abstract

The concept of interactivity and its implications for Web-based learning system design is re-examined. The author reviews the literature on the interactivity concept from the perspectives of communication, computer-assisted instruction, distance education, and interactive dimensions and functions for Web systems. A proposal is then made for a technical framework for including such dimensions and functions in Web-based learning systems. To enhance the framework's ease-of-use and overall effectiveness, each interactive function was submitted to two panels of experts for assessment and evaluation in terms of instructional necessity and programming difficulty. A discussion of the panels' feedback and the potential for future research concludes the article.

Introduction

Interactivity—a fundamental aspect of traditional face-to-face teaching—is a central concern in the design of such mediated instructional settings as computer-assisted instruction (CAI), computer-assisted learning (CAL), Internet-based learning, and Web-based learning (WBI). Draves (2000) argues that it is the quality of interaction, but not content, that determines whether real learning takes place. Sim (1997) believes that interactivity plays a crucial role in knowledge acquisition and the development of cognitive skills, and that interaction is intrinsic to effective instructional practice and individual discovery. He is careful to point out that interactivity in computer technology was often limited to simple menu selections, clicking on objects, and linear sequencing. In the field of human-computer interaction, interactivity has generally been measured in terms of input or output devices—for instance, the number of "point and click" opportunities on a computer screen (Shneidermann, 1998). As Sim (1997) also notes, basic interactivity should not automatically be deemed as inappropriate, but it should be scrutinized according to levels of interaction that are considered adequate or relevant to knowledge acquisition or skills development. Educational applications especially require higher degrees of interactivity in order to enhance learning potential.

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As the Internet gains greater stature as a major teaching/learning technology, the interactivity concept will need continuous re-examination and updating in terms of operational guidelines for designers. If interactivity is accepted as one of the most important features of Internet- and Web-based learning systems—as it is for all other teaching and learning processes—then we must identify what makes some systems effective while others fail. As Berge (1999) and Northrup (2001) note, interaction doesn't just happen—it must be intentionally incorporated into a Web-based learning design.

Accordingly, this article is to re-examine the interactivity concept and its implications for interactive function design in Web-based learning systems. Based on the Internet's dual status as a communication and educational technology, the following literature review will focus on the interactivity concept from the perspectives of communication, CAI, and distance education. The review will also include studies on interactive Web site functions. A proposal will then be offered for a technical framework for interactivity dimensions and interactive functions for Web-based learning systems. To enhance the framework's ease-of-use and overall effectiveness, each interactive function was submitted to two panels of experts for assessment and evaluation in terms of instructional necessity and programming difficulty.

Interactivity in communication technology

Current communication technologies that feature increased interactivity include two-way cable television, computer-mediated communication systems, and computer networks. Rice (1984) defined "new media" as consisting of communication technologies that "allow or facilitate interactivity among users or between users and information" (p. 35). According to Heeter (1989), the term "interactivity" was rarely defined directly, yet it was nevertheless cited as a concept that distinguished new technologies. He went on to describe six dimensions of interactivity in these technologies as:

1. Complexity of available choice, meaning the amount and variety of user choices; also referred to as "selectivity".
2. The effort that any user of a media system must exert to access information.
3. Responsiveness: according to Rafaeli's (1985) definition, interactivity is a continuous variable measuring how "actively responsive a medium is to users". Also referred to as "conversationality".
4. Information use monitoring, that is, how well information selection can be monitored across an entire population of users.
5. Ease of adding information, meaning the degree to which users can add information for access by a mass, undifferentiated audience. The most common example is Bulletin Board Systems (BBS) that are comprised almost entirely of user-generated content.
6. Interpersonal communication facilitation, which comes in at least two forms: asynchronous (allowing users to respond to messages at their convenience) and synchronous (allowing for concurrent participation).

