Construction and Selection of Usefulness Evaluation Items

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Abstract—The purpose of this research was to construct a set of indicators or items that could measure the usefulness of mathematics courseware (MC). Usefulness is a quality attribute to which a person believes that using a particular MC would enhance students mathematical understanding of certain topics and engage them in learning activities. In order to construct the items, open ended survey forms were distributed to five mathematics courseware developers. They were asked to list down the essential factors and items that are important in a of good mathematics courseware. In parallel to that several mathematics courseware reviews and evaluation instruments were analyzed. Ultimately, the preliminary survey and literature-based produced a checklist with 85 items consisting of three factors, which were usability, functionality and efficiency and seven criteria which were ease of use, attractiveness, concepts presentation, assessment, reinforcement, accuracy and learning support material. The mapping of items according to their criteria and factors are discussed. The items were then reviewed by 10 experts in two rounds of content validity check. Finally 66 usefulness items from seven factors with reliability range between 0.723 to 0.911 were produced.

Keywords— Mathematics courseware, Usefulness attribute, Usefulness model, Usefulness items.

I. INTRODUCTION

Computer aided learning material such as mathematics courseware (MC) packages encourage learners to use them effectively if they are designed appropriately. Research findings on the use of computers in teaching and learning mathematics, appears that computer use has tremendous potential to improve mathematics education. For example, using courseware packages in teaching and learning help students understand mathematics. Those packages improve the learning of mathematics and influence the achievements of students in the subject [17, 18, 23]. Study by [16] has shown that students seem to enjoy working with mathematics courseware (MC) and their attitude toward mathematics, computer and courseware was positively encouraging. Consequently, teaching and learning packages for mathematics has significantly increased.

With a large number of e-learning materials that are developed in addition to text and reference books in the markets, students themselves have to identify to what aspects of MC are important in their learning process. Choosing good courseware has become a main concern in e-learning by educational institution administrators, teachers, parents and learners [15]. When considering whether or not to use a courseware, it is recommended that teachers carry out a full evaluation to reveal whether the developers have tackled a subject according to its educational objectives. However, with such a large number of MC developed, teachers have problems to select the right one [6,16]. This is because a valid and reliable evaluation instrument for mathematics courseware is still lacking.

Evaluation of educational effectiveness is the primary area with which developers of learning software must concern [4, 10, 20]. There are many factors that should be taken into account when evaluating educational software. Such software might be usable but not educational, or vice versa. The final goal must be for courseware to be both usable and educational. Most previous studies, however, have focused on the multimedia or courseware design adequacy. Unfortunately only a few have examined the quality of both educational and human-computer interaction adequacy. Developers hardly field test their courseware products or provide empirical evidence of its effectiveness. But if they have, they usually design their own evaluation instruments in order to evaluate the courseware that they have developed. Only a few researchers [12, 14] employed systematic procedure to develop and validate an instrument for evaluating educational software.

Consequently, this study is to produce a reliable and valid evaluation factors and items to measure the usefulness of mathematics courseware. The instrument could be used by teachers in selecting useful MC for their students. The

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instrument provides teachers with external quality elements, which are pedagogical adequacy as well as human-computer interaction elements. This factors and indicators also could be used by MC developers as a guideline in the development process or before the MC are sent to the market.

The first section of this paper discusses on methodology of the research. The second section presents the discussion of usefulness model of MC and follows by usefulness items collection, expert review and item analysis results. The last section discusses the conclusion of the paper.

II. Methodology

The methodology involved was gathering related items from a preliminary survey, several mathematics review papers and existing evaluation instruments. Next, the items were matched accordingly to predefined usefulness factors and criteria. Then, the checklist was reviewed by experts in two rounds of content validity check to produce a set of questionnaire. Finally, data were collected and the reliability of the items were analyzed.

The first phase of the study was to gather a pool of items that were related to evaluating mathematics courseware. It was done by preliminary survey conducted to five courseware developers. They were given open-ended questionnaire and asked to list down all characteristics of good mathematics courseware. Literature based on mathematics courseware review and evaluation instrument were done in order to collect more items that deemed relevant to mathematics courseware. Consequently, from the mapping of the items collection and the developed usefulness model 85-item checklist were constructed.

