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The technical framework of interactive functions for course-management systems: Students' perceptions, uses, and evaluations

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ABSTRACT

This study explores the interactivity of course-management systems (CMSs). First, this study reviews the concepts of interactivity, interactivity dimension, and interaction type on the basis of related theories and studies. Second, this study analyzes the interactive functions attributable to the six major CMSs in Taiwan colleges and universities, and re-constructs a technical framework containing five interaction types, nine interactivity dimensions, and 83 possible interactive functions. This study has found that a total of 21 interactive functions were featured in the six CMSs, while six functions identified from theories and research were not. In terms of interaction type, the results indicate that these six CMSs possessed the highest percentage of possible interactive functions for facilitating human interactions (e.g., learner–learner interaction and learner–instructor interaction), followed by learner–interface interaction and learner–self interaction, with the lowest percentage corresponding to learner–content interaction. In terms of interactivity dimension, these six CMSs seemed more likely to feature a learner-centered design approach than a system-centered one. Also, this study conducted user surveys on students' perceptions, use, and evaluation of these interactive functions. A total of 491 valid sets of data were collected from six CMS user groups. The results indicate that, for their online learning, students considered the function of "Assignment handling" to be the most known, frequently used, and useful function. In addition, students were well familiar with, and made use of, any functions that would help them monitor or track their learning process. Students required more content-related interactive functions than were currently available in CMSs. Last, the regression results indicate that the more positively the students perceived the CMS interactivity, the usefulness of CMS for learning, and the interactive functions, the more positively these students perceived their CMSs.

1. Introduction

With the advent of information technology, many colleges, universities, and other higher-education institutions worldwide nowadays use various course-management systems (CMSs) to manage learning-related materials and student-learning processes (Malikowski, 2008; Malikowski, Thompson, & Theis, 2006; West, Waddoups, & Graham, 2007). Indeed, the typical CMS contains a variety of technical capacities to support online learning. Among the factors in successful online-learning experiences, interactivity remains the central one (Williams, Rice, & Rogers, 1988). Rafaeli (1988) based his definition of 'interactivity' on communication theories' view that it as an expression of the extent of a given series of communication exchanges. Other researchers (e.g., Borsook & Higginbotham-Wheat, 1991; Evans & Sabry, 2003; Ghose & Dou, 1998; Ha & James, 1998; Yacci, 2000) asserted that 'interactivity' refers to those functions or operations that are available to the users and that enable them to work with content presented in a computer-mediated environment and receive feedback. Maor and Volet (2007) further concluded that interactivity was essential and well established in the online-learning literature, and was a critical factor in the successful outcomes of, and the quality of, online learning.

Many early studies on Web-based interactivity deal with business fields (e.g., Ghose & Dou, 1998; Ha & James, 1998), followed by studies addressing interactivity issues in educational settings. An example of the latter type of study is Evans and Sabry (2003), which concerned interactivity concepts in an Internet-learning environment functioning as a three-way model (initiation, response, and feedback). Also of

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note is Bannan-Ritland (2002), which defined 'interactivity' as active involvement by the learner in a wide range of instructional activities and technologies, including patterns of learner–instructor communication and social/cooperative/collaborative exchanges.

In order to categorize dimensions as well as types, Chou (2003) proposed a technical framework of functions in Web-based learning systems and used panels of experts to assess these functions regarding instructional necessity, interface design, and programming difficulty. Peng, Chou, and Chang (2008) proposed a technical framework of functions in ubiquitous learning systems and used experts to evaluate the overall effectiveness of the framework. However, to date, as more and more universities adopt CMSs to deliver courses and facilitate students' learning, there is no existing validated technical framework whose design rests on interactivity- and learner-centered theories and practices. The current study reflects our attempt to re-visit interactivity and to re-establish a technical framework in the context of CMSs. In this study, we define our three major terms as follows:

- Interaction type: the dialogue between two or more participants and objects (self, learner, instructor, content, and interface) in the technology-mediated distance-learning process (ref. Evans & Sabry, 2003).
- Interactivity dimension: the abstract characteristics (such as "facilitation of interpersonal communication") of interaction types (such as "learner–instructor interaction") in which message loops can occur synchronously or asynchronously (ref. Muirhead & Juwah, 2004).
- Interactive function: the technical feature (such as a built-in email) that concretely realizes the interactivity dimension for each interaction type (Chou, 2003).

A detailed illustration of one interactive function is a situation where "the CMS's email function can facilitate interpersonal communication for learner–instructor interaction." In order to enhance reading comprehension, we use "dimension," "type," and "function" as abbreviations of "interactivity dimension," "interaction type," and "interactive function" in the following sections.

To enhance the effectiveness of this technical framework, this study has analyzed the functions attributable to the six most commonly used CMSs in Taiwan colleges and universities. Also, this study has attempted to shed light on learners' perceptions of these six CMSs and has investigated possible factors underlying the overall assessment of CMSs. To achieve these goals, this study has reviewed relevant literature on the interactivity of CMSs and has examined the existing functions of currently available CMSs. Furthermore, this study has developed a user survey to collect quantitative data and feedback from learners. The research questions here are three in number:

(1) What are the adoptions of these interactive functions by CMSs?
(2) What are the perceptions, the actual uses, and the usefulness-related evaluations that students have had with regard to the interactive functions of the CMSs?
(3) What are the relationships among students' perceptions, uses, and evaluations of the CMSs' interactive functions?

2. Literature review

2.1. The interactivity dimensions in CMSs

The features of interactivity have been defined differently in terms of types and dimensions. For example, Muirhead and Juwah (2004) defined 'interactivity' in online education as the form, function, and impact of interactions in teaching and learning. Having synthesized the interactivity-design studies of Borsook and Higginbotham-Wheat (1991), Chou (2003), Ha and James (1998), Heeter (1989), and Ghose and Dou (1998) proposed nine dimensions to support interactivity in communication technology, computer-assisted instruction, distance learning, and Web systems. Later, Peng et al. (2008) applied these nine dimensions to ubiquitous learning systems. With the integration of dimensions addressed by Chou (2003) and Peng et al. (2008), with levels of interactivity addressed by Guay (1995), and with interactivity-evaluation criteria addressed by Evans and Sabry (2003), the aim of this study is to identify these abstract dimensions in CMSs and to present brief definitions of each dimension, as follows:

(1) Choice: Learners can select types of information and types of multimedia formats, and can set up functions in a non-sequential environment (Borsook & Higginbotham-Wheat, 1991; Evans & Sabry, 2003; Ha & James, 1998; Heeter, 1989; Liaw & Huang, 2000).
(2) Non-sequential access of information: On the basis of their preferences, learners can access information from various channels (Borsook & Higginbotham-Wheat, 1991; Evans & Gibbons, 2007).
(3) Monitoring of information use: A CMS can collect data on learners' choices, and this collection enables learners to monitor the status of their own information use and promotes their reflection process (Evans & Sabry, 2003; Ha & James, 1998; Heeter, 1989).
(4) Facilitation of interpersonal communication: A CMS provides learners with synchronous and asynchronous communication channels (Heeter, 1989; Malikowski, Thompson, & Theis, 2007).
(5) Ease of adding information: Learners can easily make information available to the public in the CMS (Heeter, 1989).
(6) Responsiveness to the user: A CMS and learners have mutual communication channels, and a CMS responds to learners in a non-delayed fashion (Borsook & Higginbotham-Wheat, 1991; Evans & Sabry, 2003; Ghose & Dou, 1998; Ha & James, 1998; Heeter, 1989).
(7) Personal-choice helper: A CMS helps learners locate desired paths or Web pages by providing a basic navigation function (Evans & Sabry, 2003; Ghose & Dou, 1998; Guay, 1995).
(8) Adaptability: A CMS provides adapted feedback in accordance with learners' characteristics, needs, learning tasks, and learning conditions (Borsook & Higginbotham-Wheat, 1991; Evans & Sabry, 2003; Guay, 1995).
(9) Playfulness: A CMS has a mechanism to arouse learners' curiosity and to draw their attention (Evans & Sabry, 2003; Ghose & Dou, 1998; Ha & James, 1998).

