Development of an e-library for supporting mobile and ubiquitous learning

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http://www.idlslab.net/
IDLS (Intelligent Distance Learning Systems) lab

- **Mobile and Ubiquitous Learning**
  - Funded by NSC of Taiwan with NT$15,000,000 per year
  - Natural science courses
  - Social science courses
  - Computer science courses
  - English courses

Research Issues and Applications of Mobile and Ubiquitous Learning
The backgrounds of the members in this lab include Computer Science and Educational Technology.
Academic Publications of IDLS Lab

- 150 journal papers
  - Computers & Education
  - Educational Technology & Society
  - Innovations in Teaching and Education International
  - British Journal of Educational Technology
  - Electronic Library
  - Interactive Learning Environment
  - Ecommerce Research and Application
  - IEEE Transactions on Education (SCI)
  - IEEE Transactions on SMC, Part C (SCI)
  - IEEE Transactions on Mobile Computing (SCI)
  - Expert Systems with Applications (SCI)
  - Other SCI/EI/TSSCI journals

- 250 papers presented in conferences

- 8 book chapters
Six SSCI (Social Sciences Citation Index) journals of e-learning

- Computers & Education (C&E)
- Educational Technology & Society (ETS)
- British Journal of Educational Technology (BJET)
- Innovations in Education and Teaching International (IETI)
- Educational Technology Research & Development (ET R&D)
- Journal of Computer Assisted Learning (JCAL)
Sample groups selected for mobile and ubiquitous learning studies from 2001 to 2010

<table>
<thead>
<tr>
<th>Sample group</th>
<th>Elementary school students</th>
<th>High school students</th>
<th>Higher education</th>
<th>Teachers</th>
<th>Working adults</th>
<th>Non-specified</th>
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</table>

Research learning domains selected from 2001 to 2010

<table>
<thead>
<tr>
<th>Learning domain</th>
<th>Science</th>
<th>Mathematics</th>
<th>Language &amp; Art</th>
<th>Social science</th>
<th>Engineering (including Computers)</th>
<th>Others</th>
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<td>22</td>
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</table>
M-learning/u-learning with sensing technologies

- Some researchers have tried to conduct m-learning or u-learning activities with sensing technologies.
- This has lead to context-aware ubiquitous learning (Hwang, Tsai, & Yang, 2008)
- The learning system is able to detect and record the real-world learning status of the students.
- More learning supports can be provided by the learning system for guiding the students to learn in the real world.

Ubiquitous Learning
(anywhere and anytime learning)

Mobile Learning
(Learning with mobile devices and wireless communications)

Context-Aware U-Learning
(Learning with mobile, wireless communications and sensing technologies)

E-library for mobile and ubiquitous learning

- Developing a digital library to support mobile and ubiquitous learning (i.e., u-library).

- U-library is a digital library that has GPS and RFID positioning reference codes that allows digital resources to be prompted according to users’ environment and needs.

- The u-library system provides learning materials and relevant information for the learning activities.
Features of the u-library

- To facilitate the use of mobile learning, there are two versions of websites: the PC version and the PDA version.
- Students can use handheld mobile device with small screen, such as PDA or mobile phones, to retrieve digital resources from the u-library when they are learning in the field.
- The server and database of U-Library are built with APACHE+PHP+MYSQL programming languages.
Learning Objects (Creatures and Plants)
1. Texts
2. Graphics
3. Videos
原來牠有一隻長長的、外形像是琵琶的嘴巴，
連兩道上眼睛的周圍都是黑色，
全身白色的羽毛，
長長的腳和不長短的脖子，
外型和琵琶差不多，
因此就被稱作琵琶琵琶了。
<table>
<thead>
<tr>
<th>Name</th>
<th>Habit</th>
<th>Leaf</th>
<th>Flower</th>
<th>Fruit</th>
<th>Special Feature</th>
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<td>多年生草本</td>
<td>葉片並列，長椭圆形，葉柄基部收窄</td>
<td>花序花序</td>
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<td>葉片線形，基部收窄</td>
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<td>花序花序</td>
<td>黄色</td>
<td></td>
</tr>
</tbody>
</table>
User Interface

