Using ICT with Competence Indicators for the Learning of Mathematics

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摘要

九年一貫課程設計以學生為主體，配合學生的學習需要設計教材及教學活動，國小教師為了達到「有教無類」及「因材施教」的教育理想，大家無不絞盡腦汁設計各式各樣的教材以適應各種不同需求的學生，在資訊融入各科教學的發展理念之下，希望能將教材加以整合並做適當的分類。本研究的主要目的在於提出可行的學習資源分類方法，並設計一套跨越教科書版本藩籬的數位化教學素材應用系統，讓教師們在從事資訊融入教學時方便取用，又可讓學生在自我學習時免於迷失於茫茫網海。

關鍵詞：能力指標、分年細目、知識地圖

Abstract

The design of Grade 1-9 Curriculum is mainly based on students, teachers design teaching materials and activities for students' requirements. In order to obtain the required information, the teachers and students search in extensive Internet environment. This study proposes feasible categorization method of learning resources and designs the application system of digital teaching materials. The learning management system uses the Separating-Grade Detailed Items of competence indicators to manage the knowledge. By surveying research on mathematics for the case of numbers in the third grade in the elementary school, the results show that the proposed system significantly increases the learning achievement. Therefore, the learning management system and the methodologies decrease the difficulties of resource retrieval for teachers and increase the learning achievement of learners.

Keywords: competence indicators, SGDI, knowledge map

1. Introduction and Theoretical Background

The fundamental equipments of information education are set up for elementary school in recent years. The students should understand and use the technology to learn [1]. But when facing boundless information in the Internet and many versions of textbooks, the instructors are difficult to use the undersigned materials, and the students are also difficult to get the adaptive learning materials. The ideal of applying information technology comprehensively in each text material is not reached. To reach the goal of adaptive learning and customized teaching, elementary school teachers have tried their best to design various kinds of

teaching materials for students of different requirements. In the development concept of blending information into teaching in each course, they hope to integrate the materials into proper categories. The Separating-Grade Detailed Item (SGDI) is viewed as the index of knowledge map and the Information and Communication Technologies (ICT) are used to manage the knowledge. ICT, and in particular the desktop computer, are now a part of teaching and learning culture in classroom [2][3]. The interest in ICT in school is unequivocal support for the value of computers in educational settings and a political commitment to the creation of a knowledge economy. The main goal of this study is to propose feasible categorization method of learning resources and design the application system of digital teaching materials that cross the borders of different editions of textbooks for the use of teachers when blending information into teaching and help students from getting lost in the Internet.

1.1 Pedagogy Review

1.1.1 Programmed Instruction

Skinner thought that enhanced training is the main mechanism of organism learning procedure [4]. When stimulation repeats and causes proper responses, the response stimulation is controlled. The main point is: the teaching materials are divided into many small units and evaluation is made after each small unit right away and response is given after the evaluation. The advantage is that it conforms to the principle of individual teaching; feedback is obtained right away after reaction to form the responsive learning situation; reparation of teaching materials goes from ease to difficulty to maintain learning motives and to exclude interference of external factors.

It is estimated that a student requires fifty thousand times of enhancement to truly learn a skill [5]. As teachers are unable to provide so many times of enhancement, teaching machines are required as a result. Machines can provide materials, interact with students and provide immediate response to students' answers according to the sequence of teaching materials. If students answer correctly, they can continue learning. Acquiring correct answers and opportunities to operate the machines can be regarded as enhancement to behaviors.

1.1.2 Information Processing Theory

Gagné made use of the viewpoint of cognitive psychology to explain the human behavior [6]. It is a kind of learning to explore learning procedures in the view of information management and interpret human "learning and memory" as "information management" with changes generated during the procedures. According to Gagné's idea, three principles help learning:

- Analyze the components of final task to perform teaching activities.
- Ensure that each component element is skilled.
- Arrange component elements in order to ensure that final task can be acquired.

The ultimate goal of teaching is to have potential of students fully developed. To achieve such a goal, planning in teaching is required. A planned teaching has to adopt scientific design principle, that is, to verify the importance of teaching goals and emphasize the description of form in nature. When making teaching design, one shall base it on analysis of level tasks. At establishment of teaching activities and learning design stage, the internal conditions of

learners and external situation outside learning have to be noticed to obtain the best learning results. Evaluation measures, standards and tools are to be determined to measure students' performances and conduct teaching evaluation.