Peng et al. (2008) divided these nine dimensions into two categories, in consideration of the roles that learners or systems play in the interaction. Dimensions 1–5 refer to "learners' determination to make a choice in the system," and dimensions 6–9 refer to situations

wherein a "system provides services that react to learners' action" (p. 56). Regardless of the roles that learners or systems play, the degree of interactivity is highly dependent on the efforts that learners must exert; in other words, the more effort the learners exert, the stronger the degree of interactivity with the system.

2.2. The interaction types in CMSs

Moore (1989) was the first to attempt to identify three interactive relationships associated with distance learning: learner–content (e.g., information) interactions, learner–instructor interactions, and learner–learner interactions. Later, Hillman, Willis, and Gunawardena (1994) suggested a fourth type, learner–interface interaction. Soo and Bonk (1998) argue that self-regulation skill should be one of the most important instructional goals for online learning; therefore, learners should interact with themselves in order to carry out self-directed learning. Hirumi (2002, 2009) further classified interaction into four types: learner–self, learner–human, learner–"non human" (content, interface, and environment), and learner–instruction. On the basis of the above studies, this study proposes the following five learner–centered interaction types and includes Fig. 1 to display the relationships among different types in a learner-centered CMS.

(1) Learner–interface interaction: Learners can access desired information with a user-friendly interface in a CMS. This type serves as the foundation for the remaining types. The interface grants learners efficient and easy access to functions in the CMS. In other words, this type is an integral part as learners perform certain tasks (Hillman et al., 1994; Hirumi, 2002, 2009; Peng et al., 2008; Vrasidas & McIsaac, 1999).
(2) Learner–self interaction: Learners can monitor their learning progress by reflection facilitated by CMS functions (Berge, 1999; Hirumi, 2002, 2009; Northrup, 2001; Soo & Bonk, 1998).
(3) Learner–content interaction: Learners can access multimedia learning contents in a CMS (Hirumi, 2002, 2009; Moore, 1989; Northrup, 2001; Sims, 2000; Vrasidas & McIsaac, 1999).
(4) Learner–instructor interaction: Learners can interact with instructors by using digital channels provided by a CMS (Berge, 1999; Hirumi, 2002, 2009; Moore, 1989; Sims, 2000; Vrasidas & McIsaac, 1999).
(5) Learner–learner interaction: Learners can interact with other learners by using CMS-based digital channels (Berge, 1999; Hirumi, 2002, 2009; Moore, 1989; Northrup, 2001).

2.3. The need for re-visiting the technical framework of CMSs' interactive functions as derived from theories, research, and practices

The technical framework proposed in this study mainly extends Chou's (2003) framework, which presented only 36 functions. However, as research has identified more types (e.g., learner–self), and as Web 2.0 technology has advanced rapidly, there is a growing need to re-visit the technical framework of CMSs' functions. In addition, the functions listed in Chou's (2003) and Peng et al.'s (2008) studies stem mainly from theories and related research rather than from existing CMSs in practice. The current study presents a new technical framework of functions based on this study's examination of all possible functions in Taiwan colleges' and universities' six major CMSs. In other words, this study identifies and categorizes the union of six CMSs' functions in addition to the functions identified from theories and related research, and uses the new framework to analyze the adoptions of these functions across the six CMSs. Furthermore, this study explores CMS-user perceptions, uses, and evaluations of the usefulness of these functions for learning. More descriptions of CMSs' selection and the new framework of functions for CMS are included in Sections 3.1 and 3.2.

3. Research methods

3.1. The six CMSs to be evaluated

This study selected the six most commonly used CMSs (Blackboard, e-Campus III, iCAN XP, Moodle, TopLearn, and Wisdom Master) in Taiwan colleges and universities. With the consent of course instructors and learners, the researchers could log into these online courses and could distribute a user survey to students. The criteria for selecting online courses for this study were that instructors must use their respective CMS as (1) the major content-delivery channel, (2) the only system with which instructors would manage students' learning

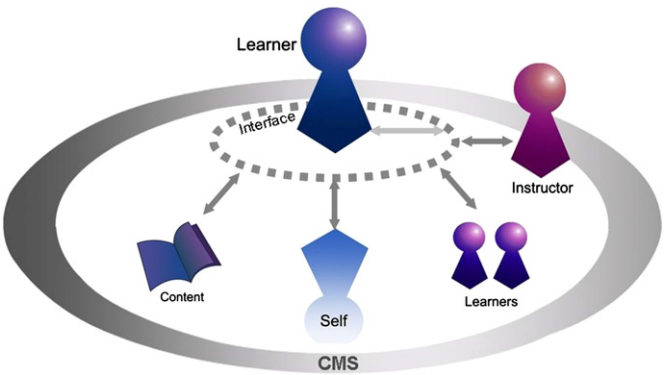

Fig. 1. The concept of a learner-centered CMS (adapted from Peng et al., 2008).

process and the face-to-face meetings that would take place no more than three times during the semester, and (3) part of a cooperative environment for group assignments or projects.

Of the six CMSs to be examined, five CMSs (Blackboard, e-Campus III, iCAN XP, TopLearn, and Wisdom Master) were commercially available packages produced by universities or companies. Moodle, in contrast, is an open-source software package designed to help educators create their own CMS (http://moodle.org). Many universities in Taiwan have adopted Moodle as their major campus-wide CMS, and therefore, its interactive functions reflect the individual university's needs. Nevertheless, the Moodle system in the major Taiwanese university that we chose to examine has served as the only campus-wide CMS for delivering over 3000 courses for more than four years.

It is worth noting that, except for the Blackboard and Moodle systems, the other four CMSs have been produced and used mainly in Taiwan and in the Chinese world generally (e.g., mainland China); therefore, the authors are fully aware that many readers of this article are not familiar with them. However, since the major purpose of this study does not cover reporting on the functions or the interactivity qualities of each CMS, the study collectively assesses the adoptions and the users' perceptions of functions without specifying the given individual CMS.