Burgoon *et al* (2000) discussed two additional dimensions that support or permit interactivity in communication technology: a) a dimension that allows participants to act

as both senders and receivers of verbal and nonverbal messages and feedback, rather than senders transmitting one-way messages or receivers passively accepting them; and b) a "modality- and information-rich" dimension that provides participants with full access to a wide array of environmental, visual, audio, verbal, and other types of sensory information—in other words, multimedia.

Examining the Internet as a communication technology consisting of Heeter's (1989) and Burgoon *et al*'s (2000) dimensions makes it a richer source of content for users—also described as greater selectivity, meaning that users must exert some effort to access information. With the proper design features, the Internet can be responsive to users' needs and monitored in terms of information use. Internet users can add information by constructing web systems, participating in news groups or chatrooms, or sending posts to a BBS. The Internet's email and chatroom functions allow users to act as equal partners in the communication process, while the Web facilitates access to text, graphics, animation, and audio—in brief, all of the interactivity dimensions described above.

Interactivity in computer-assisted instruction

Borsook and Higginbotham-Wheat (1991) believe that the computer's interactive potential makes it unique in the history of educational/instructional technology and sets it apart from all other instructional devices. They proposed the following "recipe" for interactivity to be followed by all educational software designers:

1. Immediacy of response: to take advantage of the computer's ability to immediately respond to information requests.
2. Non-sequential/non-linear access to information.
3. Adaptability, so that two parties can access information and make alterations non-sequentially.
4. Feedback: that is, the information upon which adaptations are based.
5. A sufficient number of user options.
6. Bi-directional communication channels.
7. Appropriate grain-size, meaning the length of time required for any given sequence before allowing further input; also described as interruptability.

Borsook and Higginbotham-Wheat describe their recipe as a basic guideline of key ingredients that does not require exact duplication in every situation. It is possible for a piece of creative educational software to contain only a "dash" of a particular ingredient, or have different quantities of ingredients in unique combinations. In other words, designers (who they refer to as "cooks") can alter the recipe in order to meet the needs of educators and learners within a particular set of circumstances.

The literature contains numerous definitions and descriptions of interactivity. Weller (1988) describes it as occurring when a learner actively adapts to information being presented by a form of technology, which in turn adapts to the learner; this process is commonly referred to as feedback (see also Vrasidas and McIsaac, 1999). According to Merrill, Li and Jones (1990), interactive transactions in learning involve real-time,

dynamic, and mutual give-and-take between an instructional system and a learner—especially exchanges of relevant information. These definitions address interactivity in terms of the relationship between a learner and the instructional content presented by a teacher or instructional system; in other words, they emphasize learner–computer and learner–information (content) interaction.

Interactivity in distance learning

Moore (1989) has identified three interactive relationships associated with distance learning: learner–content, learner–instructor, and learner–learner interactions. However, Hillman, Willis and Gunawardena (1994) argue that Moore's three relationships do not account for interactions that occur between learners and the technologies that deliver instruction and/or content, and therefore added a fourth: learner–interface. They describe it as the interaction between learners and a technological medium that must occur for the former to have any effective contact with content, an instructor, or other learners. Since successful interaction is highly dependent upon how comfortable a learner feels working with the delivery medium, French *et al* (1999) argues that a) interactivity must be designed to support learning objectives, and b) the interface and infrastructure that support the content must be taken into account when designing interaction features. Therefore, the four types of interactive relationships (or interaction) can help us differentiate the participatory parties (learner, instructor, content, and infrastructure/interface) and their relationships during the newest distance learning environment—the Web-based learning systems.

Interactivity for Web systems

A few researchers have offered guidelines for designing technically interactive Web-based learning functions. French, *et al* (1999) argue that many Web pages have built-in interactivity, even in the absence of interaction with other learners or instructors—for instance, feedback forms, check boxes, and search engines. At the next level of interactivity they list such mechanisms as email, listservs, bulletin boards, and chatrooms. Draves (2000) put together a list of interaction modes that includes single-thread asynchronous discussion forums, threaded bulletin boards, real-time synchronous chatrooms, and email. Draves did not discuss embedded interactivity in Web systems.

