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The Taxonomical Analysis of Science Educational Software in Malaysian Smart Schools

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Abstract

The taxonomical study related to the pedagogical, communication and media dimensions of the interactive teaching-learning science educational courseware that is currently being utilised in the Malaysian Smart Schools is reported. The pedagogical and communicative dimensions studied included aspects of the instructional configuration, the instructional model, cognitive processes, and loci of control, learning resources, evaluation, interactive types of teaching, feedback and help functions. The extent of media utilisation such as texts, images, interactive images, animation and sound was also studied. The results revealed that the instructional configuration of the courseware was predominantly in the form of individual instruction rather than in the preferred collaborative learning format. The instructional means most widely deployed was the information-based mode with a low level utilisation of the favoured inquiry-based mode of teaching. The interactive types of teaching deployed were mostly in the form of multiple choice questions and simple activities with very minimal utilisation of online tools and/or consultation with the experts. The cognitive processes utilised were mostly information retrieval and memorising and involved the minimal usage of problem solving, decision making, creation and invention possibilities inherent in the courseware. The media analysis revealed that a combination of texts, images, interactive images, animation and sound was incorporated into the courseware to make learning interesting.

INTRODUCTION

The Smart Schools concept is part of the Malaysian Information Technology (IT) agenda that exposes students, teachers, administrators and parents to IT in every aspect of education at the administrative and classroom levels. At the pilot project stage, 90 schools were selected to take advantage of the programme which commenced in 1999 and ended in 2002. This concept also aims to systematically change the education system from rote learning and examination-oriented culture to a thinking and creative knowledge culture (Foong-Mae, 2002). School classrooms in this programme feature such technology-enablers as individual desktop personal computers, multimedia computer laboratories, video conferencing systems and high-speed Internet connections. Learning will thus be self-directed, collaborative, individually paced, continuous and reflective, utilising teaching materials that are not only limited to printed books, but also include electronic books, multimedia software, courseware catalogues and databases (Umat, 2000).

The pilot project involved the trial testing of the Smart School Integrated Solution that contains various components. The main component is the teaching-learning courseware relating to curriculum, pedagogy, assessment and teaching and learning which has been designed using a Browser-based platform with the aim of making lesson deliveries more effective, efficient and meaningful resulting in better realisation of the students' capabilities and potential and allowing them to take greater responsibilities for their own learning (Umat, 2000).

The teaching and learning courseware designed for the Smart Schools utilises the Internet/Web or Browser-based environment. Such a learning environment should normally focus on three distinctively advantageous features, namely the communicative feature, the access to a plethora of information/resources and the integration of the appropriate mix of media. Where communicative features are concerned, perhaps the most useful feature of the Web-based learning is its ability to serve as a multifaceted environment for communication. A considerable number of communication modes and tools (both synchronous and asynchronous) can be made available to students such as the e-mail, IRC chats, bulletin boards for discussion groups and synchronous video and audio support for collaborative work. The communicative features of the Browser-based learning have the ability, therefore, to implement unique learning transactions and modes by involving both the students and experts in network-supported group work. This fosters an engaging learning environment where students are captivated by the creative approaches to learning where collaboration and a sense of community are cultivated (Edelson et al, 1996; Hiltz et al, 1999; Idrus & Atan, 2002).

Web-based learning is more than an information environment. It enables the students to do their own exploration into the wealth of information and resources. It also allows learners to determine their individual pace of study with a set of tools that enables personalisation of content and allows them to choose the way in which they learn most effectively. The combination of the communicative features, access to resources and the integration of various media leads to unique learning experiences whereby students have the luxury of comprehensive learning experiences, from synchronous learning to threaded discussions then to self-paced study, all involving a combination of various strategies (Harasim et al, 1997).