In the next phase, 10 panel members or experts were asked to review the 85-items checklist through two rounds of content validity. First, the checklist was sent to eight experts, who were lecturers from three local universities for the first round of content validity. The experts were assigned to explore three MCs (MC-A, MC-B, MC-C) in order to identify any items they deemed relevant to the dimensions. They were asked to identify whether or not the items should be in a useful MC and give comments on each item. The experts were encouraged to add or drop items, criteria or factors which were inappropriate. Feedbacks from the expert were analyzed and the checklist questions were changed to questionnaire items.

Next, the questionnaire was sent to four experts (two of them were involved in the first review) to check the appropriateness of its format. The members reviewed on operational issues such as items sentence clarity and sequence, as well as relevant item to its criteria and factor. Finally the questionnaire was administered to 35 mathematics teachers. They were asked to use the questionnaire to evaluate a MC. Data from the evaluation activity were used to analyzed the items reliability.

III. Results

The usefulness model and items produced are discussed. The results of item reliability analysis are produced.

A. Usefulness Model of MC

First phase of this study employed an in-depth approach to obtain an evaluation model for usefulness quality attribute of a MC that could be used by teachers. The usefulness evaluation model was constructed based on the study of McCall FCM model, Boehm model and ISO 9126 [11] and Nielsen Acceptance model [9]. This study emphasized on the related attributes to measure software before acceptance, which are an evaluation on a MC before used by students. Usefulness is the issue of whether the system can be used to achieve some desired goal [9]. In the context of educational software, the definition of usefulness is a quality attribute to which a person believes that using a particular MC would enhance students mathematical understanding of certain topics and engage them in learning activities. As shown in Fig. 1, usefulness attribute is divided into two sub-attributes, which are utility and usability. Utility is measured by functionality and efficiency factors. It is implied to teachers' perception of MC educational adequacy that is useful as a self-learning material. Functionality factor includes the suitability criterion as a tutorial material and the curriculum accuracy of MC. Suitability is measured by concept presentation, reinforcement and assessment. While, efficiency factor of a MC is measured through the availability of its learning support material.

Usability, in the context of MC, is related to technical adequacy that engages students using MC, which are ease of use and attractiveness. Ease of use criteria is measured primarily by its friendliness, intuitiveness and ease of navigation. Attractiveness refers to MC user interface, readability, appearance and visual design. All usefulness criteria would be measured by evaluation items.

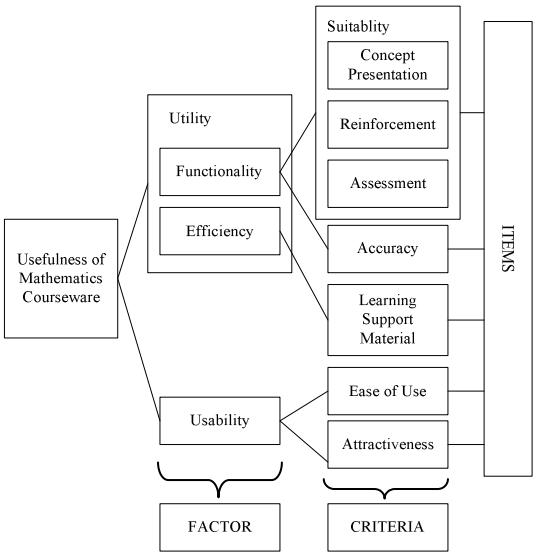

Fig. 1 Usefulness Evaluation Model

B. *Usefulness Items Collection*

A pool of evaluation items were collected based on MC preliminary evaluation survey. Three developers and two mathematics lecturer who were directly involved in developing and evaluating courseware were given an open ended questionnaire and a MC to explore. They were asked to list down the strengths and weaknesses of the MCs' educational and technical adequacy. In addition to that, other items were collected from related articles on MC reviews [2, 5, 8] and based on several existing evaluation instruments [3, 13, 16].

The collection of statements and items were judged and assigned to a tentative checklist with 85 items consisting of three factors, which were usability, functionality and efficiency and seven criteria which were ease of use, attractiveness, concepts presentation, assessment, reinforcement, accuracy and learning support material. The mapping of items according to their criteria and factors are discussed below.

