Research Issues and Applications of Mobile and Ubiquitous Learning

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Dr. Gwo-Jen Hwang is currently a Distinguished Professor in the Department of Information and Learning Technology, and Dean of the College of Science and Engineering at National University of Tainan in Taiwan. His research interests include mobile and ubiquitous learning, computer-assisted testing, expert systems and knowledge engineering.

Dr. Hwang has published more than 300 academic papers, including 117 journal papers. One of his research papers was recognized by the well-established *Computers & Education* as one of the top 10 most frequently cited papers. Owing to the good reputation in academic research and innovative inventions of e-learning, in 2007, he received the annual Most Outstanding Researcher Award from the National Science Council in Taiwan.

IDLS (Intelligent Distance Learning Systems) lab

- **Mobile and Ubiquitous Learning**
  - Funded by NSC with about NT$15,000,000 per year
- Artificial Intelligence in Education
- Web-based Learning

Team of Computer Technology

Team of Educational Technology

Academic Publications of IDLS Lab

- 117 journal papers
  - Computers & Education (SSCI)
  - Educational Technology & Society (SSCI)
  - Innovations in Teaching and Education International (SSCI)
  - British Journal of Educational Technology (SSCI)
  - Electronic Library (SSCI)
  - Interactive Learning Environment (SSCI)
  - Ecommerce Research and Application (SSCI)
  - 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
- 200 papers presented in conferences
- 3 book chapters
- 12 papers submitted to journals (under review)

M-Learning vs. U-Learning

- M-Learning
  - Emphasizing the portability of the learning devices or the mobility of the learners.
  - the use of mobile technology in learning.
- U-Learning
  - An educational ideal
  - People can learn anywhere and anytime with access to what they need

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

- Educational Technology & Society (ETS)
- Computers & Education (C&E)
- 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)

Impact Factor from 2005 to 2008

Journal	2008	2007	2006	2005
Computers & Education	2.19	1.602	1.085	0.968
Journal of Computer Assisted Learning	1.065	0.8	0.532	0.556
British Journal of Educational Technology	1.041	0.574	0.406	0.593
Educational Technology & Society	0.904	0.475	0.469	0.267
Educational Technology Research and Development	0.695	0.27		0.364
Innovations in Education and Teaching	0.25	0.18	0.103	0.2

Number of papers published from 2006 to 2009

	2006	2007	2008	2009
C&E	56	123	230	211
BJET	61	85	72	65
ET&S	85	81	84	99
JCAL	37	40	43	40
ETR&D	31	28	32	41
IETI	33	31	39	34
Total	303	388	500	490

(short papers and book reviews are not counted in this table)

Number of m-learning/u-learning papers published from 2006 to 2009

	2006	2007	2008	2009
C&E	2	4	11	15
BJET	2	3	2	5
ET&S	5	7	10	13
JCAL	2	5	3	5
ETR&D	0	1	1	1
IETI	0	1	0	3
Total	**11**	**21**	**27**	**42**