The inherent characteristics of Web-based learning also support the current and the accepted constructivist learning theory of knowledge construction where learning is student-centred rather than teacher-centred, and the teaching activity is interactive rather than didactive (Wilson, 1996). The role of the teacher changes from that of the content expert to the facilitator of knowledge construction while the student's role is no longer that of a passive listener but more of an active collaborator (Agostinho, 1997). The instructional emphasis in this process is more of critical thinking rather than fact and rote learning with the demonstration of learning success being no longer on retention but rather on assimilation (Black & McClintock, 1996). This proposed teaching process is more on collaboration and interactivity rather than traditional drill and practice with the knowledge construction being brought about through transformation of facts and ideas rather than the accumulation and retention of facts (Idrus & Atan, 2003).

With the enormous benefit that Web-based learning can offer in terms of its pedagogical and communicative dimensions, the educational science courseware that has been designed for Smart Schools has generated high expectations among educators. One would expect that such a design would incorporate the various forms of the communicative features that support collaborative learning while at the same time, utilises the current and accepted constructivist educational strategies. This study was thus undertaken to assess the extent that the courseware developed for the Smart Schools has realised the potential, power and versatility that Web-based learning offers through its communicative features and the extent to which the design has fulfilled the expectations of the pedagogical approach that has been used.

THE SCIENCE EDUCATIONAL SOFTWARE

The science educational software involved in this study was the pilot project software that was used in the teaching and learning of science among Form One students (13 years old) in designated Malaysian Smart Schools. The design platform was Browser-based and consisted of eight main topics, namely, the physical quantities and their measurements, the cell as a unit of life, living things and their classifications, matter, resources on earth, the air around us, sources of energy and heat; the Web pages ranged from 13 to 33 pages. Table 1 shows the main topics under discussion and the corresponding number of Web pages embedding the respective main topics.

Table 1. Contents of the Form One (13 years old) Science Interactive Software

Topic	No of Web pages
Physical quantities and their measurements	21
The cell as a unit of life	17
The variety of living things and their classifications	21
Matter	25
The variety of resources on Earth	13
The air around us	33
Sources of energy	17
Heat	25
Total (N_t)	172

METHODOLOGY

The taxonomical approach used in this study was adapted from the taxonomy of the Web-based Learning Environment (WBLE) developed by Nachimas et al, (1999). It involves the sorting of the Web pages according to the instructional and learning variables that are embedded in these pages. A total of 10 pedagogical variables were selected for this study. They were the following: the instructional configuration, the instructional model, instructional means, interactive types of teaching, cognitive processes, loci of control, feedback, the help function, learning resources and evaluation. Each page was carefully studied and evaluated in terms of the pedagogical dimensions it posed. The pages that contained the categorised pedagogical variables in the design were recorded and the frequencies calculated. As for the communicative dimensions, three aspects of communicative features were selected; these being the interactive type, feedback and help functions.

In terms of the media supported by the courseware, a similar technique was deployed. The media dimension was categorised according to the text, image, interactive image, animation and sound. Each page of the courseware was carefully studied and the pages that contained the selected media dimensions were recorded and the frequencies calculated. The calculated frequencies allowed the distribution of media by representational means to be constructed.

RESULTS AND DISCUSSION

The Pedagogical Dimensions

The current pedagogical approaches support the learning processes that require the students' active participation in the construction of knowledge which create an environment for their high level cognitive processes (analysis, synthesis and evaluation). Such an approach requires students to actively seek knowledge, redesign, manipulate, reinvent and assess the new knowledge so that it becomes more meaningful and permanent. In the constructivist Web-based learning environment, an antidote for reproductive learning is to engage learners in active, manipulative, constructive, intentional, complex, authentic, cooperative (collaborative and conversational) and reflective learning activities (Jonassen, 1999). The model of a constructivist learning environment proposed by Jonassen (1999) includes problem representation/problem manipulation, related experiences, information resources, cognitive (knowledge construction), conversation and collaboration tools and social/contextual support. The expectation is that the development process of the educational courseware in the Malaysian Smart Schools would be based at least on some of these approaches. Moreover, given the innovative character of the technology, it should also be expected that the design of the courseware would give rise to new pedagogical forms and instructional strategies.