1.1.3 Scaffolding Instruction

Vygotsky (1978) thought "learning leads development". Scaffolding accounts for how a more knowledgeable partner can assist the cognitive development of a less able one [7][8][9]. Good learning should transcend the developed zone. The best teaching and evaluation are in the zone of proximal development (ZPD). By means of leading through the possible developed zone, the students obtain a temporary support [10]. The framework of self learning scaffold assists the learners to understand the meaning and purpose of the learn contents [11]. The focus of learning is transferred from the teachers to the students [12].

Some feasible scaffold behaviors in teaching include: providing relevant examples, assistant counseling and posing questions. Scaffold behaviors are divided into the following links:

- Building scaffolds: circling the current learning themes and building conceptual frames under "near development area."
- Entrance into situations: guiding students into certain question situations.
- Independent exploration: making students explore independently.
- Cooperative learning: group negotiation and discussions.
- Evaluation of effects: evaluation of learning effects includes self-evaluation by students and learning evaluation by learning groups of individuals.

The final goal of scaffold teaching is to achieve learning moving and self-orientation learning of learners, that is, to assist learners in developing their own learning scaffold.

1.2 SGDI — Index in Knowledge Map

1.2.1 Learning Areas and Competence Indicators

The major features of the Grade 1-9 Curriculum which is implemented gradually from 2001 are to bring up the "lifelong learning" ability of students. The competence indicators in learning area of mathematics are divided into four stages: the first learning stage for grade 1-3, the second for grade 4-5, the third for grade 6-7, and the fourth for grade 8-9. The mathematics contents have five subjects: numeral and quantity; geometry; algebra; statistics and probability and linkage. The competence indicators of the learning stages are shown in Table 1.

Table 1. The competence indicators of the learning stages in mathematical area

	Numeral and Quantity	Geometry	Algebra	Statistics and Probability	Linkage
First learning stage	N-1-01 ⋮ N-1-17	S-1-01 ⋮ S-1-17	A-1-01 ⋮ A-1-05	D-1-01 ⋮ D-1-03	Undefined
Second learning stage	N-2-01 ⋮ N-2-19	S-2-01 ⋮ S-2-08	A-2-01 ⋮ A-2-04	D-2-01 ⋮ D-2-04	Undefined
Third learning stage	N-3-01 ⋮ N-3-17	S-3-01 ⋮ S-3-06	A-3-01 ⋮ A-3-14	D-3-01	Undefined
Fourth learning stage	N-4-01 ⋮ N-4-05	S-4-01 ⋮ S-4-15	A-4-01 ⋮ A-4-07	D-4-01 ⋮ D-4-07	Undefined

The competence indicators are arranged in three codes. The first is the theme; the second the stage and the third serial number, representing indicator serial number under the subcategory. For example: N-1-06 indicates the understanding of Nine-to-Nine Multiplication (N: the numeral and quantity, 1: first learning stage, 06: the sixth competence indicator).

The SGDI of competence indicators represents the relation for learning order. It also represents the level that the materials are easy or difficult. The system will select the SGDI of the grade 1-9 curriculum as the classified item, in accordance with it to establish the knowledge indexed map. Thus, the other teachers also conveniently use the learning elements. The system uses the SGDI for the classification of the learning and evaluating elements, such as the index of the knowledge map. Table 2 shows the learning progression with the SGDI.

Table 2. The learning progression with competence indicators and SGDI (Grade 3)

Competence Indicator	N-1-01	N-1-02	.....	N-1-16	N-1-17
SGDI	3-n-01	3-n-02 3-n-08	.....	3-n-12 3-n-14	3-n-14 3-n-16

1.2.2 Learning Elements as External Knowledge

From the related documents of knowledge management, it shows that learning elements are regarded as external knowledge. And the information technology could be applied for the external knowledge management to preserve, reuse, share and reproduce. Figure 1 shows the relation between ZPD and the indicators of SGDI.