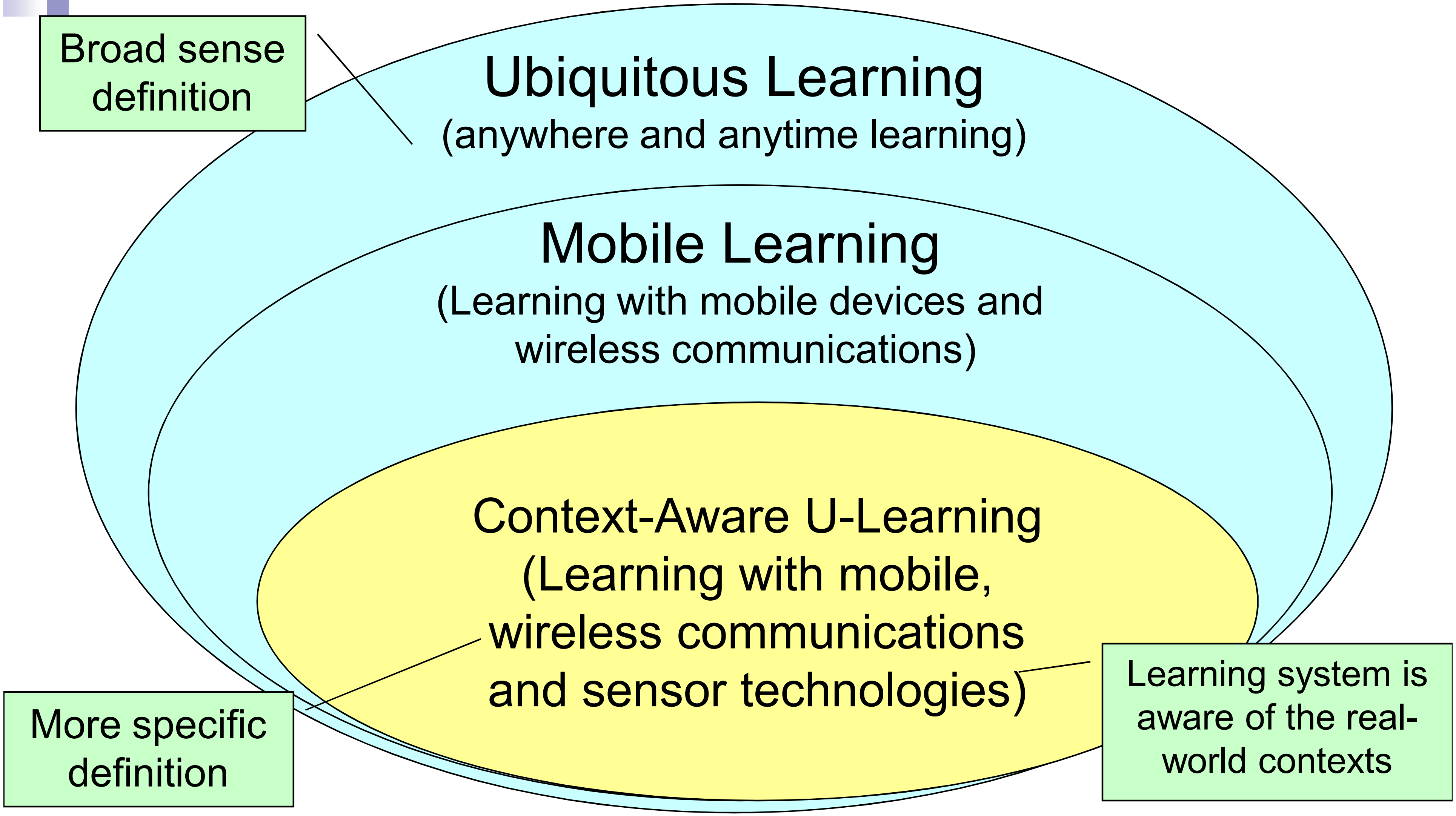
Ratio of m-learning/u-learning papers published from 2006 to 2009

	2006	2007	2008	2009
C&E	3.6%	3.2%	4.7%	**7.1%**
BJET	3.2%	3.5%	2.7%	**7.7%**
ET&S	5.8%	8.6%	11.9%	**13.1%**
JCAL	5%	12.5%	7%	**12.5%**
ETR&D	0%	3.5%	3.1%	2.4%
IETI	0%	3.2%	0%	**8.8%**
Total	**3.6%**	**5.4%**	**5.4%**	**8.6%**

IJMLO (International Journal of Mobile Learning and Organisation).