Several studies have addressed interactivity in business websites, and have reported data that could be useful for distance learning research and design. Ha and James (1998), in their baseline analysis of business websites' interactivity, defined interactivity as the extent to which the communicator and audience respond to—or are willing to facilitate—each other's communication needs. They identified five dimensions of Web interactivity that fulfill different communication needs:

1. Playfulness: measured by the presence of such curiosity-arousing devices as QandA formats and games.
2. Choice: measured by the number of alternatives for color, speed, language, and other non-informational aspects.

3. Connectedness: measured by the presence of information about the product, company, third-parties, and other content of interest to visitors.
4. Information collection: measured by the presence of such monitoring mechanisms as registration forms and counters.
5. Reciprocal communication: measured by the presence of response mechanisms, including the Webmaster's e-mail address, surveys, and purchase orders.

The primary difference between Ha and James' study and those that preceded it is that the former discussed interactivity within the specific context of websites, and therefore might be considered as providing more useful interactivity measures in that context.

In another article focused on business websites, Ghose and Dou (1998) consider interactivity as an influential factor in improving business website quality. They describe interactivity in a Web context as a multidimensional concept featuring five of 23 possible interactive functions: customer support (eg, online problem diagnostics, feedback), marketing research (eg, site surveys), personal-choice helpers (eg, key word search, dealer locators), advertising/promotions/publicity (eg, online order, sweepstakes), and entertainment (eg, games). Their comprehensive list includes all possible interactive functions. Some—such as "order status tracking"—are very commercial- and consumer-oriented; in a learning context, this particular function could be used for the purpose of "class-status", "assignment-completion", or "questions-to-be-answered tracking" (the last one tracks students' questions to be responded to by the instructor/teaching assistant. (The other 15 interactive functions are: software downloading, electronic-form (e-form) inquiry, order status tracking, comment, product survey, new-product proposal, personal-choice helper, virtual reality display, electronic coupon, user groups, multimedia shows, push media, interactive job placement, electronic post card, and surfer postings.) In a similar manner, the sweepstakes function could be modified to provide special learning incentives to entice student participation in Web-based learning systems. Other examples include using new product proposals for new courses, and using dealer locators as local instructor locators.

A Technical framework of interactive web functions

The interactivity framework described in this article builds on identifiable learner–interface, learner–content, learner–instructor, and learner–learner interaction types, as described by Moore (1989) and Hillman *et al* (1994). The nine interactivity dimensions listed in Table 1 correspond to these interaction types. For instance, the choice dimension has similar counterparts (with different names) described by Heeter (1989), Burgoon *et al* (2000), Borsook and Higginbotham-Wheat (1991), and Ha and James (1998). In Table 2, the technical framework of interaction types is shown in the left column, their interactivity dimensions in the middle column, and their interactive functions in the right column. The list of interactive functions includes some of Ghose and Dou's (1998) 23 items, and the interactivity analysis combines Ha and James' (1998) findings with the present researcher's experience with Web-based learning system design.

Table 1: The interactivity dimensions concluded in this study, their definitions and source

Interactivity dimension	*Definition*	*Source*
1. Choice	The amount and multimedia type of information users (learners and instructors) have access to. It also covers the non-information options users can choose.	Complexity of choice available (Heeter, 1989), modality- and information-rich (Burgoon *et al*, 2000), Options (Borsook and Higginbotham-Wheat, 1991), Choice and Connectedness (Ha and James, 1998)
2. Non-sequential access of choice	Users can access information in a nonlinear way.	Non-sequential access of information and adaptability (Borsook and Higginbotham-Wheat, 1991)
3. Responsiveness to learner	The system responses to a user's request in a non-delayed way.	Responsiveness to the user (Heeter, 1989), Immediacy of response (Borsook and Higginbotham-Wheat, 1991)
4. Monitoring information use	The system can collect data on the users themselves, their selections, their use of information, and so on. The users can monitor information regarding themselves.	Monitoring information use (Heeter, 1989), Information collection (Ha and James, 1998)
5. Personal-choice helper	Information helps learner make better choice of instructional content.	Personal choice helper (Ghose and Dou, 1998)
6. Adaptability	The interaction process and the exchange of information are adapted to individuals.	Adaptability (Borsook and Higginbotham-Wheat, 1991)
7. Playfulness	Information helps to arouse learners curiosity and to entertain themselves.	Playfulness (Ha and James, 1998)
8. Facilitation of interpersonal communication	Difference users can communicate each other asynchronously and/or synchronously.	Facilitation of interpersonal communication (Heeter, 1989)
9. Ease of adding information	Users can add information to the system, content and so on.	Ease of adding information (Heeter, 1989)

