The Integration of Concept Mapping in a Dynamic Assessment Model for Teaching and Learning Accounting

David Tawei Ku¹, Ju-ling Shih²* and Su-Huan Hung²

¹Department of Educational Technology, Tamkang University, New Taipei City 25137, Taiwan // ²Department of Information and Learning Technology, National University of Tainan, Tainan City 70005, Taiwan // dtk@mail.tku.edu.tw // juling@mail.nutn.edu.tw // abby5917@yahoo.com.tw

*Corresponding author

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ABSTRACT

The purpose of this study is to integrate the idea of concept map into dynamic assessment model for accounting education in vocational high school. By using the expert concept map and the objectives as the main reference to generate assessment questions for diagnosis purposes, students should be informed the shortcoming of learning and receive proper guidance to improve learning. A quasi-experimental single group pre-posttest design was conducted for this study. Subjects were given a pretest before treatment and posttest after treatment. In order to truly compare the performance between the treatments, the final grades of previous semester course were used to distinguish three different (high, medium, and low scores) student groups. The results show that after the intervention of computerized dynamic assessment system, posttest scores were significantly higher than pretest scores in all three groups. In addition, regardless of learning styles, when students were willing to commit time to follow the guidance, they could result in a good learning progress. Moreover, students with high degrees of completion performed significantly better than low degrees of completion students in posttest-pretest progress. Recommendations for using dynamic assessment system in accounting learning are also discussed.

Keywords

Concept map, Dynamic assessment model, Computerized dynamic assessment system, Accounting

Introduction

Low learning willingness and sluggish understanding typically result in low academic achievement because students fail to thoroughly and effectively learn. Without appropriate after-school learning programs or remedial strategies, students can easily fall behind and lose interest in learning. To diagnose students’ learning difficulties, provide students with remedial strategies for learning problems, and enable students to develop their learning potential, this study implements a dynamic assessment model in the instructional process.

Many studies have highlighted that learning assessments effectively promote the improvement of teaching and learning (e.g., Airasian, 1989, 1986; Linn & Gronlund, 1995; Linn & Miller, 2005). However, traditional static learning assessments are limited in their applicability for evaluating students’ learning achievements, identifying their learning potential, and providing precise and useful solutions to learning difficulties. Vygotsky (1978) proposed the concept of the zone of proximal development (ZPD), which is defined as “the distance between the actual developmental level, as determined by independent problem solving, and the level of potential development, as determined through problem solving under adult guidance, or in collaboration with more capable peers” (p. 86). This highlights the feasibility of probing and exploring individual learning potential through guidance. Feuerstein (1979) found that traditional assessments emphasize students’ learning failures instead of their learning process and learning potential; thus, he developed a dynamic assessment tool for implementing corresponding improvements. Through teacher guidance, dynamic assessments can diagnose students’ learning difficulties, provide intermediary assistance, and create meaningful interactions that stimulate students’ learning potential.

Based on the concept of dynamic assessments, Vye, Burns, Delcos, and Bransford (1985, 1987), and other scholars advocated the development of a continuous dynamic assessment model that comprised the following two main cores: the standardized graduated prompting assessment and non-standardized meditational assessment models. Research has also indicated that dynamic assessments can effectively promote individual learning potential and achievement, enhance the relevance of learning content, provide intermediary teaching assistance, and develop a more efficient remedial teaching system (Xu, 2004).
However, dynamic assessments do not always provide customized learning remedies. Typically, they identify learning difficulties or failures without offering solutions to improve student learning. To develop a more effective remedial teaching and learning system, this study employs a concept map established by experts (teachers) to structure a curriculum that integrates learning content and provides the required teaching and learning contexts.

Novak (1991) proposed a new concept of learning based on prior acquisition. Functionally, concept maps can be regarded as scaffolding that supports learning and assessments. During teaching activities, instructors serve as experts who understand the in-depth conceptual structure of the learning content. If instructors provide a concept map of the learning content, learners can understand the conceptual structure of experts and follow a guided learning path. Concept maps can also be used for learning assessments. According to the stage and difficulty level of student mistakes, a concept map can identify the area of mistakes and provide timely remedial instruction.