Context-Aware Ubiquitous Learning

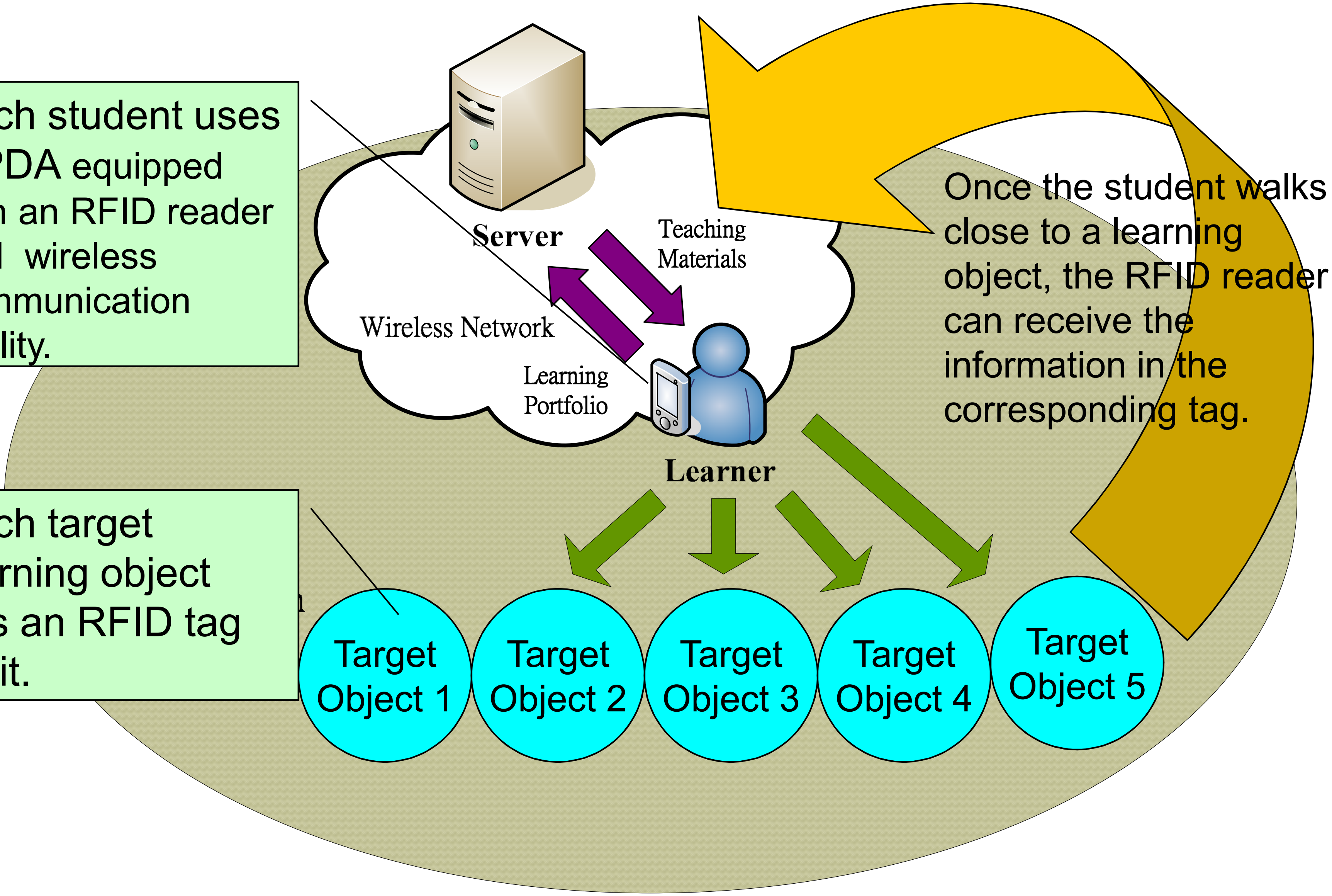
- The advance of **sensing technologies** have been providing new directions for technology-enhanced learning.
- This has lead to **context-aware ubiquitous learning** (Hwang *et al*., 2008)
- The learning system is able to detect and record the real-world behaviors of the students.
- Students are guided to interact and learn with the target learning objects in which the sensors are embedded (Curtin *et al*., 2007).



Gwo-Jen Hwang*, Chin-Chung Tsai and Stephen J.H. Yang (2008), “Criteria, Strategies and Research Issues of Context-Aware Ubiquitous Learning”, *Educational Technology & Society*, 11(2), 81-91. (SSCI)