1) *Functionality Factor*

Functionality is measured by suitability and accuracy. This factor is to assure all mathematics learning and teaching requirements are implemented. The evaluation of this factor is to determine the suitability and accuracy of content and teaching strategy are met.

Items or indicators that can measure suitability criterion and eventually measuring functionality factor are the items that measure the suitability of content and learning strategy which are concept presentation, reinforcement and assessment. Based on the definition, related items for suitability criterion were chosen from a pool of collected items as shown in Table 1.

Table 1 Suitability Criterion

	Concept Presentation
1	Does the concept related to the stated mathematics topics?
2	Does the courseware include a sufficient amount of information?
3	Are Malaysian moral values emphasized?
4	Does the depth of the concept meets student's level?
5	Does the content presentation using appropriate approach?
6	Does the mathematics experiment and exploration provide information about definition, theorem and the sense of self-discovery?
7	Does the courseware provide sufficient activities?
8	Is the mathematics concepts presented with appropriate graphics?
	Reinforcement
9	Is interactive example for hands-on exploration of a mathematical concept provided?
10	Is example with visualization provided?
11	Does the courseware provide multiple types of examples?
12	Does the courseware provide games and simulation to enhance student's understanding of a mathematical concept?
13	Are multiple problems solving techniques illustrated?
14	Are problems with random parameters provided?
15	Are Multiple types of questions provided?
16	Are problems enriched critical and creative thinking skill?
17	Could drill questions be solved in appropriate times?
18	Are hints or solving suggestions provided?
19	Does the question arrange from easy to complex.
	Assessment
20	Does the courseware allow user to create test according to topics, number of questions and degree of difficulty?
21	Could the self assessment be accessed any time?
22	Does the courseware generate a test report?
23	Does the formative assessment meets learning objectives?

Accuracy is another criterion of functionality. This criterion is the capability of a MC to present its content through mathematics learning strategy that met mathematics curriculum and objectives. Items that measure the accuracy criterion eventually measure the functionality factor by evaluating the accuracy of content and learning strategy. Based on the definition, items as shown in Table 2 are produced.

Table 2: Accuracy Criterion Items

24	Is mathematics curriculum for secondary school met?
25	Are Mathematics terms defined and used correctly?
26	Is the concept introduced with an induction set?
27	Are moral values embedded indirectly?
28	Are information presented clearly?
29	Are real-life application presented using video, animation, music or graphic?
30	Is mathematics concept presented together with its application?
31	Are moral values shown in the induction set?
32	Are questions presented clearly and test student understanding?
33	Does practice problem provide step-by-step worked out solution?
34	Could the answers be checked by the system?
35	Does the right answer display after students answer wrongly several times?

36	Is the student's summative evaluation based on the stated learning objectives?
37	Is the score shown really reflected student's knowledge?
38	Could the courseware determine students' weaknesses?

2) Efficiency Factor

Efficiency factor refers to the amount of resources used and the duration of such use. Efficiency criteria for measuring the usefulness attribute refer to how a MC uses multimedia and computer capabilities to deliver teaching material and support learning activities. The efficiency items chosen from the collected items are related to the items that can measure element of learning support material such as customizable and automated practice and test system that would engage students in learning activities [19]. Based on this definition, efficiency items as shown in Table 3 were gathered.

Table 3 Efficiency Criterion Items

39	Are presentation of learning objectives shown in attractive flow chart and mind map?
40	Is the induction set presented creatively?
41	Is the recall modul or student's prior knowledge provided?
42	Is calculator provided?
43	Is reference material provided?
44	Does the courseware provide the history related to a mathematics concept?
45	Is glossary provided?
45	Does the courseware provide graph for a mathematical equation?
47	Does the calculation by computer attract students learning and help understanding?
48	Does the Mathematics experiment and idea exploration interesting?
49	Does the courseware use completely the power of visualization?
50	Are instructional games activities provided?
51	Is feedback by system relevance?
52	Is the feedback given understandable?
53	Does the system provide learning activities for multiple intelligence students?
54	Can the student learn according to their level?
55	Are learning tips provided?
56	Is the analysis of student's mistakes in answering questions provided?
57	Is FAQ with answers provided?
58	Are multimedia element used to give feedback when students give input (type, click, drag and drop)?
59	Does multimedia element help students to master a mathematics concept?
60	Can the system suggest students to proceed to recovery or enrichment modul based on his performance?