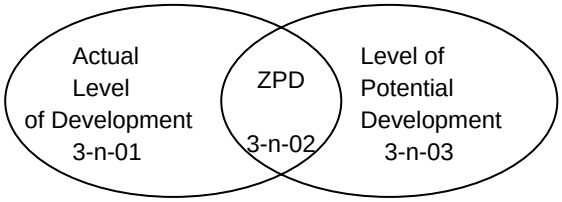

Figure 1. ZPD and the indicators of SGDI

From the ZPD theory, it shows that the student develops two concepts, real level of development and potential level of development. If someone has learned the ability with the SGDI, the next SGDI becomes the ZPD.

2. The System Architecture

2.1 The Design of the System

The computer as a partner providing feedback and assistance might provide support to young learners [13]. The system provides a temporary support (the scaffolds) to help the students develop their self-scaffolding as the capability of the learner advanced. It is based on the SGDI of the competence indicators in Grade 1-9 Curriculum to build knowledge index map for the convenient use of teaching elements by teachers. Figure 2 shows the learning flow chart for three-grade students. Students are dependent on the sequence of SGDI for advanced learning. The teaching elements that teachers upload are divided with SGDI to avoid the complication from detailed categories of teaching materials of programmed instruction. It helps teachers upload teaching elements in yearly detailed items. To realize the control on learning procedures, the system has two parts, the first one is learning elements and the other is the evaluation elements. Students have to do two things—to browse learning elements and take

tests.

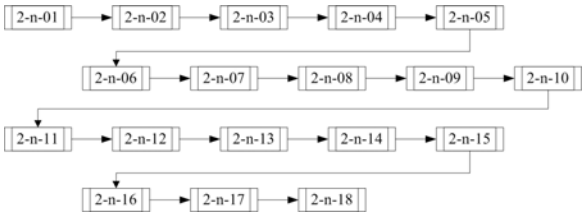

Figure 2. The learning flow chart for three-grade students

2.2 The Function of System Modules

The system is designed for two types of users: teachers and students. The function of system modules is shown as figure 3.

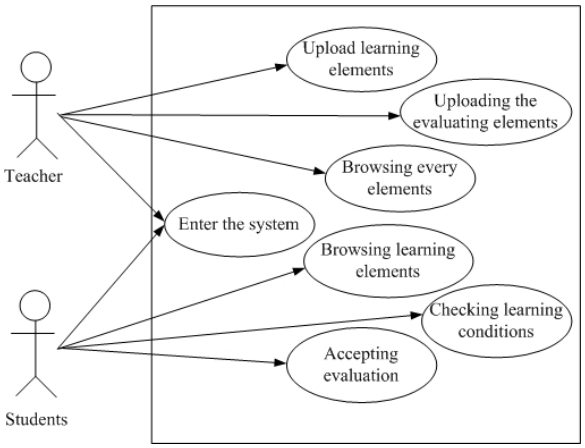

Figure 3. The use case of the whole system functions

- Entering the system: For all of the users, add the account, then use it.
- Uploading the learning elements: For teachers, store it in the learning database based on the SGDI.
- Uploading the evaluating elements: For teachers, store it in the evaluating database based on the SGDI.
- Inquiring any elements: Inquiring any elements by means of the SGDI.
- Browsing learning elements: For students, after they enter the system, the system provides students with teaching material list based on their learning conditions. Students select one of the teaching materials and the system will transmit the elements to the monitor of student's computer.
- Accepting evaluation: For students, after they enter the system, the system provides students with evaluation list based on their learning conditions. Students click to accept evaluation and the system provides students with questions in random order. Students have to complete all the questions in fifteen minutes or they have to start from the beginning again.
- Checking learning conditions: For students, they click to check learning conditions and the system responds them to the computer screen.

Figure 4 shows the teachers use SGDI to stores the learning elements in the learning database based. Figure 5 is the teacher inquiring some of the learning elements. Figures 6-7 show an example of the learning elements.