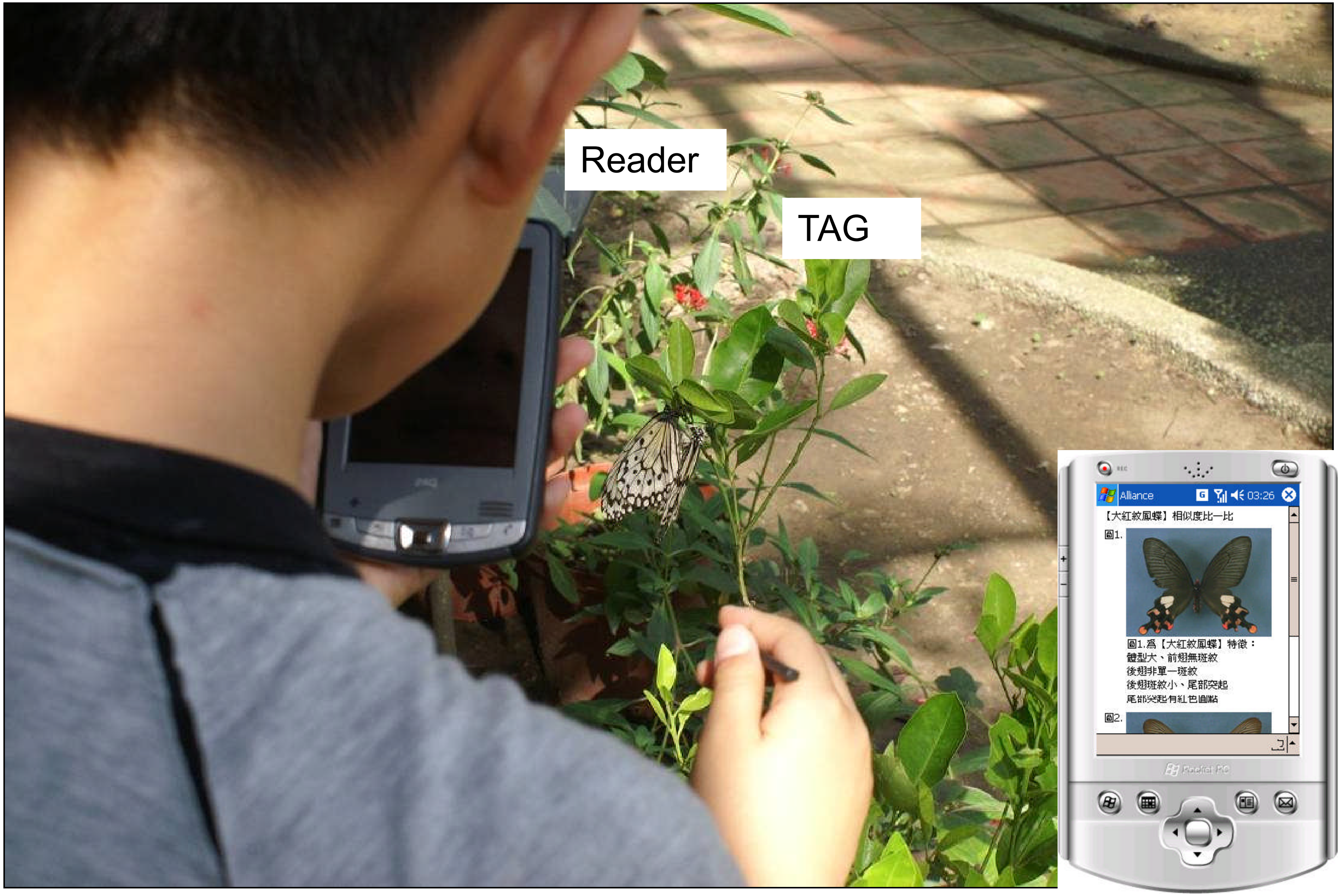
Context-Aware U-Learning Environment

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



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

Each target learning object has an RFID tag on it.


Reader
TAG
Alliance
03:26
【大紅紋鳳蝶】相似度比一比
圖1.
圖1.為【大紅紋鳳蝶】特徵：
體型大、前翅無斑紋
後翅非單一斑紋
後翅斑紋小、尾部突起
尾部突起有紅色圓點
圖2.

How sensor technologies benefit learning activities?

- Ease the burden of the students for finding the learning materials or learning missions
- It is able to provide more information to support adaptive learning
- It is able to guide the students to learn in the real world
- It is able to more actively provide necessary information to the learners

Hint the student before something actually going 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 sensor's ID and location, the environmental temperature, humidity, air ingredients, and other parameters of the environment around the sensor
- **Feedback from the sensing devices**: the sensed values of the target, 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 lab, the time table of using the lab

Research Issues concerning mobile and ubiquitous learning

- Proposing new strategies for adaptive or cooperative/collaborative u-learning
- Studying the learning status of students
  - "cognitive Load" issue
  - "learning style" issue
  - "cognitive style" issue
  - "Self-efficacy" issue

Context-Aware U-Learning System as a Personal Tutor for Science Observations

Background and Motivation

- Observation and classification abilities are two important learning objectives for science education.
- In Natural Science courses of elementary schools in Taiwan, the students need to learn to observe and classify some target learning objects (e.g., plants on school campus, butterflies in the garden)

Conventional "Butterfly and Ecology" learning activity

A teacher usually needs to train 10 or more students at the same time.

It is difficult to provide personalized instructions and record the learning portfolios of the students.

Scenario 1: Butterfly museum

Students are asked to follow the instructions displayed on PDA to observe and classify various types of butterflies based on their appearances.