In order to examine CMS interactive functions, two researchers logged into the six CMSs and familiarized themselves with the CMSs' functions. Starting from its literature review, this study proposes a technical framework that contains five types, nine dimensions, and 39 functions. Two researchers carefully tested all the functions of each CMS and classified the functions in accordance with a pre-determined framework, referring to features instead of names. A few refinements to the framework were permissible if new functions were found during the examination. This refined framework enabled the researchers to sift through abstract interactions with relative ease in a systematic fashion and, therefore, served as a foundation to evaluate various kinds of interactions in CMSs. This study adopted the Holsti (1969) method to calculate inter-rater reliability, and the results exhibit a satisfactory degree of agreement (.95) and reliability (.97) among raters.

3.2. The refined technical framework of CMS

This refined framework has integrated functions from theories and related research, and from examination of existing CMSs' functions. The following paragraphs are to provide detailed comparisons in order to describe differences of functions among frameworks for CMSs, frameworks for Web-based learning systems (Chou, 2003), and frameworks for ubiquitous-learning systems (Peng et al., 2008).

After the examination, the framework extended to a total of 83 functions in nine dimensions and of five learner-centered types (see Table 1). Among the 18 learner–self functions, several functions bore dual types; for example, the three individualized mechanisms—1–7 (Individualized learning record), 1–8 (Individualized instruction), and 1–9 (Individualized test/quiz)—would open communication channels between learning content and learning experiences, so that these three functions can correspond to both a "learner–self' type and a "learner–content" type. In addition to learner–self interaction, Functions 1–10 to 1–18 share the characteristics of the functions of learner–interface interaction. Take Functions 1–13 (Assignment-completion tracking) and 1–16 (Grade-status tracking) as an example: learners need to interact with the system interface (by, for example, logging onto the system) before monitoring their assignment and grade.

For learner–interface interactions, six functions (2–2, 2–3, 2–8, 2–9, 2–10, and 2–11) were not included in Chou's study (2003) in which Functions 2–15 (Email to Webmaster) and 2–16 (Comments on the system) were identified as being of the "learner–instructor" type; yet in our revised version, we re-identified Function 2–16 as being of the "learner–interface" type because the responses that learners would receive through using this function could familiarize the learners with the system. Further, since the "Webmaster" is not an instructor, we re-categorized this system-related function as part of the "learner–interface" interaction. We believe that the personal-choice helper plays an important role in guiding learning and system use, and that, therefore, the three functions 2–13 (FAQs about the system), 2–14 (Online system-related problem diagnostics), and 2–17 (Learning-difficulty detection) are also of the "learner–content" type (also labeled as Functions 3–8, 3–9, and 3–10).

Regarding learner–content interactions, Chou's study (2003) does not include Function 3–6 (Online examination). In addition to the learner–self interaction and the learner–interface interaction, Function 3–14 (Materials-viewed tracking) allows learners to interact with learning materials and, therefore, can also be considered an aspect of learner–content interaction. Regarding learner–instructor interaction, we newly included Functions 4–5 (Social tools), 4–6 (Grouping), 4–7 (Assignment handling), and 4–8 (Online examination) as learner–instructor interaction. In addition, although Function 4–8 belongs to learner–instructor interaction, this function can also serve as instructional feedback and as an indication of learners' learning effectiveness, and therefore, we identify it also as learner–content interaction. For learner–learner interaction, we identify the new Functions 5–7 (Sharing and emulation) and 5–8 (Peer evaluation) as "learner–learner" interaction.

3.3. User survey of the six CMSs

For gathering user perceptions of interactivity and interactive functions, students who were enrolled in pertinent CMS courses received paper questionnaires (i.e., the survey) two weeks before the final examination. The self-report survey had five parts:

(1) Background information: gender, age, and grade level.
(2) Internet-use and online-learning experiences: questions covered information pertaining to online experience, hours spent online per week, frequency of CMS log-ins during the semester, and average duration of each log-in.
(3) A list identifying the courses' CMS interactive functions (using the correct names of the specific CMS): Sampled students needed to answer the following questions: (a) Do you know about this function in the system (yes/no)? (b) If yes, how frequently have you used it (never, once, seldom, occasionally, usually, every log-in)? (c) To what extent do you agree that this function is useful for your online learning (answers on a 5-point Likert Scale, ranging from strongly disagree to strongly agree)? The function list is from the list of all possible functions in Table 1, and each function was provided with a brief definition.
(4) Students' overall evaluation of CMSs' value, CMSs' interactivity, and related collections of functions: Students were required to give a score between 0 and 100 (no value to the highest value) for each of these three inquires, since Taiwan college students were familiar

Table 1
The framework for interaction types, interactivity dimensions, and interactive functions.

Types of interaction	Dimensions of interactivity	Interactive functions	Types of interaction	Dimensions of interactivity	Interactive functions
Learner–self	Ease of adding information	1–1 Diary and reflective journal	Learner-content	Choice	3–1 Links to related educational systems
		1–2 Note-taking		Non-sequential access of information	3–2 Links to related learning materials
		1–3 Electronic portfolio		Responsiveness to the user	3–3 Multimedia presentation
	Choice	1–4 Calendar & schedule reminder			3–4 Push media
		1–5 Task-list			3–5 Online quiz for self-evaluation (same as 1–6)
	Choice	1–6 Online quiz for self-evaluation			3–6 Online examination
	Non-sequential access of information			Personal-choice helper	3–7 Study guide
	Responsiveness to the user				3–8 Frequently asked questions (FAQs) about contents
	Adaptability	1–7 Individualized learning record			3–9 Online help with contents
		1–8 Individualized instruction			3–10 Content-difficulty detection
		1–9 Individualized test/quiz		Adaptability	3–11 Individualized learning record (same as 1–7)
	Monitoring of information use	1–10 Login-status tracking			3–12 Individualized instruction (same as 1–8)
		1–11 Materials-viewed tracking			3–13 Individualized test/quiz (same as 1–9)
		1–12 Learning-completion tracking		Monitoring of information use	3–14 Materials-viewed tracking (same as 1–11 & 2–20)
		1–13 Assignment-completion tracking			
		1–14 Presentation-status tracking		Ease of adding information	3–15 Note-taking (same as 1–2)
		1–15 Examination-status tracking			3–16 Learner contribution to learning materials
		1–16 Grade-status tracking		Playfulness	3–17 Sweepstakes
		1–17 Learning dashboard			3–18 Educational games
		1–18 Report transformer			3–19 Jokes
Learner–interface	Choice	2–1 Fixed-frame (menu) design	Learner–instructor	Facilitation of interpersonal communication	4–1 Class roster
	Non-sequential access of information	2–2 Language choice		Ease of adding information	4–2 Email to instructors
					4–3 Bulletin board systems (BBSs)
	Responsiveness to the user	2–3 Individualized web-browser design			4–4 Synchronous communication
		2–4 Sitemap			4–5 Social tools
		2–5 Keyword search			4–6 Grouping
		2–6 Database search			4–7 Assignment handling
		2–7 Software downloading			4–8 Online examination (same as 3–6)
		2–8 System announcement			4–9 Online voting
		2–9 System message			4–10 Online survey
		2–10 Subscription to learning information			4–11 Comments on the course and instructors
		2–11 System updates			
	Personal-choice helper	2–12 User guidance for a system	Learner–learner	Facilitation of interpersonal communication	5–1 Class roster (same as 4–1)
		2–13 Frequently asked questions (FAQs) about the system		Ease of adding information	5–2 Email to other learners
		2–14 Online system-related problem diagnostics			5–3 Bulletin board systems (BBSs) (same as 4–3)
		2–15 Email to webmaster			5–4 Synchronous communication (same as 4–4)
		2–16 Comments on the system			5–5 Social tools (same as 4–5)
		2–17 Learning-difficulty detection			5–6 Grouping (same as 4–6)
	Monitoring of information use	2–18 Online registration			5–7 Sharing and emulation
		2–19 Login-status tracking (same as 1–10)			5–8 Peer evaluation
		2–20 Materials-viewed tracking (same as 1–11)			
		2–21 Learning-completion tracking (same as 1–12)			
		2–22 Assignment-completion tracking (same as 1–13)			
		2–23 Presentation-status tracking (same as 1–14)			
		2–24 Examination-status tracking (same as 1–15)			