In recent years, concept maps have been gradually computerized. Using a concept map created for a specific subject, relevant systems can identify learning difficulties and student advantages and provide appropriate individual learning guidance to enhance academic performance (Hwang, 2003; Chang, Sung, Chang & Lin, 2005; Liu, Chen & Chang, 2010). Studies have shown that students who construct personal concept maps are able to identify misconceptions. Accordingly, computer systems and teaching instructors can provide students with timely support and guidance based on these misconceptions.

Concept maps of teaching content constructed by experts should be more comprehensive and organized than those constructed by students. Thus, instructors can also adopt expert concept maps when designing learning instruction and activities to further benefit students.

This study used the Accounting Entry section of a second-year vocational high school Accounting program as the primary subject. Employing an expert concept map to establish the relevance of learning concepts for intermediary support of the teaching context, a computerized dynamic assessment system was developed. By referencing an expert concept map and teaching objectives when developing assessment questions, students can exploit the adaptive functions to explore their learning difficulties and receive appropriate guidance to improve learning performance.

**Literature review**

**Dynamic assessment**

Budoff (1974) proposed the learning potential assessment model (test – train – test) to assess the abilities of educable mentally handicapped children. Based on cognitive development theory proposed by Piaget (1950), Paour (1992) suggested that assessments should incorporate logical thinking instructions to evaluate changes in children’s cognitive structure. Feuerstein (1979) further highlighted that mediated learning is a necessary condition for cognitive development, and proposed the Learning Potential Assessment Device (LPAD; pretest – mediate – posttest).

Based on the ZPD established by Vygotsky (1978), Campione and Brown (1987) proposed the graduated prompting assessment model (pretest – learning – transfer – posttest) as an alternative to the non-standardized intervention developed by Feuerstein (1979), using a standardized progressive teaching support as an intermediary. Embretson (1987) emphasized the variability of cognition and developed a psychometrics-oriented dynamic assessment model (psychometric approach), which employs spatial reasoning tests as training materials and uses “pretest – train – posttest” procedures to assess learning results.

Burns, Vye, and Bransford (1987) indicated that learning is a continuous direct experience. Burns and colleagues integrated the LPAD developed by Feuerstein (1979) and the graduated prompting assessment model established by Campione and Brown (1987) to construct the continuum of assessment model. The experimental results showed that intermediary teaching can better promote learning transfers compared to progressive prompting and enhance learner performance in dynamic assessments.

Ding (2002) stated that the current mainstream form for assessments is the standardized intervention “pretest – intervention – posttest” model, which is primarily based on the graduated prompting assessment model of Campione.
and Brown (1987). Because the standardized assessment system design can be easily extended to various subjects, it is the most commonly used dynamic assessment model. Moreover, by combining the standardized and non-standardized intermediary teaching processes of multi-stage dynamic assessments, Xu (2004) found that continuous assessments can eliminate learning problems and enhance learners’ problem-solving abilities.

Therefore, this study adopts the continuum assessment model as the core system architecture for the Accounting Entry subject. By integrating a concept map, this system can investigate students’ learning difficulties and identify potential learning problems to facilitate learning and promote effective learning and teaching.

Concept mapping

Based on meaningful learning theory established by Ausubel (1963), Novak and Gowin (1984) developed the concept mapping method. In the book Learning How to Learn, they defined concept maps as a graphical metacognitive tool for learners to express their understanding of the knowledge theme.

Concept mapping involves using the appropriate link to connect one or more concepts, thereby expressing the complete meaning and relationship between the concepts. Concept maps can also provide a visualization of the hierarchy and structure of a system. Furthermore, teachers can use concept maps drawn by students to assess their understanding, logical ordering abilities, and other capabilities in relation to the particular subject or concept.

Since Novak and Gowin (1984) applied concept mapping to the field of science learning, it has been employed in other disciplines for teaching, learning, searching, and assessment. Concept maps have also been verified to be effective learning tools that promote positive learning attitudes and achievement (Allan, 2003; Nakhleh, 1994). Moreover, concept maps can be used as a learning diagnostic tool for remedial instruction and provide clear guidance for low achievers or solutions to learning difficulties (Tsai, Lin, & Yuan, 2001; Donald & Barbara, 2003).