The learner–interface interaction type includes four interactivity dimensions and nine corresponding interactive functions that can be included in any system. The primary purpose of these functions is to allow learners to access a Web-based learning system more easily and efficiently. The learner–content interaction type includes seven interactivity dimensions and eleven interactive functions, all meant to help learners grasp richer, deeper, and more individualized learning materials. The learner–instructor (two interactivity dimensions and seven interactive functions) and learner–learner (two

Table 2: The framework for interaction type, interactivity dimensions, and interactive functions in learning web systems

Types of interaction	*Dimensions of interactivity*	*Interactive functions in learning Web systems*
Learner–interface	• Choice • Non-sequential access of choice • Responsiveness to users • Monitoring information use	1. Fixed-frame (menu) design 2. Site map 3. Keyword search 4. Database search 5. Online problem diagnostics 6. Software downloading 7. Online registration 8. Grade status tracking 9. Assignment completion tracking
Learner–content	• Choice • Non-sequential access of choice • Responsiveness to users • Adaptability • Personal-choice helper • Ease of adding information • Playfulness	10. Links to related educational sites 11. Links to related learning materials 12. Multimedia presentation (text, graphics, animation, audio etc) 13. On-line quiz for self-evaluation 14. Push media 15. Individualized learning database 16. Individualized instruction 17. Individualized test/quiz 18. Frequently-asked-questions (FAQ) 19. On-line help on content 20. User guidance on system 21. Study guidance 22. Learner contributing to learning materials 23. Educational games 24. Jokes 25. Sweepstakes
Learner–instructor	• Facilitation of interpersonal communication • Ease of adding information	26. Email to instructors 27. Email to Web master 28. Bulletin board systems (BBSs) 29. Chatrooms 30. Online voting 31. Online survey 32. Comments on the sites, course, instructor, etc
Learner–learner	• Facilitation of interpersonal communication • Ease of adding information	33. Class roster 34. Email to other learners 35. Bulletin board systems (BBSs) 36. Chatrooms

interactivity dimensions and four interactive functions) types are designed to facilitate two-way interpersonal communication.

For the purpose of this article, the interaction types can help categorize relationships between or among participants—including system/interface, content, learner, and

instructor. In order to achieve interactivity goals, interactive technical functions need to be designed into Web-based learning systems. For example, if more monitoring of learner–interface interaction is desired, then current grade status and assignment completion tracking can be incorporated into the system. To facilitate learner–content interaction by providing more content choices, designers can set presentation links to related learning materials on the Web. Or, if learner–learner interaction is the desired focus, interpersonal communication facilities such as chatrooms can be installed.

It is worth noting that some native Web browser features that encourage and facilitate information exchange (eg, back, forward, home) are not listed in the framework. Gilbert and Moore (1998) note that these features only scratch the surface of possibilities for facilitating instructional interactivity. Such specific interactivity dimensions as interpersonal communication (perhaps in the form of a chatroom) still need to be programmed into a Web system. The framework described here assumes that email, chatroom, and shared whiteboard functions are standard parts of Web-based learning systems, so that learners do not need to leave a Web system to use another application for such basic tasks as opening and sending email.