User

Tools

Retrieval

Interpretation

Search

Search List

Browse

Online Exhibition

Browse

Articles

Link

Reference

Identification

Name

Metadata

Digital Data

Multimedia Objects

GPS/RFID Reference Codes
<table>
<thead>
<tr>
<th>Contents</th>
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<tr>
<td>目錄</td>
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<td>校長序</td>
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<td>前言</td>
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<td>小灰蝶科</td>
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<td>(1) 劍舞蝶與沖繩小灰蝶</td>
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<td>(2) 蛋殼草與薩小灰蝶</td>
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<tr>
<td>(3) 台灣黑蝶與台灣小灰蝶</td>
<td>19</td>
</tr>
<tr>
<td>(4) 蘇魯與華國小灰蝶</td>
<td>25</td>
</tr>
<tr>
<td>蝴蝶科</td>
<td>31</td>
</tr>
<tr>
<td>(5) 平伏宜花白蝶與粉蝶</td>
<td>32</td>
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<tr>
<td>(6) 阿勃勒與水青粉蝶 - 淡黃蝶</td>
<td>43</td>
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<td>蝴蝶科</td>
<td>51</td>
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<td>(7) 帝吉蝶與孔雀粉蝶</td>
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<td>(8) 紅蓋黑與錦斑粉蝶</td>
<td>56</td>
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<td>(9) 臭椿粉蝶與錦斑 - 台灣黃粉蝶</td>
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<td>(10) 阿勃勒與大白粉蝶</td>
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</tr>
<tr>
<td>(11) 紅椿粉蝶與粉蝶</td>
<td>76</td>
</tr>
<tr>
<td>(12) 白玉蝶與綠斑粉蝶</td>
<td>84</td>
</tr>
<tr>
<td>(13) 紅椿粉蝶與粉蝶</td>
<td>88</td>
</tr>
<tr>
<td>(14) 紅椿粉蝶與粉蝶</td>
<td>99</td>
</tr>
<tr>
<td>尾頁</td>
<td>107</td>
</tr>
</tbody>
</table>
Resource-based learning

- Related to inquiry learning and problem-based learning that are oriented from constructivist teaching and learning approach.
- It is student-centered and allows students to discover knowledge for themselves.
- It is an educational model designed to actively engage students with multiple resources in both print and non-print form (Campbell, Flageolle, Griffith, & Wojcik, 2002).
Illustrative example of a context-aware u-learning environment

The learning system and the u-library system is executed on the server.

Each student uses a PDA equipped with an RFID reader and wireless communication facility.

Once the student walks close to a learning target, the RFID reader can receive the information from the corresponding tag.

Each learning target has an RFID tag on it.

Target Object 1  Target Object 2  Target Object 3  Target Object 4  Target Object 5
The student holds a PDA equipped with an RFID reader.

Each ecology area of butterflies has an RFID tag.

Learning missions or supplementary materials.
Benefits of using sensing technologies

- The learning system is able to guide the learners in the real world via detecting their locations.
- The learning system can more actively provide learning supports to the learners if necessary.
  - E.g., Give hints to the students who are doing a dangerous chemical experiment before something goes wrong.
More parameters in a context-aware u-learning portfolio

- **Personal context in the real world**: learner’s location, time of arrival, body temperature, heartbeat, blood pressure, etc.
- **Environmental context**: the learning target’s ID and location, the environmental temperature, humidity, air ingredients, and other parameters of the environment around the sensor.
- **The data collected by the students in fields**: e.g. PH value of water.
- **Personal data in the database**: learner’s profile and learning portfolio, such as the predefined schedule, starting time of a learning activity, the longest and shortest acceptable time period, place, learning sequences.
- **Environmental data in the database**: equipment in the lab, the rules of using the equipment, the time table of using the lab.
Earlier applications - Serving as a Guide for Science Observations

The u-learning system serves as a guide for observing a set of learning targets in the real world.
Background and Motivation

- Observation and classification abilities
  - important learning objectives for science education.