Research of concept maps focuses on the following three main applications:
1. As a teaching method: Teachers can include concept maps in the teaching unit as a formative assessment or convergence tool to connect units.
2. As a tool for learning and teaching strategies: Concept maps benefit knowledge reconstruction and retention and can enable students to learn concepts and derivative meanings, thereby expanding the scope of a single learned point.
3. As a tool for assessing and identifying misconceptions: Concept maps are not only extremely powerful learning tools but also effective assessment tools. They enable students to confirm whether their knowledge of a concept is correct (Mintzes, Wandersee, & Novak, 2000). In addition, concept maps can be used to assess concept structuring and change processes, and are a good tool for identifying misconceptions and knowledge flaws.

Zeilik et al. (1997) applied concept maps to the subject of Astronomy and found that students experienced tremendous success in distinguishing misconceptions and learning concepts. Heather, Joel, and Richard (2003) used concept maps as a tool for assessing learning outcomes, where students could benefit from the entire knowledge base of a concept, instead of depending on the trivial fragments retained.

Computerized concept mapping

Donovan (1983) highlighted that concept mapping is the process of constructing meaning. The main processes are as follows: (a) Screen important concepts; (b) reflect the concept of chronological order; (c) use appropriate links to show the relationship between concepts; (d) cross-link the relationships between concept branches; and (e) provide specific examples that illustrate the concepts. Concept mapping is an effective teaching technique that enables students to build an organization and illustrate changes in cognitive structures. In addition, concept mapping serves as an important strategy for improving the concept of learning.

However, the traditional paper and pencil style of concept mapping is extremely inconvenient and a burden for instructors. With the rapid development of computer technology, the use of computerized concept maps to support teaching and learning has gradually increased. Computerized concept mapping systems can be adapted to individual differences and provide diverse teaching methods that attract learners’ attention. More importantly, the calculation
speed and analysis ability of a computerized system provides multidimensional organized information for diagnosis, remedial instruction, and learning.

Ausubel (1963) highlighted that meaningful learning is based on students’ prior knowledge and builds new knowledge. Traditional teaching methods involve teachers providing guidance and presenting appropriate materials. As experts, teachers design the structure of a curriculum and its activities, and students follow the design to learn gradually.

By presenting teachers’ instructional architecture as a concept map, this study develops a dynamic assessment system based on an expert concept map. When employed, this dynamic assessment system can identify incorrect items, determine the error type, and provide guidance by directing students to the appropriate content unit for review based on the expert concept map. Through the system architecture of an expert concept map, the assessment process follows a continuous learning model. According to the system responses, learners can enhance their learning processes and learning effectiveness.

**Learning styles and profiles**

Identifying learning styles to facilitate teaching and learning is a crucial issue in education. Keefe (1979) classified learning styles as “characteristic cognitive, affective, and psychological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to learning environments” (p. 4). Learning styles not only indicate the learning characteristics of learners, but can also imply possible disciplinary differences (Kolb, 1981). Interestingly, learners’ learning tendencies and characteristics can also be used to identify their learning style. That is, by analyzing learners’ learning processes, their learning problems and preferred learning styles can be identified. Traditional assessments only provide short-term and partial learning outcomes; however, learning profiles can provide instructors with crucial information such as learning paths and preferences.

As mentioned previously, concept mapping enables learners to accumulate knowledge by linking concepts logically or even chronologically (Donovan, 1983). According to Felder and Silverman (1988), sequential/global learning style dimensions can be well described by constructing concept maps. Sequential learners progress toward understanding in continual steps, whereas global learners holistically develop comprehension in large increments. By employing this system, the dynamic assessment model and expert concept map allow learners to identify learning difficulties. Student learning profiles also supply unique information that enables instructors to provide appropriate guidance to various individuals.