Table 1 (*continued*)

Types of interaction	Dimensions of interactivity	Interactive functions	Types of interaction	Dimensions of interactivity	Interactive functions
		2–25 Grade-status tracking (same as 1–16) 2–26 Learning dashboard (same as 1–17) 2–27 Report transformer (same as 1–18)			

with the 0–100 scale in relation to value judgment, and since the pilot-test results had confirmed the satisfactory validity and reliability of this scale. Moreover, students were required to indicate the extent of their agreement with the assertion that the given CMS was useful for their online learning (answers on a 5-point Likert Scale, ranging from strongly disagree to strongly agree).

(5) A list identifying the functions *not* in their school's CMSs: Students needed to indicate the extent of their requirement that this non-existing function (with a brief definition) be added to their CMSs, and the extent of their belief that this non-existing function would be useful for their online learning (answers on a 5-point Likert Scale, ranging from strongly disagree to strongly agree).

Since every CMS has a different number of functions and function names, as well as unavailable functions (compared with our 83-function list), each CMS user group received a different version of the survey designed specifically to their CMS. A total of 660 questionnaires (110 questionnaires for each university or college) were distributed, and 609 were returned. After a strict screening, 218 questionnaires with inconsistent responses or five or more missing values were removed, leaving 391 valid questionnaires (valid-return rate = 64.20%) for further analyses. The respondents' age range was from 17 to 44 with a mean of 20.44, and a standard deviation of 1.84. Of all valid responses, 218 (55.75%) were from male students; that is, 173 (44.25%) were from female students. Undergraduate students numbered 355 (90.79%), the remainder being graduate students. There were 127 (32.48%) students with online experience of 8–9 years, 90 (23.02%) with 6–7 years, and 82 (21.97%) with 10 years or more. Regarding their average number of hours spent online weekly, 108 (27.62%) reported 1–10 h, 81 (20.71%) reported 11–20 h, 117 (29.92%) reported 21–30 h, and 79 (20.20%) reported more than 30 h.

Of the 391 students who reported the frequency of their course-CMS log-ins during the semester, 43 students (11.0%) reported a frequency of several times a day, 28 (7.16%) once a day, 139 (35.55%) several times a week, and 73 (18.67%) once per week. However, there were 30 students (7.67%) reporting a frequency of about once every two weeks, 31 (7.93%) about once every month, and 47 (12.02%) about once every few months. In comparison with their total time online, students spent remarkably little time on their per-CMS log-ins: 127 (32.48%) at most 10 min, 193 (49.36%) 11–30 min, 49 (12.52%) 31–60 min, and 22 (5.63%) over 1 h.

Table 2
The adoption or non-adoption of interactive functions by interaction types in the six CMSs.

Interactive functions	Interaction type				
	Learner–self	Learner–interface	Learner–content	Learner–instructor	Learner–learner
Maximum number to be adopted	108 (18 × 6)	162 (27 × 6)	114 (19 × 6)	66 (11 × 6)	48 (8 × 6)
Actual number adopted by six CMSs	58	112	49	60	45
Average adoption rate by six CMSs (%)	53.70	69.14	42.98	90.91	93.75
Functions adopted by all six CMSs	• Individualized learning record • Grade-status tracking	• Fixed-frame (menu) design • Keyword search • Database search • User guidance for a system • Email to Webmaster • Online registration • Grade-status tracking	• Links to related learning materials • Multimedia presentation • Online examination • Individualized learning record • Learner contribution to learning materials	• Class roster • Email to instructors • BBSs • Synchronous communication • Social tools • Assignment handling • Online examination • Online survey	• Class roster • Email to other learners • BBSs • Synchronous communication • Social tools • Sharing and emulation
Functions NOT adopted by any CMSs	• Individualized test/quiz	• Online system-related problem diagnostics	• Push media • Online help with contents • Content-difficulty detection • Individualized test/quiz • Sweepstakes		

4. Results

4.1. The six CMSs' adoption of interactive functions

Table 2 presents a summary regarding the functions adopted by the six CMSs that we examined. We calculated "the maximum number of functions to be adopted" by multiplying the number of possible functions by six (i.e., the number of CMSs). For example, in the new framework, we have identified 18 possible functions for the "learner–self" interaction type; if every CMS adopted these 18 functions, a total of 108 would be counted. In this case, however, only 58 functions were adopted by these six CMSs, and therefore, the average adoption rate for this type was 53.70%. Table 2 indicates that, all together, six CMSs possessed different numbers of possible functions to support each type. Regarding interaction type, the highest adoption rates attributable to the six CMSs were 93.75% for learner–learner, and the lowest adoption rate was 42.98% for learner–content.

Table 2 also shows that, under the five types existing in all six CMSs, there was a total of 28 functions. Among these 28 functions, the Bulletin Board System (BBS) is one popular computer application in Taiwan. Once logged in, users can read news and postings, and interact with other users either synchronously or asynchronously. If we were to deduct multiple counting of the same functions under different types, 21 interactive functions would remain on this list. As indicated in Table 2, theories and research have identified seven possible functions that *no* CMS has adopted. Deducting the functions that were counted more than once, we are left with six interactive functions on this list.

Table 3 further indicates the adoption of functions in terms of five user-oriented or four system-oriented dimensions. We found that the "Facilitation of interpersonal communication" dimension had the highest adoption rate (92.11%), and the "Playfulness" dimension had the lowest rate (11.11%).

4.2. Learner perceptions of and usefulness of interactive functions

Table 4 summarizes student perceptions of, use of, and evaluations of functions, arranged from Divisions A to C. The functions were collected from the top three functions of each CMS-user survey. It should be noted that the number in parentheses after some functions indicates the number of CMS-user groups that chose the particular function as top three. It should also be noted that we double counted the same functions under different interaction types, and therefore, the total number of functions in each division was usually more than 18 (3×6).

Division A of Table 4 shows that Grade-status tracking, System announcement, Assignment handling, and BBSs are the four best-known functions across the six CMS-user groups. Division B lists students' most "frequently used" functions and reveals a relatively diverse style therein. Nevertheless, the function of Assignment handling was chosen by five of six CMS-user groups. Lastly, Division C lists the functions that students rated as most useful for their learning. Of all listed functions, the three most useful for learning were Keyword search, Learner contribution to learning materials, and Assignment handling.