The analysis of the pedagogical dimensions is shown in Table 2. In terms of the instructional configurations, a total of 82.6% of the Web pages supported individual instruction whereas the preferred class collaborative learning constituted only 13.4%. The Web-based collaborative learning involving the network supported group constituted an even lower composition of 8.1%. An analysis of the instructional models embedded in the pages showed that a traditional, hierarchical, highly structured and directed instruction mode still prevailed (79.7%). Only 36.6% of the pages supported inquiry-based learning.

The Web technology offers a wide range of possibilities in terms of instructional means. The analysis revealed that most frequent means implemented were informational (72.7%), structured (44.2%) and open-ended (40.2%) activities. Tools and a virtual environment were included in 16%-6% of the pages. Very few pages included the online adaptive mechanism. The most frequent cognitive processes elicited by activities were information retrieval (48.8%) and memorising (47.1%). Information analysis and inferencing were supported by activities in approximately one-third of the total pages studied. Only a few Web pages contained high level processes such as problem solving, creation and invention.

In terms of the loci of control, the students' control over their work was supported by 84.9% of the pages. However, this figure should also be considered in relation to the finding of the interactive mode of teaching that is shown in Table 3. This teaching was mostly achieved through multiple choice questions and simple activities, the students primarily engaged in the use of the computer keyboard and either dragging or clicking icons to different positions. They would receive feedback to every response they entered and incorrect responses meant that they could retry until the correct answers appeared.

Table 2. Pedagogical Features of the Form One Science Courseware (N_t = 172)

Pedagogical Features		N	%
Instructional configuration	Individual instruction	142	82.6
	Classroom collaborative learning	23	13.4
	Web-collaborative learning	14	8.1
Instructional model	Directed	137	79.7
	Inquiry based	63	36.6
Instructional means	Information based	125	72.7
	Tools	26	15.1
	Structured activity	76	44.2
	Open-ended activity	69	40.2
	Virtual environment	12	6.9
	Student modelling/adaptive mechanism	9	5.2
Cognitive process	Information retrieval	84	48.8
	Memorising	81	47.1
	Information analysis and inferencing	54	31.4
	Problem solving and decision making	14	8.1
	Creation and invention	7	4.1
Loci of control	Student controlled	146	84.9
	Software environment controlled	26	15.1
	Mixed initiative	11	6.4
Learning resources	Resources within the page	38	22.1
	Additional external resources	12	6.9
	Asking an expert	0	0
	Asking a peer	0	0
Evaluation	Standardised test	82	47.7
	Alternative evaluation	49	28.5

The educational Web could be considered as a bundle of varied representational and pedagogical resources. In this category of taxonomy, different types of resources within the Web pages as well as externally via the communicative features of the Web through the facilitation of experts or collaboratively among peers were looked for. It was found that 22.1 % of the pages relied on resources within the page. External resources contributed to 6.9% and there was no page that referred to experts or peers, either online or offline, as learning resources. The evaluation aspect of the courseware in the form of standardised tests constituted 47.7% of the pages whereas alternative evaluation was embedded in 28.5% of the pages.

The Communicative Dimensions

Interactivity can be considered as one of the major potential contributions of digital technology to instruction. The unique features of the Web technology with its inherent group networking capabilities appear to create an ideal milieu for the implementation of most educational processes involving the interaction among peers and experts such as collaborative learning, distributed cognition and scaffolding (Jonassen, 1999).

However, interaction with other people (e.g., with experts or peers) that involved synchronous and asynchronous activities was not recorded. No provision for e-mail, chats, forum boards or video conferences was incorporated into the design of the courseware. The type of interaction recorded focused very much on the user aspect where the students interacted with the presentation and were able to browse, annotate and elaborate within the specified databases. The quality of interaction was thus a function of the nature of the learners' response and the computer's feedback.

As indicated in Table 3, the most frequent form of interaction was the question-and-answer tasks involving multiple choice questions (71.5%). That type of activity involved students giving a response to a question that was accompanied by a series of answers. Students obtained immediately feedback to their responses. A simple interaction, in which clicking and dragging objects occurred on the screen when activated by a predetermined script, appeared in 61.2% of the pages. More complex interaction, (e.g., manipulation of a number of variables) constituted 26.2% of the pages.