3) Usability Factor

Usability is related to the interface efficacy and efficiency and to user reaction to the interface [7]. Usability issue includes not only interface and navigation design aspects but also content organization, accessibility and memorization properties [20]. According to [1] usability focuses on three aspects: easy to learn, easy to use and user satisfaction in using a system. The researcher combine easy to learn and easy to use become ease of use and user satisfaction is measured by its attractiveness. Usability factor measures how MC provides user interface elements that allow users control their learning environment and engage them in learning activities. Based on the definition of ease or use, suitable items are chosen from a pool of usefulness items as shown in Table 4.

Table 4 Ease or use Criterion items

61	Are active buttons clearly highlighted?
62	Is exit or main menu clearly provided?
63	Is command button clear?
64	Are words on the button understandable?
65	Are icons meaningful?
66	Does the user interface layout help navigation?
67	Is instruction easy to understand and follow?
68	Is button with tool tips provided?
69	Can the computer provide system status to user?
70	Can the user control the sequence of presentation?
71	Is good interactive control such as scroll bar, edit box and animation button used?
72	Is help button available in each screen?

Attractiveness criterion is the measure of how a MC displays its aesthetic elements that encourage students to use the MC. The attractiveness items could measure the multimedia elements in a MC. Based on the definition of attractiveness, suitable items are chosen from a pool of usefulness items as shown in Table 5.

Table 5 Attractiveness Criterion Items

73	Can the user control audio?
74	Is the information in help menu accessible?
75	Is the combination of colors appropriate?
76	Is the screen background attractive?
77	Are texts readable?
78	Does graphic enhance the instructional effect?
79	Does video enhance the instructional effect?
80	Is animated illustration good?
81	Is background music good?
82	Is screen area used effectively?
83	Is screen layout consistence?
84	Can user skip video or animation?
85	Is shortcut for expert user provided?

The mapped items formed a set of Mathematics Courseware Usefulness checklist. The checklist comprises of three factors, seven criteria and 85 items. The number of items are summarized in Table 6.

Table 6 Number of Items

FACTOR	CRITERIA	ITEMS
Functionality	Concept presentation	1-8
	Reinforcement	9-19
	Assessment	20-23
	Accuracy	24-38
Efficiency	Efficiency	39-60
Usability	Ease or use	61-72
	Attractiveness	73-85

4) Expert Review Output

Expert panels were given three MCs to explore and 85-items checklist. They were encouraged to inspect the MCs heuristically. Those courseware present different topics and different learning approached. They have to tick in the checklist forms whether the items should be accepted or deleted. They were free to give comments on any item. This activity helped experts to decide which items should be in a good MC.

Feedbacks from the experts were analyzed. The analyses of the feedbacks are shown in Table 7. It shows the percentage of items that should be accepted by each panel member and the rating for each MC evaluated. This score is based on the scale from 1 to 4 (bad – good) at the end of the checklist. Overall the experts agreed that 85.9% to 100% of the items should be maintained. The mean scores for MC-A MC-B, MC-C were 2.34, 3.14 and 3.64 respectively. This value shows that the instrument is capable to differentiate the rating of different MCs.

Tabel 7: Experts Panel Analysis

Expert	Accepted Items Percentage (%)	Evaluation Score		
		MC-A	MC-B	MC-C
1	98.8	3.00	4.10	4.10
2	100	2.00	2.50	3.00
3	85.9	2.50	2.50	3.50
4	89.4	3.00	4.00	3.75
5	100	2.25	4.00	4.50
6	97.6	2.00	3.50	3.75
7	100	2.00	2.00	2.50
8	94.1	2.00	2.50	4.00

Comments from the experts are summarized as follows:

1. They agreed that the items were comprehensive and can measure the seven factors.
2. There were too many items measuring one factor. Furthermore some items were redundant or repeated in different words.
3. Items which were not measurable should be reviewed or deleted.
4. Some terms should be reviewed and used consistently.
5. Avoid asking too many questions in one item.
6. There were similar items measuring different factors.
7. There were some vague statements in the checklist.
8. Items should be in positive sentence.
9. Item sentence should be short and simple, not a complex sentence.
10. Items should be reduced.