- In the Natural Science courses of elementary schools in Taiwan
  - the students need to learn to observe and classify some learning targets (e.g., plants on school campus, butterflies in the garden)

- In the followings, several learning activities are designed for the “Butterfly and Ecology” unit of a natural science course
Conventional “Butterfly and Ecology” learning activity

A teacher usually needs to train 10 or more students at the same time.
In such a one-to-many instruction mode:
It is difficult to provide personalized instructions or feedback to the students or to record their learning status.
Scenario 1: Butterfly museum

Students are guided by the u-learning system to learn to identify different types of butterflies based on the appearances of the butterflies.
Location of the target butterfly

What is the name of the butterfly in front of you?

The most significant feature of the target butterfly

Observe and compare the target butterfly with other butterflies based on the feature.

1. 請問您面前的標本是那一隻蝴蝶呢？
   - 霧香鳳蝶
   - 綠斑鳳蝶
   - 紅紋鳳蝶
   - 大紅紋鳳蝶

   確定

   您答錯了！
   正解：【大紅紋鳳蝶】
Scenario 2: Butterfly ecology garden

- The Butterfly Ecology Garden consists of **25 ecology areas** for raising **host plants of butterflies**.

The students are guided by the learning system to observe the host plants and the butterfly ecology in each target area.
Some preliminary findings in the earlier studies

- Advantages of the u-learning approach
  - Providing a personalized guide for individual students
  - Providing supplementary materials and hints in the right place and at the right time
  - Motivating the students to learn

- To engage students in higher order thinking, more effective learning supports or knowledge construction tools are needed
Recent applications
- Leading in Mindtools for u-learning activities
Definitions of Mindtools

- Jonassen (1999, p9) described Mindtools as “a way of using a computer application program to engage learners in constructive, higher-order, critical thinking about the subjects they are studying.”
Mindtools used in our studies

- Grid-based Mindtool
  - Helping the students identify and differentiate a set of learning targets based on the features of the targets

- Concept maps
  - Helping the students organize their knowledge via linking the new knowledge and their prior knowledge
Repertory grid (Kelly, 1955)

- A repertory grid is represented as a matrix or table
  - Its columns are labeled with **elements**.
  - Its rows are labeled with **constructs**.
- A 5-scale rating mechanism is usually used.

### Elements (e.g., plants)

<table>
<thead>
<tr>
<th>Trait (1)</th>
<th>Golden Chinese banyan</th>
<th>Arigated-leaf croton</th>
<th>Cuphea</th>
<th>Indian almond</th>
<th>Opposite (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf-shape is long and thin</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>Leaf-shape is flat and round</td>
</tr>
<tr>
<td>The leaf has a tapering point</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>The leaf has a hollow point</td>
</tr>
<tr>
<td>Perfectly smooth leaf edge</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>The leaf edge has deep indents</td>
</tr>
</tbody>
</table>

Trait (1) ←----- Constructs (features of the plants) ---> opposite (5)
Two stages for providing learning supports based on the repertory grid

- 1st stage - creating the **objective repertory grid** by teachers

- 2nd stage - using the objective repertory grid to help students develop their repertory grids
### The Objective RG

<table>
<thead>
<tr>
<th>Trait Construct</th>
<th>Lalang Grass</th>
<th>Arigated-leaf croton</th>
<th>Cuphea</th>
<th>Indian almon d</th>
<th>Money Tree</th>
<th>Crown of thorns</th>
<th>Pink ixora</th>
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</tr>
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<td>5</td>
<td>1</td>
<td>The leaf edge has deep indents</td>
</tr>
<tr>
<td>The leaf vein has few branches</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>The leaf vein has many branches</td>
</tr>
</tbody>
</table>

The learning mission: observing the “leaf shape” of “Lalang grass” and answer the following question.

The student is asked to observe the “leaf shape” of “Lalang grass” by asking a question.
### The Objective RG

The student has correctly answered the “leaf shape” of “Lalang grass” to be “long and thin”, and is asked to describe more detailed features of the leaf shape.