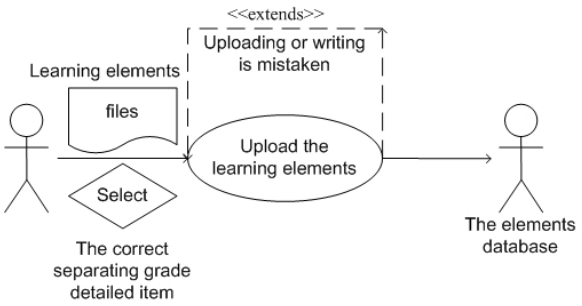

Figure 4. Uploading the learning elements

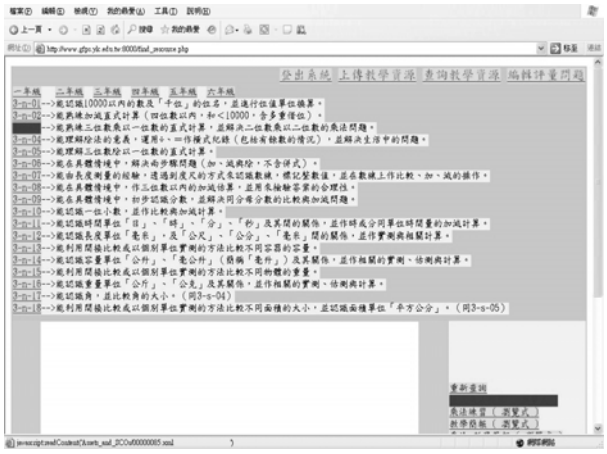

Figure 5. The teacher inquires some of the elements

Figure 6. The learning element for students

Figure 7. The learning element

3. Method and Result

3.1 Subjects and Design

Forty participants are randomly selected male and female three-grade students enrolled in elementary school. The test instrument is the Mathematical Achievement Test. There are twenty-five questions in numeral. It examines the numeral for three-grade students. The cognitive level includes knowledge, realization, application and analysis. The applied category includes addition, subtraction, multiplication, division and mixed situation in the case of money, measurement, time and statistical table. The reliability is .80, the concurrent validity compared with "Mathematical Ability Develop Test" is .77.

The experiment is the one-group pretest-posttest design. The performing procedure has pretest, using the system for a month, and then posttest.

3.2 Result and Discussion

The original scores are transferred into percentage scores and the descriptive statistics of experimental results are shown in Table 3.

Table 3. Means and Standard Deviations of Pretest and Posttest

	Pretest	Posttest
M	63.9	73.4
SD	21.57	18.11

The results were analyzed by the one-way analysis of variance (ANOVA) of randomized block design that the system is considered as an independent variable, whereas the score of mathematical achievement test is dependent variable defined in the section of experimental design. ANOVA is used to uncover the direct effect of one or more independent variables on

the dependent variable. The key statistic is the F-test of difference of group means. The analysis of ANOVA shows that the result is significant (Table 4).

Table 4. The summary table of ANOVA

	SS	*df*	*MS*	*F*
$SS_{b.subject}$	27571.69	39		
$SS_{w.subjects}$	5121.50	40		
$SS_{b.treatment}$	1757.81	1	1757.81	20.38**
$SS_{residual}$	3363.69	39	86.25	
SS_t	32693.19	79		

**$F.99_{(1, 39)} = 7.32$, $p < .01$

Table 4 shows the difference of the score of mathematical achievement test between pretest and posttest. The students spend approximately a month reading and training the materials and elements. The statistical result is significant ($F_{1,39} = 20.38$**, $p < 0.01$). The system benefits students a lot in calculation ability which should be derived from the smoothness training on numeral. It also helps students improve in mathematical application ability.

From the above tables show that:

Teaching of mathematical concept might not be a field where computer system can develop. The elements provided by the system can not complete teaching of mathematical concept. Improvement of students' calculation ability might be pushed under the training of the system and pressure of time. Most of the evaluation elements are application questions and solving more application questions helps students solve questions. Feasible learning resource categorization method is established in order to build the networked learning environment.

4. Conclusions and Future Research

The system helps students improve mathematical ability on their own. Therefore, this study infer that using nine-year ability index yearly detailed item as the control of teaching material categorization and learning progress are feasible. It proposes concrete suggestions on current use of teaching resource network. From research on effects of remedy teaching on junior high school students with poor performance in English, students with low academic achievements can improve their achievement after taking remedy teaching. At the moment, each city/county is aggressively building teaching resource websites with the main consideration for teachers to blend the information into their teaching. If students use the learning system after classes into consideration, they can also improve their academic achievements. Using yearly detailed items to categorize learning elements helps teachers upload and acquire teaching materials and it is as well as a simple mechanism of learning procedure control for students when they study on their own.

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