Generally all experts agreed that the items were comprehensive and relevant to all criteria and factors. Feedbacks from the panel such as, redundant and not measurable items, unclear and confusing sentences were reviewed. Due to recommendations from the panel, 19 items were eliminated, 12 items were modified, 53 items remained and one item added. Eventually a total of 66 items were obtained. The experts supported the factors and criteria for usefulness evaluation. The 66 items sentences were revised and formed a set of questionnaire with five-point-Likert-scale with response choices ranging from one (1) to five (5) representing strongly disagree, disagree, quite agree, agree and strongly agree respectively. This instrument is called a MC usefulness evaluation instrument version 1 (MCUE_1). The items are shown in Table 8.

Table 8 Usefulness Questionnaire

Concept Presentation	
CP1	Concepts are related to the stated mathematics topics.
CP2	The depth of the concept meets student's level.
CP3	Malaysian moral values are emphasized.
CP4	Courseware includes a sufficient amount and quality of information.
CP5	Mathematics experiment and exploration provide information about definition, theorem and the sense of self-discovery.
CP6	Courseware provides sufficient activities with student's ability.
CP7	Contents are presented using appropriate approach.
CP8	Mathematics concepts are presented with appropriate graphics.
Reinforcement	
r9	Interactive example for hands-on exploration of a mathematical concept is provided.
r10	Example with visualization is provided.
r11	Multiple problem solving techniques are illustrated.
r12	Problems with random parameters are provided.
r13	Multiple types of questions are provided.
r14	Problems enrich critical and creative thinking skill.
r15	Drill questions can be solved in an appropriate times.
r16	Questions are arranged from easy to complex.
Assessment	

a17	User is allowed to create his own test according to topics, number of questions and degree of difficulty.
a18	Self assessment can be accessed any time.
a19	Courseware can generate a test report.
a20	Summative evaluation are based on stated learning objectives.
	Accuracy
ac21	Mathematics curriculum for secondary school met.
ac22	Mathematics terms are defined and used correctly.
ac23	Concept is introduced with an induction set.
ac24	Mathematics concept is presented together with its application.
ac25	Good values are embedded indirectly.
ac26	Drill question are presented clearly and test student understanding.
ac27	Step-by-step worked out solution are provided.
ac28	System can check the answers.
ac29	Right answer displays after students answer wrongly several times.
ac30	Formative assessment meets learning objectives.
	Ease of Use
e31	Icons are meaningful.
e32	Command buttons are clear.
e33	Active buttons are clearly highlighted.
e34	Exit or main menu is clearly provided.
e35	User interface layout helps navigation easier.
e36	Button with tool tips provided.
e37	Computer provides system status to user.
e38	User controls the sequence of presentation.
e39	Good interactive control such as scroll bar, edit box and animation button is used.
e40	Help button is available in each screen.
	Attractiveness
at41	User control audio.
at42	Combination of color is appropriate.
at43	Screen background is attractive.
at44	Texts are readable.
at45	Graphics enhance the instructional effect.
at46	Videos enhance the instructional effect.
at47	Animated illustration is good.
at48	Background music is good.
at49	Screen area is used effectively.
at50	Screen layout is consistence.
at51	User can skip video or animation.
at52	Shortcut for expert user is provided?
Efficiency	
ef53	Induction set are presented creatively and stimulatively.
ef54	Calculator is provided.
ef55	Additional reference materials are included.
ef56	History related to a mathematics concept is provided.
ef57	Glossary is provided.
ef58	Graph for mathematical equation is illustrated.
ef59	Calculating power of the computer enhances the enjoyment and understanding of concepts.
ef60	Experiment and exploration of mathematical idea are interesting.
ef61	Visualization power is utilized effectively.
ef62	Instructional games activities are provided.
ef63	Feedbacks are provided in appropriate manner.
ef64	Instructional activities for student with multiple intelligences are provided.
ef65	Learning tips are provided.
ef66	Multimedia element helps student master the concept.