The list presented in Table 2 is not exhaustive, but it can serve as a foundation for later expansion. Brief definitions and some examples of 36 interactive functions are presented in the Appendix.

Technical framework evaluation

Two panels, each with five members, were established to evaluate the functions in terms of effectiveness and ease of use. The first consisted of five instructional designers, each with between four and eight years of experience designing Web-based learning systems. They were asked to evaluate the necessity of each interactive function to support such cognitive interactions as engaging and reflecting, questioning, answering, and discussing (as listed in Berge, 1999), and how those functions might be included in an ideal, generic system. For each function, panel members were asked to check one of four boxes: "must have", "should have", "nice to have", and "OK if missing". Panel discussions were conducted for each item in an attempt to reach a consensus on instructional necessity.

The second panel consisted of five Web programmers, each with three to seven years' experience programming Web-based learning systems. They were asked to evaluate how difficult it would be to implement individual interactive functions in an ideal system. They were asked to check one of four boxes for each function: "very difficult", "difficult", "not difficult", and "easy". A panel discussion was conducted to reach a consensus on the programming difficulty of each interactive function.

Results for the two panels are shown in Table 3. None of the five instructional designers checked "OK if missing" for any of the interactive functions. They agreed on five "must have" and four "should have" learner–interface functions for an ideal interac-

Table 3: The instructional necessity level and difficulty level of each interactive function evaluated by two panel evaluations

Types of interaction	*Interactive functions in learning Web systems*	*Instructional necessity level*	*Programming difficulty level*
Learner–interface	Fixed-frame (menu) design	Must have	Easy
	Online registration	Must have	Not difficult
	Grade status tracking	Must have	Not difficult
	Assignment completion tracking	Must have	Not difficult
	Keyword search	Must have	Difficult
	Software downloading	Should have	Easy
	Site map	Should have	Not difficult
	Database search	Should have	Not difficult
	Online problem diagnostics	Should have	Very difficult
Learner–content	Frequently-asked-questions (FAQ)	Must have	Easy
	Links to related educational sites	Must have	Easy
	Links to related learning materials	Must have	Easy
	Multimedia presentation (text, graphics, animation, audio etc)	Must have	Not difficult
	User guidance on system	Must have	Not difficult
	On-line quiz for self-evaluation	Should have	Not difficult
	Push media	Should have	Not difficult
	On-line help on content	Should have	Not difficult
	Learner contributing to learning materials	Should have	Not difficult
	Individualized learning database	Should have	Difficult
	Individualized instruction	Should have	Difficult
	Individualized test/quiz	Should have	Difficult
	Study guidance	Should have	Difficult
	Jokes	Nice to have	Easy
	Sweepstakes	Nice to have	Easy
	Educational games	Nice to have	Difficult
Learner–instructor	Email to instructors	Must have	Easy
	Email to Web master	Must have	Easy
	Bulletin board systems (BBSs)	Must have	Not difficult
	Chatrooms	Must have	Not difficult
	Comments on the sites, course, instructor, etc	Must have	Not difficult
	Online survey	Should have	Not difficult
	Online voting	Nice to have	Not difficult
Learner–learner	Email to other learners	Must have	Easy
	Bulletin board systems (BBSs)	Must have	Easy
	Chatrooms	Must have	Not difficult
	Class roster	Should have	Not difficult

tive learning system. From the programmers' perspective, some were "easy" to add (eg, fixed-frame design) whiles others were "not difficult" (eg, grade status tracking). The programmers did mention that online problem diagnostics that automatically locate and solve student problem are very difficult to program, especially when students report such problems in natural language.

For learner–content interaction functions, the instructional designers listed five as "must have", eight as "should have", and three as "nice to have". The "nice" functions were jokes, sweepstakes, and educational games—all belonging to the playfulness dimension. While the instructional designers considered these functions as less necessary, the programmers stated that creating links to pages of jokes or adding mechanisms for sweepstakes were "easy" tasks, but that incorporating high-quality educational games was relatively difficult. Furthermore, they described FAQ presentations and links to related educational systems or materials as being technically easy, while stating that customized features (eg, learning databases, instructional content, or tests for individual students) require complex, high-level programming techniques.