Table 5 presents a summary of the least-known (Division D) and the least-used (Division E) functions available in at least one CMS. It is interesting to find that although the functions of Fixed-frame [menu] design and Social tools existed in all six CMSs, three groups of CMS users did not know of their existence. Similarly, all six CMSs provided the function of Database search, but two user groups seemed not to recognize its existence.

As in Division E in Table 5, the three least-used functions were Email to Webmaster, Comments on the system, and Synchronous communication. This finding means that few students needed to consult the Webmaster for system-related problems, and that most learners did not have the experience of communicating with synchronous tools.

Table 6 summarizes the functions absent from at least one of these six CMSs but required by students. As shown in Division F in Table 6, the function Online help with contents was the most-required non-existing function according to the CMS-user groups. Other functions, such as Online quiz for self-evaluation, Links to related educational systems, and FAQs about contents were also required functions for learning assistance, yet they were not effectively included. In Division G, students rated the functions Online quiz for self-evaluation, Online help with contents, and FAQs about contents as probably the most useful for learning if these functions would have been in existence. It is worth noting that students required no non-existing function in the learner–instructor or learner–learner interaction types. This finding suggests that students probably considered all existing human-communication functions to be satisfactory in their CMSs.

4.3. Regression analysis of learners' evaluation of CMSs

In order to explore the relationships among learner perceptions of and evaluations of the usefulness of the functions, we performed a stepwise regression analysis with "overall value of CMSs" as the dependent variable and the other items (learners' demographic profiles, Internet-use behaviors, CMS-use behaviors, overall value of CMS interactivities, overall value of the collection of

Table 3
Adoption of interactive functions of user- and system-oriented interactivity dimensions by six CMSs.

Categories	Interactivity dimension	Interactive functions		Adoption rate (%)
		Maximum number to be adopted	Actual number adopted	
User	Facilitation of interpersonal communication	114(19×6)	105	92.11
	Ease of adding information	144(24×6)	117	81.25
	Monitoring of information use	120(20×6)	85	70.83
	Choice	120(20×6)	78	65.00
	Non-sequential access of information	108(18×6)	70	64.81
System	Responsiveness to the user	108(18×6)	70	64.81
	Personal-choice helper	60(10×6)	29	48.33
	Adaptability	36(6×6)	14	38.39
	Playfulness	18(3×6)	2	11.11

Table 4
A summary of users' most-known, most-"frequently used," and most-useful CMS interactive functions.[a]

	Interaction type				
	Learner–self	Learner–interface	Learner–content	Learner–instructor	Learner–learner
(A) The most-known functions	• Grade-status tracking (2) • Individual learning record • Materials-viewed tracking • Assignment-completion tracking	• System announcement (3) • Grade-status tracking (2) • Online registration • Materials-viewed tracking • Assignment-completion tracking	• Individualized-learning database • Materials-viewed tracking	• Assignment handling (5) • BBSs (2) • Online survey	• BBSs (2)
(B) The most-"frequently used" functions	• Materials-viewed tracking (2) • Assignment-completion tracking (2) • Individual instruction • Grade-status tracking	• System announcement (2) • Materials-viewed tracking (2) • Assignment-completion tracking (2) • Online registration • Grade-status tracking	• Materials-viewed tracking (2) • Study guide • Individualized instruction • Learner contribution to learning materials	• Assignment handling (5) • BBSs (2)	• BBSs (2)
(C) The functions most useful for learning	• Individualized learning record • Assignment-completion tracking • Software downloading • System announcement • User guidance for a system • FAQs about the system	• Keyword search (2) • Assignment-completion tracking	• Learner contribution to learning materials (2) • Individualized-learning record	• Assignment handling (3) • Email to instructors • BBSs • Grouping	• Email to instructors • BBSs • Grouping • Sharing and emulation

[a] The number in parentheses indicates the number of CMS-user groups who chose this particular function as top three.

functions) as the independent variables. The regression helped assess whether these independent variables predicted the most variance in the analysis.

As Table 7 indicates, the results reveal that 66.0% of variance in "the overall value of CMSs" is explained by changes in the above three independent variables ($F(3,338) = 218.726$, $p = .000$), with an adjusted R squared value of 65.7%. In sum, the stepwise regression entered "the overall value of CMS interactivity" into the regression model first, and therefore, "the overall value of CMS interactivity" was assumed the best predictor, followed by "the usefulness of the CMS for learning" and "the value of the CMS collection of the interactive functions."

5. Discussions

5.1. New framework for CMS interaction type, interactivity dimension, interactive function

Interactivity in CMS-based learning is a process where the learner is actively involved in the give-and-take of information that takes place among a CMS, a learner, and a technology-facilitated instructor or peers. On the basis of interactivity theories and the learner-centered view of CMSs, this study has proposed a technical framework that contains five learner-centered types and nine dimensions. We have used the proposed technical framework to examine the functions relative to the six major CMSs that are used in Taiwan colleges and universities. The dimensions of the proposed framework remained consistent with Chou's (2003) nine dimensions, so that we might explain potential functions in CMSs. However, our refined framework is somewhat different from the one in Chou's study. First, this study integrated the structures of Northrup (2001), Peng et al. (2008) and Soo and Bonk (1998), and proposed a fifth type (learner–self interaction) to represent

Table 5
A summary of users' least-known and least-used CMS interactive functions.[a]

	Interaction type				
	Learner–self	Learner–interface	Learner–content	Learner–instructor	Learner–learner
(D) The least-known functions	• Learning dashboard (2) • Diary and reflection journal • Note-taking • Report transformer	• Fixed-frame (menu) design (3) • Database search (2) • Learning dashboard (2) • Report transformer • System updates	• Note-taking • Educational games • Jokes	• Social tools (3) • Synchronous communication	• Social tools (3) • Synchronous communication • Peer evaluation
(E) The least-used functions	• Calendar & schedule reminder • Diary and reflection journal • Report transformer	• Email to webmaster (4) • Comments on the system (3) • Subscription to learning information • Report transformer	• Learner contribution to learning materials • Educational games • Jokes	• Synchronous communication (2) • Social tools • Grouping	• Synchronous communication (2) • Social tools • Grouping

[a] The number in parentheses indicates the number of CMS-user groups that chose this particular function as top three.

Table 6
A summary of users' most-required and possibly most-useful non-existing CMS interactive functions.[a]

	Interaction type				
	Learner–self	Learner–interface	Learner–content	Learner–instructor	Learner–learner
(F) The most-required non-existing functions	• Online quiz for self-evaluation (2) • Electronic portfolio • Calendar & schedule reminder • Assignment-completion tracking	• Language choice • Assignment-completion tracking	• Online help with contents (4) • Online quiz for self-evaluation (2) • FAQs about content (2) • Study guide • Links to related educational systems • Content-difficulty detection • Individualized test/quiz		
(G) The non-existing functions possibly most helpful for learning	• Online quiz for self-evaluation (3) • Electronic portfolio • Calendar & schedule reminder • Individualized test/quiz • Learning-completion tracking	• Language choice • Online system-related problem diagnostics • Learning-completion tracking	• Online help with contents (5) • Assignment-completion tracking • Online quiz for self-evaluation (3) • FAQs about content (2) • Links to related educational systems • Content-difficulty detection		

[a] The number in parentheses indicates the number of CMS-user groups that chose this particular function as top three.

the interactivity wherein a system features information and mechanisms with which learners can reflect on their learning progress. Second, considering the participants involved in system use and the interactivity characteristics, we created some functions or double-labeled some functions under different types, resulting in a total of 83 possible functions: 18 for learner–self interaction, 27 for learner–interface interaction, 19 for learner–content interaction, 11 for learner–instructor interaction, and eight for learner–learner interaction.