In the second round content validity check, MCUE_1 was sent out to four experts to review the appropriateness of its format. Based on the panel judgments item cp7 was removed since any MC would use an appropriate approach. The word graphics in item cp8 was changed to visuals. Item r14 was separated into two items which are "Problems enrich critical thinking skill" and "Problems enrich creative thinking skill." Item ac22 was divided into two items which were "Mathematics terms are defined correctly." and "Mathematics terms are used correctly. Consequently a questionnaire consisted of 67-items and called MCUE_2 was produced.

5) Result of Item Analysis

Next MCUE_2 was administered to 35 mathematics teachers to determine the internal consistency of the instrument, Analysis of reliability using Cronbach Alpha was conducted. Table 9 shows the results of the analysis.

Table 9: Items Reliability

Items	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
	Concept presentation	
CP1	.586	.831
CP2	.619	.826
CP3	*.472*	*.849*
CP4	.646	.821
CP5	.689	.814
CP6	.651	.821
CP7	.613	.826
	Reinforcement	
r8	.615	.879
r9	.611	.879
r10	.646	.876
r11	.662	.875
r12	.681	.873
r13	.729	.869
r14	.729	.869
r15	.481	.889
r16	.634	.877

	Assessment	
a17	.558	.774
a18	.632	.729
a19	.643	.723
a20	.599	.745
	Accuracy	
ac21	.606	.862
ac22	.637	.861
ac23	.645	.861
ac24	.508	.868
ac25	.558	.866
ac26	.641	.860
ac27	.616	.861
ac28	.640	.859
ac29	.523	.868
ac30	.489	.874
ac31	.643	.860
	Ease of use	
e32	.692	.899
e33	.723	.897
e34	.717	.897
e35	.711	.898
e36	.742	.896
e37	.646	.902
e38	.640	.903
e39	.669	.901
e40	.607	.904
e41	.579	.906
	Attractiveness	
at42	.445	.917
at43	.665	.906
at44	.698	.905
at45	.660	.906
at46	.748	.903
at47	.719	.904
at48	.739	.903
at49	.652	.907
at50	.731	.904
at51	.683	.906
at52	.596	.909
at53	.550	.911
	Learning support material	
ef54	.597	.896
ef55	.544	.900
ef56	.616	.896
ef57	.506	.900
ef58	.615	.896
ef59	.648	.894
ef60	.710	.892
ef61	.633	.895
ef62	.562	.898
ef63	.641	.895
ef64	.670	.893
ef65	.620	.895
ef66	.604	.896
e67	.517	.899

From Table 9, an examination of the items comprising the attribute of usefulness scale indicates that items cp3 and at43 have the lowest corrected item-total correlations. This indicates that those items should be reviewed or eliminated (Ebel and Frisbie, 1986). If these four items were removed from the scale, the Alpha if Item Deleted column shows that overall reliability would increase slightly. Therefore deletion of these itemss considered appropriate. From the analysis, cp3 item was modified and at42 were eliminated and the improved instrument MCUE_3 with 65 items was formed. The reliability of each criterion is; concept presentation (0.848), reinforcement (0.889), assessment (0.793), accuracy (0.874), ease of use (0.909), attractiveness (0.914) and learning support material (0.903). These values (0.972) indicate that the reliability of the instrument is good [21, 22]. The number of item are summarized in Table 10

Table 10 Number of Items

Factor	Criteria	Items
Functionality	Concept presentation	7
	Reinforcement	9
	Assessment	4
	Accuracy	11
Usability	Ease or use	10
	Attractiveness	11
Efficiency	Learning support material	13

IV. Final remarks

This paper focuses on construction of checklist items based on the developed usefulness model. The items identified from this study included various aspects of usefulness attribute of quality. The checklist was reviewed by experts to verify the appropriateness of the measures. After the review, the items were formed into questionnaire items. The questionnaire items again were reviewed by four experts and refined. Based on the reliability test, a couple of items were eliminated. Even though the reliability of items and criteria are very good, the validity of them should be tested. Further testing of the questionnaire would be done to larger respondents in order to validate the construct. Exploratory and confirmatory factor analysis would be conducted to reduce the number of items and to validate the usefulness factors, criterion and items and to validate the constructed usefulness model.

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