**Research methods**

**System design**

As the foundation of accounting, Accounting Entry includes the concepts of accounting classification, principle of duality, and double-entry bookkeeping. Any unclear concept will lead to an incomplete knowledge of Accounting Entry, and hinder successful learning of subsequent areas of accounting. Therefore, Accounting Entry is an appropriate subject for this study because a dynamic assessment system can facilitate the resolution of students’ learning difficulties. The system also reinforces adaptive remedial instruction, which enables students to develop a complete understanding of Accounting Entry and gain confidence in their ability to learn accounting.

The structure of the continuum dynamic assessment model is shown in Figure 1. Students can begin from any learning area. However, during the formal test, the students are instructed to complete each unit’s Accounting Entry area to pass the evaluation.

To clarify the system structure based on the hierarchical concept mapping design concept (Stice & Alvarez, 1987), the concepts of the content areas mentioned previously were gradually extended into an expert concept map, as shown in Figure 2. The oval represents the three conceptual areas of “accounting classification,” “principles of duality,” and “accounting entry.” In each area, the rectangle represents the sub-concept, and all concepts are connected to each other by various means. The arrows denote a linear connection between two concepts, and the
dotted lines indicate that the concept can be extended to various concept areas, of which the acronym PC in the figure represents “possible cause.” This expert concept map becomes the underlying content structure of the system, which can be regarded as the road map of the dynamic system. The system evaluates students’ understanding in each concept, shows their learning difficulties, and identifies potential learning problems when students fail to answer the questions. Moreover, the system offers adaptive assistance by bringing them back and forth to the specific concepts they should be familiar with until they complete the course.

**Figure 1.** The content structure of the dynamic assessment system for accounting

![Diagram of the content structure of the dynamic assessment system for accounting](image1)

**Figure 2.** The expert concept map of the content of Accounting Entry

![Diagram of the expert concept map of the content of Accounting Entry](image2)

The system interface includes three display areas, from top to button: the main menu, sub-menu, and individual progress display (Figure 3).

1. Main menu: Includes three major (main content) sections, accounting classification, duality principles, and accounting entry. Students can access all assessment sections here, and the portfolio button takes students to check their current learning progress.

2. Sub-menu: This is the question-display page. When students select one of the major sections, five sub-concept buttons (assets, liabilities, owner equity, revenue, and loss) appear for students to readily access each unit.
3. Personal progress display: After students complete unit assessment, a personal progress display presents their status. Therefore, students can adjust their learning pace and develop effective learning.

![Personal progress display](image)

*Figure 3. Main user interface of the dynamic assessment system for accounting*

**Research design**

The main subjects of this study were 34 accounting sophomores of a vocational high school in Taiwan. Integrating continuous dynamic assessments (the pretest - train - retest - train - retest...posttest model) and concept mapping, this study develops a computerized dynamic assessment system based on the content of the three main areas: Accounting Classification, the Principles of Duality, and Accounting Entries.

Standard face-to-face teaching activities are still performed in the classroom; however, if required, the computerized dynamic assessment system is used to assess the learning results, and the recommend remedial strategies are implemented. Thus, the combination of remedial teaching and assessments achieve maximum effectiveness of the remedial program.

A quasi-experimental single-group pre-posttest design was employed for this study. The participants were administered a pretest before the intervention and a posttest after the intervention. Two tests were identical. Furthermore, to truly compare the performance before and after the intervention, grades for the accounting course from the previous semester were used to create three student groups, that is, a high-scoring group (top 29%, 10 students), low-scoring group (bottom 29%, 10 students), and medium-scoring group (42%, 14 students).

**Research instruments**

*Achievement tests*

To evaluate the reliability of the pretest, 30 senior accounting students were selected to complete the pre-stage achievement test, and the results were used to determine appropriate questions.

1. **Scoring:** A total of 16 questions were included in the pretest, where each question was worth 1 point, for a total of 16 points. The questions covered all learning modules of Accounting Entry.