For learner–instructor interaction functions, the instructional designers identified five as "must have", one as "should have", and one as "nice to have". Disagreement was noted concerning "on-line voting", with some considering it a means of promoting equal student participation (thus enhancing learner–instructor interaction) and others viewing it as redundant to other two-way communication channels (for instance, chatrooms, surveys, and email). The programmers agreed that communication tools such as email were easy to add to a learning system, and that chatrooms, BBSs, and other related functions were not difficult to incorporate.

Finally, the instructional designers agreed that learner–learner interaction functions such as email, BBSs, and chatrooms were all very necessary, and the programmers stated that such interactive functions were "not difficult" to create and insert.

Of the 36 interactive functions, the instructional designers marked 18 (50.0%) as "must have", 14 (38.9%) as "should have", and four (11.1%) as "nice to have". One designer marked almost every function as "must have". These experts generally agreed that an ideal, generic Web-based learning system should provide as many interactive functions as possible, as long as they were based on a firm instructional design in which learner, content, instructional strategy, and evaluation are considered. The programmers marked 11 (30.6%) interactive functions as "easy", 18 (50.0%) "not difficult", six (16.7%) "difficult", and one (2.7%) "very difficult" to add to a Web-based learning system. Their consensus was that the general programming work would be straightforward as long as the instructional materials, related web systems and pages, email address lists, and other basic details and specifications were both comprehensive and clear.

These results can assist the designers of new Web-based learning systems to consider, along with their instructional design, what interactive functions should be incorporated—given interaction type, interactivity goals, resources (including time and budget), and required programming techniques. For systems already in operation, the results can be used as a checklist for formative or summative evaluations. It is suggested that designers follow their instructional design plan to incorporate the interactive functions marked "must have", "easy", and "not difficult", then consider including the

functions marked "should have", "easy", and "not difficult". If resources allow, all other features should be evaluated for insertion into individual systems.

Discussions and future research

In line with Borsook and Higginbotham-Wheat's (1991) interactivity recipe, this article suggests combinations of technical functions for Web-based learning system designers to consider for inclusion in their products, based on a combination of instructional plans and programming difficulty.

Sims (1997) argues that interactivity implementation can be perceived as an art in that it requires a range of skills, including a) an understanding of the targeted learner; and b) an appreciation of software engineering capabilities, the importance of rigorous instructional design, and the application of an appropriate graphical interface. If Web-based learning systems are to evolve into a valuable learning medium, and if their developers are to gain recognition as professional practitioners, we must learn what makes an application interactive, instructional, and effective.

However, the Web's transient nature (Ha and James, 1998) requires a longitudinal perspective of the evolution of Web systems. The present study is only a snapshot of the early technical stage of Web-based learning system interactivity. As the Internet and World Wide Web evolve, so will the concept of interactivity and its implications for Web-based learning system design. The interactive categories, dimensions, and corresponding functions discussed in this study are neither fixed nor complete; the same is true for each function's level of instructional necessity and programming difficulty. A complete technical framework awaits further research on categories, dimensions, and functions.

Future research efforts could focus on the relationship between technical interactivity and cognitive interactions among learners, including such complex activities as engaging and reflecting, annotating, questioning, answering, pacing, elaborating, discussing, inquiring, problem-solving, linking, constructing, analyzing, evaluating, and synthesizing (Berge, 1999). Interactive functions are thought of as being either necessary (or, in some cases, indispensable) for facilitating cognitive interactions—for example, email is required for learner-instructor asynchronous interaction. Likewise, a system without links to related learning materials will deny learners opportunities for constructing, analyzing, evaluating, and synthesizing their knowledge from assigned information sources. Thus, the correct use of this technical framework and its interactive functions to promote cognitive interactions poses a challenge for instructional designers.