#### Trait Construct
- Lalang Grass
- Arigated-leaf croton
- Cuphea
- Indian almond
- Money tree
- Crown of thorns
- Pink ixora

<table>
<thead>
<tr>
<th>Trait Construct</th>
<th>Lalang Grass</th>
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<td>Leaf-shape is long and thin</td>
<td>1</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td>5</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

#### Options
- Acicular
- Linear
- Lance-shaped
### The RG constructed by the student

<table>
<thead>
<tr>
<th>Trait Construct</th>
<th>Lalang Grass</th>
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<td></td>
<td></td>
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</tbody>
</table>

The answer “Flat and Round” to the “leaf shape” of “Lalang grass” is incorrect.

### The Objective RG

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</tr>
</tbody>
</table>

The student is asked to observe the leaf shape of “Indian Almond” and compare it with the leaf shape of Lalang grass.”
Experiment Design

- Subject unit: “Knowing the plants on school campus” of the Natural Science course
- Comparing the learning performance of the students who learned with/without the Mindtool
Comparing u-Mindtool learning with u-Learning

- **Participants**: 61 fifth graders
  - **Control group**: 29 students, learned with a tour-based u-learning system that provided location guidance and supplementary materials
  - **Experimental group**: 32 students, learned with the Repertory Grid-oriented u-learning approach
Learning Achievements

Table 1. *t*-test of the pre-test results

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
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<td>73.09</td>
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<td>.591</td>
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<td></td>
</tr>
</tbody>
</table>

No significant difference between the two groups

Table 2. Descriptive data, and ANCOVA of the post-test results

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Adjusted Mean</th>
<th>Std.Error</th>
<th>F value</th>
</tr>
</thead>
<tbody>
<tr>
<td>post-test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>32</td>
<td>52.69</td>
<td>13.45</td>
<td>52.185</td>
<td>2.236</td>
<td>7.533*</td>
</tr>
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<td>group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control group</td>
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<td>44.31</td>
<td>13.68</td>
<td>44.652</td>
<td>2.346</td>
<td></td>
</tr>
</tbody>
</table>

*p<.05
A follow-up learning activity

- The students needed to develop their own repertory grids by determining the traits for identifying the target butterflies.
The can also share their findings to peers and modify their repertory grids via a knowledge-sharing interface.

- Option for referring to other students’ repertory grid
- Delete the selected constructs
- Modify one’s own repertory grid
- Add new constructs
- Confirm if the operations are to be saved/executed
1. Develop concept maps in the classroom based on what they have learned from the textbooks.

2. Go to the butterfly garden to observe the ecology of the butterflies. Check if their concept map is correct and complete via browsing the developed concept maps on the PDA. Take notes on the PDA.

3. Go back to the classroom to modify their concept maps.
CmapTools developed by the Institute for Human and Machine Cognition (IHMC) of the Florida University System (Novak & Cañas, 2006).

Working space for developing concept maps

Set up concept map parameters

Insert the picture of the concept
The students can browse their concept maps via the mobile devices.

Take notes or record what they have found during the learning activities.

Interface for entering Chinese characters
The on-going project
Inquiry-based learning activities in Chi-Gu ecology park in southern Taiwan

In this area, there are Mangroves, Black-Face Spoonbills and Fiddler Crabs.
Ubiquitous learning system

Three-layer Inquiry Mechanism

First layer - Guided Observation with Multiple Choice Items

Second layer - Independent Observation with Short response Items

Third layer - Extended Observation with Learning Diary Development

Electronic library

Automated Scoring Feedback Mechanism

Ecology Park
The students are equipped with a smartphone (or PDA), a telescope and a set of probe devices to collect data in the ecology park.
Conclusions

- The popularity of mobile, wireless communication and sensing technologies has brought us some new aspects for perceiving education.
- Electronic libraries provide the opportunities for the learners to access digital resources in fields.
- Integrating e-library and u-learning technologies to facilitate learning in fields could be a potential research issue.
References


Thank you