2. **Item analysis:** According to the test results, the high- (11 students; top 37%) and low-scoring groups (11 students; bottom 37%) were separated, and the difficulty and discrimination of the items were determined using the following formula: The higher the \( P \) value, the higher the rate of difficulty; the higher the \( D \) value, the more accurate the discrimination rate.

\[
\text{Difficulty (P)} = \frac{P_H + P_L}{2}
\]

\[
\text{Discrimination (D)} = \frac{P_H - P_L}{2}
\]

\( P_H \) = correction percentage of the high-scoring group

\( P_L \) = correction percentage of the low-scoring group
According to Ebel (1979), a value over 0.3 indicates an acceptable discriminating ability. Huang and Jian (1991) highlighted that research should use the item analysis results to first select the items of high discrimination, followed by the items of moderate discrimination. Thus, the difficulty rate for the majority of the items will range between 0.35 and 0.65. Even when additional items, the overall difficulty rate should remain approximate to normal distribution.

With the exception of Items 7 and 16, all items possessed a discrimination rate above .30, and a difficulty rate between .23 and .77, which indicates that the items possessed good discrimination and appropriate difficulty levels. Item 7 (.47) was a moderately difficult question, with an acceptable discrimination rate of .27. Therefore, the subject matter experts recommended retaining Item 7. Item 16 was rated a high-difficulty question (.26); however, the discrimination rate was acceptable. According to the two subject matter experts, the concept of Item 16 was extremely important for the subject scope. Therefore, Item 16 was retained and modified to reduce the difficulty.

In addition, the overall Cronbach’s alpha value for the pretest was .788, which indicates good reliability.

**Data collection**

**Learning performance**

According to the accounting grades from the previous semester, the students were divided into high- (top 29%), medium- (mid 42%), and low-scoring (last 29%) groups. A paired t-test was conducted to analyze the pre-posttest scores of the three groups to determine whether the students’ performance was improved with the intervention of the computerized dynamic assessment system.

**Degree of use and completion**

To understand the treatment intervention and whether differing degrees of dynamic assessment use significantly affected learning outcomes, the degree of use and completion (high, medium, and low) were employed as independent variables. The posttest scores were used as dependent variables and one-way analysis of variance (ANOVA) was conducted.

**Research findings**

According to the research process, data were collected after the students completed a pretest, three weeks of computerized dynamic assessment treatments, and posttest achievements. Using the information collected, data analysis was conducted considering two dimensions, that is, learning effectiveness when employing the computerized dynamic assessment system, and learning outcomes in relation to the level of computerized dynamic assessment use.

**Learning effectiveness**

In this study, according to their grades for the accounting course from the previous semester, the students were divided into high-, medium-, and low-scoring groups. The intervention (a computerized dynamic assessment system) was used as the independent variable, and the students’ posttest scores were used as dependent variables for conducting a paired t-test. Both the pretest and posttest comprised 16 question items appropriate for the scope of the lesson plan. The total possible score was 16 points. Table 1 shows the paired t-test results of the three groups.

For the high-scoring group, the posttest score (M = 13.82) was significantly higher than the pretest score (M = 9.82; \( p = .000 \)). For the medium-scoring group, the posttest score (M = 10.55) was significantly higher than the pretest score (M = 6.64; \( p = .000 \)). For the low-scoring group, the posttest score (M = 7.50) was significantly higher than the pretest score (M = .45; \( p = .000 \)). These results indicate that for all three groups, the computerized dynamic assessment system significantly benefited the students’ learning performance for the Accounting Entry course. Using
the pretest – train – retest – train – retest…posttest model and expert concept map, the students were able to understand the concept of Accounting Entry and cultivate problem-solving skills in all three levels.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Pretest M</th>
<th>Pretest SD</th>
<th>Posttest M</th>
<th>Posttest SD</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>11</td>
<td>9.82</td>
<td>2.04</td>
<td>13.82</td>
<td>1.25</td>
<td>8.563**</td>
</tr>
<tr>
<td>Medium</td>
<td>11</td>
<td>6.64</td>
<td>2.69</td>
<td>10.55</td>
<td>2.54</td>
<td>5.253**</td>
</tr>
<tr>
<td>Low</td>
<td>12</td>
<td>4.50</td>
<td>2.68</td>
<td>7.5</td>
<td>3.50</td>
<td>3.555**</td>
</tr>
</tbody>
</table>

** p < .01 , *** p < .001

### Learning profile and learning styles

As mentioned previously, one extremely important reason for developing a computerized dynamic assessment system is to identify students’ learning processes and provide appropriate guidance. Thus, by analyzing student learning profiles, student learning styles can be identified and appropriate follow-up processes provided accordingly.