Another potential focus of research might be the connection between the use of interactive functions and actual learning, since more interactive functions do not automatically guarantee better learning. The proposed technical framework provides assistance to designers, but does not address qualitative or quantitative measures of learning outcome. The hypothesis to be tested would be: Do technically interactive functions built into a Web-based learning system help induce learners' cognitive interactions in

ways that enhance learning achievement? Such a hypothesis requires detailed empirical methodologies.

Another potential area for research is the association between user perceptions and usage of these interactive functions and their overall satisfaction with a particular system. Questions to be addressed would include a) Are students aware of the interactive functions provided by their Web-based learning systems, and do they like those functions? b) Do they appreciate student-centered interactivity dimensions and functions that are incorporated into a specific Web-based learning system? and c) How do they determine if and when to use such interactive functions?

The significance of the technical framework described in this article is that it identifies interaction categories and interactivity needs, then addresses currently available Internet and Web technologies for fulfilling these needs. It was assumed that interactivity is indispensable for any Web-based learning system, and acknowledged that the field of interactivity design is still in its infancy. The search for the potential and creative interactive functions of such a complex, technology-dependent learning environment represents a great challenge for instructional designers, instructors, and network programmers. The technical framework presented here serves as an initial step toward meeting this challenge.

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References

Berge Z L (1999) Interaction in post-secondary web-based learning *Educational Technology* **41**, 1, 5–11.
Borsook T K and Higginbotham-Wheat N (1991) Interactivity: what is it and what can it do for computer-based instruction? *Educational Technology* **31**, 5, 11–17.
Burgoon J K *et al* (2000) Interactivity in human-computer interaction: a study of credibility, understanding, and influence *Computers in Human Behavior* **16**, 6, 553–574.
Drave W A (2000) *Teaching online* LERN Books, River Falls, Wisconsin.
French D *et al* (1999) (eds) *Internet based learning: an introduction and framework for higher education and business* Stylus Publishing, Sterling, Virginia.
Ghose S and Dou W (1998) Interactive functions and their impacts on the appeal of Internet presence sites *Journal of Advertising Research* March/April, 29–43.
Gilbert L and Moore D R (1998) Building interactivity into web courses: tools for social and instructional interaction *Educational Technology* **38**, 3, 29–35.
Ha L and James E L (1998) Interactivity reexamined: a baseline analysis of early business web sites *Journal of Broadcasting and Electronic Media* **42**, 4, 457–474.

Heeter C (1989) Implications of new interactive technologies for conceptualizing communication *in* J L Salvaggio and J Bryant (eds) *Media use in the information age: emerging patterns of adoption and consumer use* Lawrence Erlbaum, Hillsdale, NJ, 217–235.
Hillman D C A, Willis D J and Gunawardena C N (1994) Learner–interface interaction in distance education: an extension of contemporary models and strategies for practitioners *The American Journal of Distance Education* **8**, 2, 30–42.
McIsaac M S and Gunawardena C N (1996) Factors influencing interaction in an online course *The American Journal of Distance Education* **13**, 3, 22–36.
Merrill D, Li Z, and Jones M K (1990) Second generation instructional design *Educational Technology* **30**, 2, 7–15.
Moore M G (1989) Three types of interaction *The American Journal of Distance Education* **3**, 2, 1–6.
Northrup P (2001) A framework for designing interactivity into web-based instruction *Educational Technology* **41**, 2, 31–39.
Rafaeli S (1985) *If the computer is a medium, what is the message: explicating interactivity* Paper presented at the International Communication Association Convention Dallas, USA.
Rice R (1984) New media technology: growth and integration *in* R Rice and Associates (eds) *The new media* Sage Beverly Hills, 33–54.
Shneidermann B (1998) *Designing the user interface: strategies for effective human–computer interaction* (3rd ed) Addison-Wesley, Reading, MA.
Sim R (1997) Interactivity: a forgotten art? *Computers in Human Behavior* **13**, 2, 157–180.
Vrasidas C and McIsaac M S (1999) Factors influencing interaction in an online course *The American Journal of Distance Education* **13**, 3, 22–36.
Weller H G (1988) Interactivity in micro-computer-based instruction: its essential components and how it can be enhanced *Educational Technology* **28**, 2, 23–27.