5.2. Current CMSs' adoptions of interactive functions

5.2.1. Functions focusing on facilitating human interaction types and learner–centered dimensions

With regard to the overall adoption of the five types in these six CMSs, the learner–learner type had the highest adoption rate, followed by the learner–instructor type, the learner–interface type, the learner–self type, and the learner–content type. Based on the different adoption rates of types, it can be concluded that these six CMSs were designed more for facilitating human interactions, followed by learner–interface interaction and learner–self interaction, and least for learner–content interaction.

The adoption rates may reflect the number of functions under each interaction type. For example, the total number of functions for learner–instructor interaction and learner–learner interaction are far fewer than the possible functions in the other three types. It is relatively easy for system designers and programmers to incorporate all of these functions to facilitate human interaction into one CMS, and that is the reason accounting for the higher adoption rates in these six CMSs. On the other hand, even though the adoption rates of functions in learner–interface interaction and learner–self interaction reached approximately 50%, there is much room for system improvement. Lastly, the poorest adoption rate lies in the learner–content interaction (43%), meaning that fewer than half of the possible learner–content interactive functions were being incorporated into these CMSs. This phenomenon indicates that there is a huge interactive-function gap between theories and practices. It is probable that the majority of learner–content functions are tailored toward meeting individual learners' needs, and that such individualized functions might pose difficulties for system designers and programmers.

With regard to the overall adoption of the functions under the nine dimensions in these six CMSs, most of the CMSs prioritized functions for learner–centered dimensions (such as Facilitation of interpersonal communication, Ease of adding information, Monitoring of information use, Choice, and Non-sequential access of information) rather than support system-centered dimensions (such as Responsiveness to the user, Personal-choice helper, Adaptability, and Playfulness). The system-centered approach is not mainstream because only the "Responsiveness to the user" dimension has an interactive function adoption rate of 64.81%; other system-centered dimensions' adoption rates are all under 50%. Therefore, this study concludes that these six CMSs are more likely to feature a learner-centered design approach than to provide services reactive to learners' actions. Again, this phenomenon might contribute to the noted degree of design and programming difficulties. For example, most functions of the "Facilitation of interpersonal communication" dimension and the "Ease of adding information" dimension are part of Learner–instructor interaction and Learner–learner interaction. It is easier to design and to incorporate functions that promote interactions between learners and instructors than to design and to incorporate functions under other dimensions. Other dimensions, such as Personal-choice helper and Adaptability, correspond to learner–self interactions, interface interactions, and content interactions, and exhibit

Table 7
Summary of stepwise multiple regression analysis.

Predictor	R	R^2	ΔR^2	ΔF	Standardized β
The overall value of CMS interactivity	.781	.610	.436	530.681***	.688
The usefulness of the CMS for learning	.803	.646	.036	34.388***	.212
The value of the CMS collection of the interactivity functions	.812	.660	.015	14.471***	.121

$R^2 = .660$, adj $R^2 = .657$.

greater design and programming difficulties than functions under Learner–learner interaction and Learner–instructor interaction. This finding is consistent with findings from Graf and List (2005), who considered that the issue of Adaptation, which allows systems to automatically match students' individual and contextual needs, received very little coverage in e-learning platforms. Moreover, the adoption rate of Playfulness is far lower than the adoption rate of other dimensions, owing to the essence of educational platforms whose emphasis is on learning effectiveness instead of on having fun.

5.2.2. Interactive functions adopted by all six CMSs

This study found that a total of 28 functions under five types were included in all six CMSs. After we deducted the crossover functions under different types, 21 functions remained. Possessed by all six CMSs, these functions suggest that they are probably the most basic—or the easiest to incorporate—of all possible functions when it comes to supporting basic forms of online learning. Previous studies have reached consensus on the essential functions of computer-assisted learning or CMSs (e.g., Alessi, Anderson, & Biddle, 1975; Collis & Strijker, 2002; Paulsen, 2003; Rosenberg, 2001; Runnestø & Ristesund, 2002; West et al., 2007), consisting of content-management functions (such as course-information and learning-content delivery and management) and learning-management functions (such as learning support and communication tools). Content-management functions can be easily executed in a CMS, such as the functions of Individualized learning record, Menu design, Assignment handling, Multimedia presentation, and Online examination. Learning-management functions can be executed as functions of Grade-status tracking, Keyword search, Email to instructors and to other learners, BBSs, and Synchronous communication. This dispersal of functions may suggest that, even with time constraints and budget constraints, designers could use a minimum 21-function CMS in order to ensure the occurrence of online learning.

5.2.3. Interactive functions not adopted by all six CMSs

This study also found six functions (such as Online system-related problem diagnostics, Online help with contents, Content-difficulty detection) that are supposed to be—but are not—incorporated into these six CMSs. As mentioned above, any function that needs to be more individualized for learners, or more "intelligent" in automatically detecting individual learners' difficulties with a system or content will thus need more investment in development. These six functions are in the same case. Moreover, a comparison of this non-have list (in Table 2) with the functions students both most required and believed most useful (in Table 6) suggests that future versions of CMSs perhaps should feature the functions of Online help with contents, Automatic content-difficulty detection, Online quizzes for self-evaluation, and Study-guide mechanism.

5.3. User perceptions and evaluations of CMSs' interactive functions

5.3.1. Functions that are perceived as the most-known, used, and useful for learning

The results of user surveys indicate that students are most familiar with, and most likely to use, functions for four major purposes: (1) registering for a course (registering online, building-up a personal learning record), (2) monitoring their current status (information related to their log-in, material viewed, assignment completion, grade, (3) receiving and giving course-related messages/materials (viewing system announcements, making contributions to learning materials, handing in assignments), and (4) communicating with instructor and students (using BBSs). The current study has further categorized all CMS features (functions) and found that the six major CMSs have incorporated basic functions and that their users indeed have used these functions to perform a variety of learning activities.

Reviewing all functions known, used, and rated by students (see the three divisions in Table 4), we found that Assignment handling (Function 4–7) was the best-known and most frequently used function for five of the six CMS-user groups, and was rated the most useful function in facilitating learning by three of the six groups. Other functions, such as Grade-status tracking, Materials-viewed tracking, Assignment-completion tracking, System announcement, and BBSs were also rated as the best-known and most frequently used functions for students' online learning. In general, any functions that helped students monitor their learning progress or "track" their statuses were well known and used by students. If this kind of function was unavailable in a given CMS, students would require the addition of this kind of function to their CMS.