**The high-posttest students tended to be sequential learners**

The high-posttest scorers (14 questions correct out of 16) were 9 students. The process profile of Student S03 is shown below:

1. Practiced all Accounting Classification units (G1-G5)
2. Attempted the Accounting Entry unit assessment, but did not pass
3. Ignored the system feedback
4. Practiced all Principle of Duality units (G6-G10)
5. Passed all assessments for the Principle of Duality unit
6. Passed all Accounting Entry unit assessments

According to the profiles, 7 students (high posttest scorers group) had a similar learning process pattern. According to Felder and Silverman (1988), these students were most likely sequential learners, who conduct linear thinking and problem solving sequentially. Sequential learners are adept at convergent thinking and analysis. They are considered to fully understand the learning materials, processes, and prepare appropriately. Therefore, sequential learners can effectively solve difficult and complex problems.

**The low-posttest students tended to be global learners**

Felder and Silverman (1988) stated that global learners tend to jump between concepts and feel out of sync with fellow students. This process of learning generally matched the pattern exhibited by the low-posttest scoring group. The low-posttest scorers (8 questions correct out of 16) were 8 students, who all experienced difficulty with the Accounting Classification and Principle of Duality units. During the assessment, all 8 students completely ignored the system feedback. Some attempted to complete the same unit and continued to fail because concepts were unclear. Meanwhile others wasted their time changing and switching between units. However, during the last week of this study, a number of the students were finally willing to follow the feedback and guidance provided by the system and returned to the directed units for re-practice. The results showed that the students who were willing to try achieved slight progress; however, it was too late in the course to have a significant difference.

Based on the students’ use experience and patterns, the dynamic assessment system is effective for students with various learning styles; however, learning performance is only enhanced if the system feedback and guidance are accepted. Moreover, global learners require additional time to familiarize themselves and adjust to the system. “They may feel stupid when they are struggling to master material while most of their contemporaries seem to have little trouble” (Felder & Silverman, 1988, p. 679); however, with sufficient time and patience, they can eventually master the skills. For this case, the learning process requires at least 3 to 4 weeks to achieve a noticeable difference.
Learning outcomes for the use levels

In addition to the learners’ summative scores, this section describes the analysis results of how student learning processes lead to differing learning outcomes. The following two themes were explored: (1) Whether students with differing use degrees achieved different learning outcomes; and (2) whether students with differing completion degrees achieved differing learning outcomes. The degree of use was based on the accumulated number of passed learning units. According to the students’ learning profiles, the highest value was 59 and the lowest was 11. The top 30% were classified into the highest group, the bottom 30% were the lowest group, and the remaining learners were classified into the medium group. The degree of completion was determined by the completion of each major concept area. Learners who completed one concept area (e.g., principle of duality) and passed all units were awarded 1 point. If the learners completed all three concept areas but did not pass all units, they still received 1 point. Based on the total numbers, the top 30% was classified as the highest group, the bottom 30% were the lowest group, and the remaining learners were classified as the medium group.

Learning outcomes for various degrees of use

According to the degree of use, the students were divided into high-, medium-, and low-usage groups, which were used as independent variables. The students’ posttest scores were used as dependent variables, and one-way ANOVA and a Scheffé post hoc comparison were conducted. Table 2 shows the varying degrees of use for each group. Table 3 is a comparison of the posttest scores for varying degrees of use.

| Table 2. The description of groups in different degree of using the computerized assessment system |
|---------------------------------|-----|-----|-----|
| Degree of using | N   | Mean | Std. |
| High             | 11  | 12.64| 1.80 |
| Medium           | 10  | 10.90| 3.35 |
| Low              | 13  | 8.46 | 4.14 |
| Total            | 34  | 10.53| 3.67 |