Interactivity through feedback was mostly in the form of automatic responses (27.9%), whereas human interaction (both synchronous and asynchronous) was included in 6.3 % of the pages. In terms of the help function, the help derived from the contextualised contents of materials constituted 47.1% of the pages whereas didactic help was present in 23.3% of the pages. Very limited technical help was available (4.7%).

Table 3. The Communicative Dimensions of the Science Courseware (N_t = 172)

Communicative Dimensions		N	%
Interactive type	Multiple-choice questions	123	71.5
	Simple activity	119	69.2
	Complex activity	45	26.2
	Browsing	38	22.1
	Online tools	7	4.4
	Expert consultation	0	0
Feedback	Automatic	48	27.9
	Human asynchronous	9	5.6
	Human synchronous	5	2.9
Help functions	Technical help	8	4.7
	Contextualised content help	81	47.1
	Didactic help	45	23.3

As can been seen, the gap between expectation and implementation in terms of the design of the science courseware was more evident in the communication domain than in the pedagogical domain already discussed. The technological resources for online communication already exist and they are being successfully implemented in other areas of life for people such as at their work, professional training, banking and shopping. In addition, human transactions and transactions between people and information resources are quintessential to education, and it is not difficult to conceive the endless forms of support that communication technology can offer for this process. However, this support does not as yet function in the design of the educational software for the Smart Schools that was looked at in this study.

The Media Representational Means

Any Web-based learning environment must include the combination of text, graphics, audio, video, animation, virtual environment and other multimedia aspects. The integration of all these media exposes the students to a very rich learning environment that can even outshine the level of understanding they might obtain from a classroom (Jaiballan & Asirvatham, 2002). Table 4 shows the frequency distribution of the media representational means utilised in the courseware. As expected, the text was the dominant information conveyer (76.2%). Visual means (e.g., images, photographs and illustrations) were also quite dominantly used in the courseware (64.1%). The interactive image (41.9%), animation (31.4%) and sound (31.9%) were incorporated into some of the pages. The analysis indicated that the courseware has successfully incorporated a wide range of media to make learning more interesting. As indicated by Chong (2002), the use of multimedia that involve text, audio and video materials activates the verbal and the non-verbal channels and thus provides narrative effects and enhances referential processing. The properly designed computer-based multimedia that incorporate the combination of interactive media and learner-paced activities have the ability to support the way students understand, organise and access information and assist them to gain more information in less time than if they were studying in the traditional classroom (Chong, 2002).

Table 4. Distribution of Web pages by representational means

	Not at all		Once in a pag		50% of the pages on a topic		One appearan per page		More than one appearance per page	
	n	%	n	%	n	%	n	%	n	%
Text	0	0	2	1.2	7	4.1	32	18.6	131	76.2
Image	0	0	16	9.3	10	5.8	35	20.3	111	64.5
Interactive Imag	8	4.6	9	5.2	51	29.7	32	18.6	72	41.9
Animation	15	8.7	53	30.8	25	14.5	25	14.5	54	31.4
Sound	21	12.2	72	41.9	14	8.1	10	5.8	55	31.9

CONCLUDING REMARKS

This taxonomical analysis of the Form One (13 years old students) pilot project of the science courseware for the Malaysian Smart Schools revealed that gaps and discrepancies exist between the expectations and the implementation of the design of the courseware. The current design of the courseware is predominantly information-based resulting in a directed form of instructional delivery. The cognitive processes are mostly information retrieval and memorising with little external learning resources made available. No online collaboration with peers and experts has been incorporated into the design and the interactivity has been mostly of lower level interaction with the computer databases. It is thus imperative that the design of the learning environment in the next generation of the science educational courseware in Smart Schools take into consideration the unique features that the Web can offer so that the courseware created contains a pedagogical and communicative component that is relevant not only to the power, potential and versatility of the gamut of the educational technology available today but also to the current and accepted constructivist educational strategies.

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