5.3.2. Functions that are perceived as the least-known and used

The user survey's findings also indicated functions that are perceived as least-known and least-used. For example, all six CMSs provide the Social tools function, but obviously, many students were unaware of the function's existence and, thus, probably missed the chance to take advantage of any embedded tools (such as photos, a brief self-introduction, nicknames, or emoticons) to facilitate the virtual communication. The fixed-frame design was also listed as one of the least-known functions by three of the six user groups. We believe that this finding might stem from terminology confusion because most learners would typically make selections by clicking on the menu items. In other words, students in their respective CMS perhaps used this function to navigate and perform their tasks, but were unaware of this design.

Similarly, four of the six CMSs provided the Learning-dashboard function, but two user groups seemed not to recognize its existence. These findings imply that although some CMSs may possess some functions useful for online learning on the basis of either educational theories or technical availability, students of these CMSs may be unaware of these functions and, thus, may not actually use them during learning experiences. The related findings are consistent with those attributable to Weaver, Spratt, and Nair (2008), where students were found often unaware of existing features and services of a particular CMS and were found, therefore, often unable to use these tools effectively.

5.3.3. Non-existing functions required by students

This study also identifies the non-existing functions that students required—and considered to be most useful—for their learning. Again, students voiced the greatest demand for functions of the learner-content type, such as Online quizzes for self-evaluation, Online help with content, FAQs about content, and Content-difficulty detection. As mentioned above, the design of some demanded functions should be more sensitive to learners' individual and contextual needs and, thus, could pose programming difficulties. Nevertheless, as Internet tools advance rapidly, CMS developers should start to consider the enhancement of system personalization, adaptability, and adaptation (Graf & List, 2005).

Furthermore, instructors of CMSs can help enhance learner–content interaction by providing online quizzes for student self-evaluation, FAQs regarding both content and assignments, study guides, and links to other educational systems to better engage students in the learning content.

5.4. Relationships among learner perceptions, uses, and evaluations of the CMSs' interactive functions

The regression analysis of this study indicates that students' evaluations regarding CMS interactivity and the collection of the interactive functions were effective predictors of the students' overall evaluation of CMSs. In other words, the stronger the students' perception of the CMS-interactivity levels and the stronger the students' emphasis on the interactive functions as a whole, the stronger the students' perception of the value of CMS. In addition, students who perceived CMSs as useful for learning were students who tended to place a relatively high value on their CMSs. The results imply that any improvements to the abstract interactivity and to the concrete interactive functions imbedded in a particular CMS could effectively lead to higher user assessment of that CMS.

5.5. Implications for CMS developers

1. This study has proposed a technical framework of 83 functions in nine dimensions for five types of interaction. It is, so far, possibly the most complete CMS framework based on theories, research, and real practices of six current CMSs. Any CMS developers can use this framework to examine any possible omissions or supplement in functionality.
2. The findings indicate that current CMSs have already designed many functions for human interaction (learner–instructor and learner–learner). Although students may or may not well know or fully use these functions, they seem to require no more functions for facilitating their interpersonal communication within the CMSs. Therefore, the CMS design issue may not be on the development of more human-communication functions, but on how to enhance students' full awareness and effective use of these existing functions.
3. In contrast, this study found that students demanded more functions for learner–content interaction. For example, the addition of adaptive quizzes (such as online quizzes for self-evaluation function) can provide students with meaningful information about their potential weakness and progress through the course, so that the CMS may become a useful self-evaluation tool for learning. Other examples include Links to related educational systems, Study guide, Individualized instruction/test/quiz.
4. Similarly, the findings suggest that an enhancement in system adaptability and personal-choice help may be the goal for improving current CMSs. In particular, functions such as Online help with contents, Content-difficulty detection, FAQs about content, and Online system-related problem diagnostics were required and believed to be most useful by students.
5. The findings show that students both were well familiar with and made use of any function that helped them monitor their learning progress or statuses. Examples include Grade-status tracking, Materials-viewed tracking, Assignment-completion tracking, and Calendar and schedule reminder. It is suggested that CMS developers need to focus on the function design that possesses more adaptability in serving the individual student's needs.
6. This study found that some functions, such as Learning dashboard and Social tools, were available in current CMSs but not well known and thus not used by students. Therefore, to meet the ends of supply and use, the developers of CMSs may consider conducting related studies on whether a given CMS's designed functions can really help students' learning. If the answer is yes, the CMS should make these functions more salient (on the menu bar or in the user guide) so that instructors can incorporate them into learning-activity designs and so that students can make good use of them.
7. Some of the functions which meet individual learners' needs or can automatically and intelligently detect learners' problems, such as Content-difficulty detection, Online help with contents, and Online system-related problem diagnostics, may pose greater programming difficulty for developers. However, the issues of individualization and customization should be prioritized as new advanced programming tools and techniques become available, enabling CMS developers to overcome current technical difficulties. In addition, based on our regression analysis, such enhancement of system interactivity may result in higher student satisfaction with that CMS.

5.6. Limitations and recommendations for future research

There are several concerns regarding the results of the current study. The first concern is the study's lack of a qualitative assessment of functions. The study collected only quantitative data (on the number of functions in each CMS), but we used no qualitative data (such as data on the completeness and adaptability of each function) to triangulate the findings. For example, some CMSs in our study provided the basic function of a calendar and a schedule reminder, and some even allow users to arrange or view calendars and schedules as a user preference (by event type, time unit, etc.). Therefore, five of the six CMSs may have the calendar and schedule-reminder function, but with different degrees of completeness or adaptability. Future studies can consider including a qualitative assessment of the functions.

The second concern is the versions of the CMSs examined. During the course of this study, the present researchers discovered version-related variations of certain CMSs; for instance, we found that the functions of a newly released version of a given CMS were superior to those of an older version, and that some functions were customized on the basis of specific instructional needs. Since certain enhanced functions are normally incorporated into newer versions, we suggest that future studies should include the most-up-to-date versions available (i.e., versions that have just become available).

Third, although this study conducted CMS-user surveys, our "user" amounted to students' perspectives. Of course, CMS users include both instructors who use CMS to teach and students who use CMS to learn. Much past research has focused on faculty adoptions of a particular CMS (e.g., Jackson, 2007; West et al., 2007), on faculty use of CMS features (e.g., Malikowski, 2008), or on other external factors such as school environment and class size relative to this adoption (e.g., Malikowski et al., 2006). Those studies have provided valuable empirical evidence and insights from faculty perspectives regarding CMS use in higher education. However, this field would benefit from research that investigates how instructors meet their teaching needs when perceiving, using, and evaluating CMS functions under different interaction types, and how the teachers can effectively use these functions to enhance course interactivity and learning outcomes.

Fourth, this study adopted the self-report method and applied it to CMS users, that is, we asked students to answer the survey questions concerning their perception (knowledge) and use frequency. We did not collect students' log-in records owing to our restricted access to these CMSs' user databases. In order to better understand students' actual use of a given CMS and avoid the possible unreliability of self-report data, future studies can use student log-in and navigation data (see also Black, Dawson, & Priem, 2008) and can conduct observations and in-depth interviews with students to triangulate and verify the findings.

Lastly, this study provides a new technical framework, with which we have examined six CMSs' functions in order to enhance the framework's overall effectiveness and to depict the types of interaction that characterize CMS-based learning. Peng et al. (2008) stated that "greater numbers of interactive functions do not necessarily guarantee better learning" (p. 63). In this regard, future research may investigate the relationships among users' perceptions of interactive functions, users' uses of interactive functions, and users' learning outcomes.