Appendix: Interaction types, interactive functions, and their definition and/or example

Types of interaction	*Interactive functions in learning Web systems*	*Definition and/or examples*
Learner–interface	1. Fixed-frame (menu) design	• Students have a list of menu items from which they can choose the content and system • functions for their navigation. It is similar to a perpetual table of contents by side.
	2. Site map	• Students can use this function to locate their needed information within learning systems.
	3. Keyword search	• Students can search particular words/terms throughout the Web system by entering keywords.
	4. Database search	• Students can search particular contents stored in a database connected to their learning systems.
	5. Online problem diagnostics	• Students report their problems and this function helps them to locate the problem exactly. For example, students report that they cannot access to particular database, and the system diagnoses that they have to close the proxy first.
	6. Software downloading	• Students download (free or charged) software from a system for learning purpose.
	7. Online registration	• Students have to register to the learning systems/courseware in order to become a member of a class and a learning community.
	8. Grade status tracking	• Students can track their status regarding their grade points or relative status in a class.
	9. Assignment completion tracking	• Students can track their records of complete or incomplete assignment.
Learner–content	10. Links to related educational systems	• Students can navigate to other sites that contain related information.
	11. Links to related learning materials	• Students can navigate to particular Web pages within other sites containing related information.
	12. Multimedia presentation (text, graphics, animation, audio etc)	• Students can access to the presentation of text, graphics, animation, audio, video, etc. Also covered can be quicktime movie, streamline video and so on.
	13. On-line quiz for self-evaluation	• Students can access on-line quiz items with/without feedback to evaluate their learning effectiveness.
	14. Push media	• Students select to participate and receive information directly to their online accounts on a regular basis.

	15. Individualized learning database	• Individual students can access to learning databases which are adapted or tailored to their need.
	16. Individualized instruction	• Individual students can access tailored instructional materials for their needs.
	17. Individualized test/quiz	• Individual students can access tailored test or quiz items.
	18. Frequently-asked-questions (FAQ)	• Students can access to a section of FAQ within the systems to looking for questions and answers. For example, the required format of their assignment.
	19. On-line help on content	• Students can report their questions on content and receive immediate on-line help.
	20. User guidance on system	• Students can receive guidance on how to use the system.
	21. Study guidance	• Students can receive guided information on their study progress.
	22. Learner contributing to learning materials	• A mechanism which allows students to contribute to learning materials. For example, students can provide related Web systems which contain useful information for the course.
	23. Educational games	• Students can play online games which may or may not directly related the instruction.
	24. Jokes	• Students can access to some jokes provided by the system designer or instructor. The jokes may or may not directly to the instructional content.
	25. Sweepstakes	• Events held to attract students and to encourage student participation by special incentives, for example, prize for the first student who solves the problem.
Learner–instructor	26. Email to instructors	• Students can write email to their instructors and/or peer learners.
	27. Email to Web master	• Students can write email to the manager or designer of the systems.
	28. Bulletin board systems (BBSs)	• A build-in BBS which allows instructors and students to post information.
	29. Chatrooms	• A build-in chatroom which allows instructors and students to chat synchronously.
	30. Online voting	• A function which allows students and/or instructors to vote for their learning-related affairs.
	31. Online survey	• E-form survey for students and instructors to solicits their opinions.
	32. Comments on the systems, course, instructor, etc	• Students can fill out e-forms to express their opinions about the course, systems, and instructors.
Learner–learner	33. Class roster	• A list of students in courses or sites.
	34. Email to other learners	• Students can write email to their instructors and/or peer learners.
	35. Bulletin board systems (BBSs)	• A build-in BBS which allows students to post information.
	36. Chatrooms	• A build-in chatroom which allows students to chat synchronously.