Table 3. The comparison of posttest scores in different degree of using the computerized assessment system

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Scheffé</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>105.794</td>
<td>2</td>
<td>52.897</td>
<td>4.842*</td>
<td>High &gt; Low</td>
</tr>
<tr>
<td>Within group</td>
<td>338.676</td>
<td>31</td>
<td>10.925</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>444.471</td>
<td>33</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p < .05

Table 2 shows that the high-use students who employed the dynamic assessment system achieved the highest posttest scores (M = 12.64). The posttest score for the medium-use students was 10.90, and that for the low-use students was 8.46. Furthermore, the ANOVA results showed that the posttest scores for the varying degrees of use differed significantly between groups (F = 4.842; p = .015). The Scheffé post hoc analysis results show that the posttest scores of the high-use students were significantly higher than those of the low-use students. The results indicate that additional practice using the computerized dynamic assessment system can enable students to improve their learning outcomes.

Learning outcome for various degrees of completion

To determine the learning outcomes for varying completion rates between the pretest and posttest, a completion rate calculation method was employed. If the students practiced and passed all the units of one subject area, this was considered one completion. If the students practiced and passed all the units of the three subject areas, this was considered three completions. If the students spent time practicing, but did not pass all three subject areas, this was considered one completion.

According to their degree of completion, the students were divided into high, medium, and low degrees of completion groups, which were used as independent variables. The progress magnitude between the pretest and posttest was used as the dependent variable. Furthermore, one-way ANOVA and Scheffé post hoc comparisons were conducted. Table 4 shows the varying degrees of completion for each group.
Table 4. The description of groups in different degree of completion the computerized assessment system

<table>
<thead>
<tr>
<th>Degree of completion</th>
<th>N</th>
<th>Mean</th>
<th>Std.</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>7</td>
<td>1.57</td>
<td>2.57</td>
</tr>
<tr>
<td>Medium</td>
<td>8</td>
<td>2.75</td>
<td>2.05</td>
</tr>
<tr>
<td>Low</td>
<td>19</td>
<td>4.74</td>
<td>1.79</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>3.62</td>
<td>2.37</td>
</tr>
</tbody>
</table>

Table 5 is a comparison of the pretest and posttest scores for varying degrees of completion. The results indicate that students with varying degrees of completion differed significantly regarding progress magnitude (F = 7.223; p = .003). The Scheffé post hoc analysis results showed that the progress of the high degrees of completion students was significantly greater than that of the low completion students. The results also showed that by using the computerized dynamic assessment system and consistently repeating the practice items, the students could clarify their understanding of the concepts and improve their learning outcomes.

Table 5. The comparison of the progress between pretest and posttest scores in different degree of completion

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Scheffé</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>59.131</td>
<td>2</td>
<td>29.565</td>
<td>7.223**</td>
<td>High &gt; Low</td>
</tr>
<tr>
<td>Within group</td>
<td>126.898</td>
<td>31</td>
<td>4.093</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>186.029</td>
<td>33</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** p < .01

Analysis of learning difficulty for various units

In addition, to investigate the learning progress flow and error patterns for Accounting Entry after employing the dynamic assessment system, learning difficulty analysis of two dimensions was conducted: (1) Employing the degree of use to determine students’ learning difficulties; and (2) employing the pretest and posttest error types to examine learning problems.

Employing the degree of use to determine students’ learning difficulties

The results of analyzing student learning profiles show that the students tended to practice and complete the units they felt were easy while avoiding difficult units. The five units employed were assets (193 times), revenue (189 times), liabilities (161 times), loss (155 times), and owner equity (153 times) (see Table 6). The list of learning profiles matched the general teaching experience of accounting instructors. Liabilities, loss, and owner’s equity were the more difficult units; thus, the students tended to avoid them and achieve lower scores. Guidance and positive feedback from the instructors was critical to encourage the students to continue learning.