Appendix: Interaction types, interactive functions, and definitions and/or examples

Type of interaction		Interactive CMS functions	Definitions
Learner–self	1–1	Diary and reflective journal	A built-in form for learners to write diaries and reflective journals
	1–2	Note-taking	A built-in form for learners to summarize learning contents and notes
	1–3	Electronic portfolio	A space to document learning progress in multimedia formats
	1–4	Calendar and schedule reminder	A built-in calendar to set up schedules and reminders
	1–5	Task-list	A function enabling learners to check the number and status of learning tasks
	1–6	Online quiz for self-evaluation	A function enabling learners to assess learning effectiveness by accessing online quiz functions with immediate feedback
	1–7	Individualized learning record	A learning record (e.g., My Course) that records each learner's demographic and course-information
	1–8	Individualized instruction	The tailored instructional materials (contents and activities) that meet each individual learner's needs
	1–9	Individualized test/quiz	The personalized test/quiz for each individual learner
	1–10	Login-status tracking	A function that tracks each learner's log-in information, such as times, numbers, IP address, and duration
	1–11	Materials-viewed tracking	A function that tracks and displays the status of learning materials-viewed
	1–12	Learning-completion tracking	A function that tracks learning paths and learning progress
	1–13	Assignment-completion tracking	A function that tracks the status of assignment submission
	1–14	Presentation-status tracking	A function that tracks the status of presentation
	1–15	Examination-status tracking	A function that tracks the status of examinations, including in-class quizzes and term exams
	1–16	Grade-status tracking	A function that tracks the status of grade scores
	1–17	Learning dashboard	A single view of all learning events, such as records of assignment completion, messages contributed to the discussion, materials-viewed, and time spent on learning tasks
	1–18	Report transformer	A function that transforms textual reports into visualized presentations
Learner–interface	2–1	Fixed-frame (menu) design	A list of menu items from which learners can choose learning contents and functions
	2–2	Language choice	A list of choices for different languages
	2–3	Individualized Web-browser design	A personalized browser for learners to customize their Web page design
	2–4	Sitemap	A list of pages of a Web site accessible to learners
	2–5	Keyword search	A type of search that matches documents containing one or more words specified by the learner
	2–6	Database search	A type of search that allows learners to search particular contents stored in a database connected to the learning systems
	2–7	Software downloading	Learners can download free or for-fee software from the system for a particular learning purpose
	2–8	System announcement	The system announces system-related news, such as system maintenance and data backup
	2–9	System message	The system sends learners an automatic message, such as a reminder about learning activities or about assignment deadlines
	2–10	Subscription to learning information	A function enabling learners to subscribe to periodic learning-related messages
	2–11	System updates	A function to remind learners of system updates
	2–12	User guidance for a system	A guidance feature that facilitates system use
	2–13	Frequently asked questions (FAQs) about the system	A list of the most-frequently-asked questions and answers about the system
	2–14	Online system-related problem diagnostics	A mechanism enabling learners to report system-related problems and to locate problem solutions
	2–15	Email to Webmaster	Learners can write emails to the system designer or system administrator
	2–16	Comments on the system	A built-in form with which learners can express their opinions about the system
	2–17	Learning-difficulty detection	A function that automatically detects learner difficulties and offers solutions
	2–18	Online registration	Learners have to register with the learning system/courseware in order to become a member of a class and a learning community
	2–19	Login-status tracking	Same as 1–10
	2–20	Materials-viewed tracking	Same as 1–11
	2–21	Learning-completion tracking	Same as 1–12
	2–22	Assignment-completion tracking	Same as 1–13
	2–23	Presentation-status tracking	Same as 1–14
	2–24	Examination-status tracking	Same as 1–15
	2–25	Grade-status tracking	Same as 1–16
	2–26	Learning dashboard	Same as 1–17
	2–27	Report transformer	Same as 1–18

(*continued on next page*)

(*continued*)

Type of interaction		Interactive CMS functions	Definitions
Learner–content	3–1	Links to related educational systems	A list of links to related educational platforms or databases
	3–2	Links to related learning materials	A list of links to related learning materials
	3–3	Multimedia presentation	Media (text, graphics, animation, audio, etc.) and content that use a combination of different presentation forms, including a combination of text, audio, graphics, animation, and video
	3–4	Push media	A form of automatic, regular transmissions of information to learners
	3–5	Online quiz for self-evaluation	Same as 1–6
	3–6	Online examination	A function enabling learners to assess learning effectiveness by accessing online examinations that feature instructors' immediate feedback
	3–7	Study guide	Guided information on learning progress
	3–8	Frequently asked questions (FAQs) about contents	A list of the most-frequently-asked questions and answers about contents, such as the required format for assignments
	3–9	Online help with contents	Learner assistance about topic-oriented contents in information
	3–10	Content-difficulty detection	A function that automatically detects content/learning difficulties and offers solutions
	3–11	Individualized learning record	Same as 1–7
	3–12	Individualized instruction	Same as 1–8
	3–13	Individualized test/quiz	Same as 1–9
	3–14	Materials-viewed tracking	Same as 1–11 & 2–20
	3–15	Note-taking	Same as 1–2
	3–16	Learner contribution to learning materials	A mechanism enabling learners to contribute to learning materials (e.g., example, learners can provide Web links containing useful information for the course)
	3–17	Sweepstakes	Events held to attract learners and to encourage learner participation by means of such special incentives as a prize for the first learner to solve a specific content-related problem
	3–18	Educational games	Games that have been specifically designed to teach learners about instructional contents
	3–19	Jokes	Jokes tailored specifically to instructional contents
Learner–instructor	4–1	Class roster	A list of learners and instructors in courses or sites
	4–2	Email to instructors	A built-in email system enabling learners to write a message to their instructors
	4–3	Bulletin board systems (BBSs)	A built-in BBS enabling instructors and learners to post or to view information
	4–4	Synchronous communication	A built-in mechanism enabling instructors and learners to chat synchronously
	4–5	Social tools	Built-in tools that connect learners with instructors or peers by textual or visual portrayals; tools include self-introduction, contact information, or emoticons
	4–6	Grouping	A function for classifying learners into groups
	4–7	Assignment handling	A mechanism enabling learners to hand in their assignment and to receive instructors' feedback
	4–8	Online examination	Same as 3–6
	4–9	Online voting	A function enabling learners and instructors to vote for learning-related events
	4–10	Online survey	A built-in survey system to solicit opinions of learners and instructors
	4–11	Comments on the course and instructors	A built-in form to express comments about the course and instructors
Learner–learner	5–1	Class roster	Same as 4–1
	5–2	Email to other learners	A built-in email system enabling learners to write a message to other learners
	5–3	Bulletin board systems (BBSs)	Same as 4–3
	5–4	Synchronous communication	Same as 4–4
	5–5	Social tools	Same as 4–5
	5–6	Grouping	Same as 4–6
	5–7	Sharing and emulation	A function enabling learners to exchange learning experiences or learning outcomes with peers
	5–8	Peer evaluation	A function to evaluate peer learners' learning progress and learning outcomes

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