Table 6. The usage sorting list of all five units

<table>
<thead>
<tr>
<th>Unit</th>
<th>Usage (passed number)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assets</td>
<td>193</td>
</tr>
<tr>
<td>Revenue</td>
<td>189</td>
</tr>
<tr>
<td>Liabilities</td>
<td>161</td>
</tr>
<tr>
<td>Loss</td>
<td>155</td>
</tr>
<tr>
<td>Owner’s equity</td>
<td>153</td>
</tr>
</tbody>
</table>

Using the learning progress flow pretest and posttest error patterns to explore learning problems

Analysis of the pretest results (before the intervention of the dynamic assessment system) show that the number of students who selected to correct answer for Items 1, 3, 7, 8, 13, 15, and 16 was less than 10 (less than 1/3 of all the students), and the item type included owner equity, assets, liabilities, and loss. Items 8, 13, and 15 were regarding complex journalizing, which is a relatively difficult subject for students.

After the intervention of the dynamic assessment system, the students’ posttest scores were significantly higher than those of the pretest. According to the posttest results, the correctly answered items, which was achieved by 17 students (less than half of the total students), were Items 7, 8, and 13. The item types included loss, and reduced
assets and liabilities. Item 13 covered complex journalizing. The posttest results identified the items that were difficult to learn and indicated that the rate of correct answers was greatly enhanced following the intervention. Items analysis provided both the students and instructors with further understanding and preparation.

**Conclusion and recommendations**

In this section, we consolidate the findings of this study to form our conclusion. In addition, based on the student learning profiles and teaching diagnosis, specific recommendations are proposed as a reference for future implementations of dynamic assessments in vocational high school curriculum design.

**Conclusion**

According to the assessment results from the previous semester, the students were divided into high, medium, and low groups. After the intervention of computerized dynamic assessment system, the posttest scores were significantly higher than the pretest scores for all three groups. This indicates that the computerized dynamic assessment system can improve the learning outcomes for students of all levels.

Analysis of student learning profiles showed that the learning style of high-posttest scorers was most likely sequential learners, who develop linear thinking and problem-solving skills gradually, which leads to better learning results for this particular design. The low-posttest scores tended to be global learners with unclear learning goals, who also tended to ignore the system feedback. They continually changed and switched between learning units without fully understanding the basic knowledge and wasting time with unnecessary information. However, the analysis results also indicated that if the students were willing to follow the feedback and guidance and allocated enough time, they could achieve good progress. This matched the learning and teaching style for global learners (Felder & Silverman, 1988).

Based on the degree of use of the computerized dynamic assessment system, the students were divided into high, medium, and low groups. The analysis results of the posttest scores show significant differences between the three groups. The posttest scores for the high degree of use group were significantly higher than those for the other two groups. The results indicated that high-intensity learners performed better, and the more the students used the system, the more it enhanced learning.

Comparing the degrees of completion, students with high degrees of completion performed significantly better than those with low degrees of completion regarding the posttest-pretest progress. The results confirmed that the computerized dynamic assessment system can improve students’ learning outcomes and the higher the degree of completion, the better the subsequent progress.

**Recommendations**

The findings of this study showed that the computerized dynamic assessment system offers obvious benefits for vocational high school students learning accounting using traditional paper and pencil-based assessments. However, we provide a few suggestions regarding implementation in classroom settings and integration in instructional design.

According to the results of this study, a computerized dynamic assessment system benefits students of all levels. The higher the degree of completion, the higher the learning outcomes. Instructors are recommended to integrate the system in teaching. A training session for both the teachers and students is also recommended for successful implementation. The dynamic system helps to narrow the achievement gap of the students.

The main structure of the computerized assessment system is the continuum of assessment model, which includes evaluation functions, and can identify teaching and learning problems. During the assessment process, according to the types of errors, the system can identify unclear concepts or inadequate problem-solving skills and provide feedback and guidance. Instructors can use this system to realize the learning conditions of students and provide appropriate remedial instruction. Instructors should emphasize the development of students’ learning potential.
Using the expert concept map as the framework, the computerized dynamic assessment system provides an adaptive learning capabilities system. Therefore, it can be used for individual learning units and summative assessments. Using this system, instructors can obtain achievement scores, and more importantly, the students' learning processes and potential can be identified by instructors. Thus, this system can provide critical information for teaching and learning.

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Reference