Butterfly samples

Location of the butterfly to be recognized

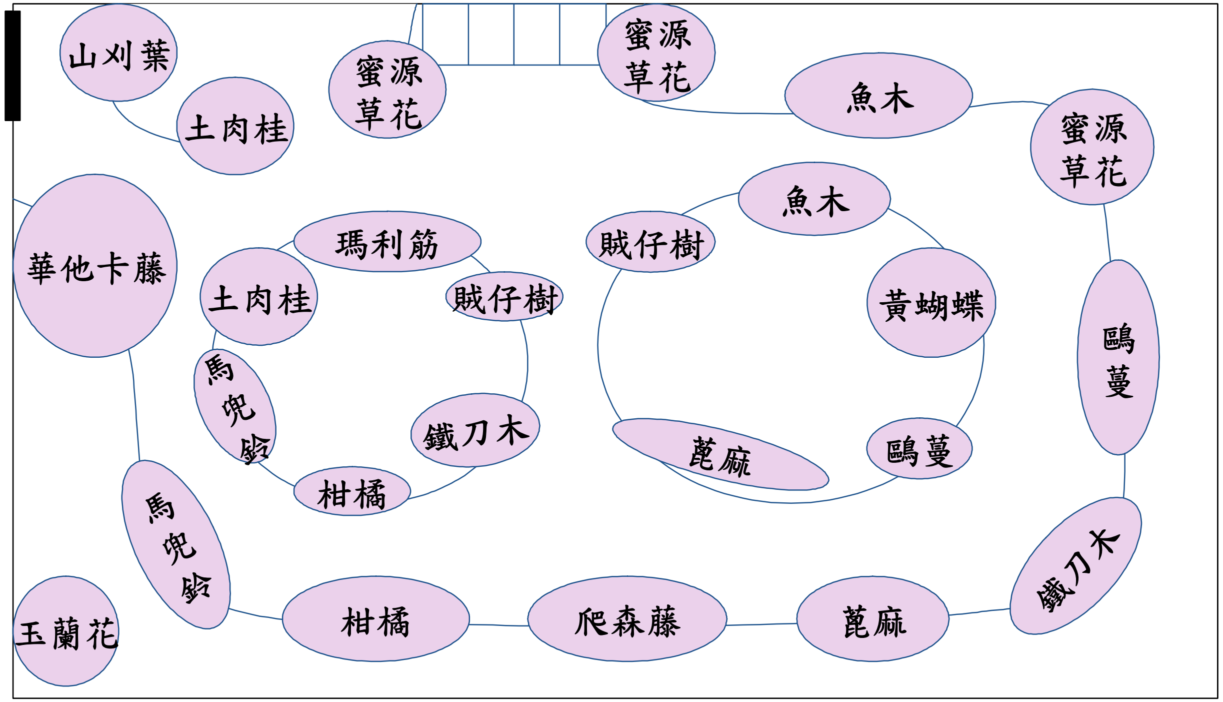
The most significant feature of the butterfly

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

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

Scenario 2: Butterfly ecology garden

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



Hui-Chun Chu, Gwo-Jen Hwang*, Shu-Xian Huang and Ting-Ting Wu (2008), "A Knowledge Engineering Approach to Developing E-Libraries for Mobile Learning", *The Electronic Library*. 26(3), 303-317. **(SSCI)**

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

Some preliminary Findings

- Advantages
  - Providing a personalized tutor for individual students
  - Motivating the students to learn
- However, to improve the learning achievements of students, more effective learning strategies or tools are needed

Development of a Mindtool for Context-Aware U-Learning

Definitions of Mindtools

- Mindtools are computer-based tools and learning environments which serve as extensions of the mind.
- Jonassen (1999, p9) described Mindtools as "a way of using a <u>computer application program</u> to engage learners in constructive, higher-order, critical thinking about the subjects they are studying".

Expert Systems as Mindtools

- Jonassen (1999) further indicated that, **the creation of the knowledge bases** of expert systems is the part of the activity that engages the critical thinking.
- The methods or tools for developing knowledge-based systems might serve as Mindtools.
  - "**Involving in Knowledge acquisition process**" is helpful to individuals in arousing their critical thinking and re-organizing their knowledge

Repertory grid (Kelly, 1955)

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

Objects to be indentified or classified

Elements (e.g., plants)

Trait (1)	Golden Chinese banyan	Arigated- leaf croton	Cuphea	Indian almond	Opposite (5)
Leaf-shape long and thin	2	2	2	4	Leaf-shape flat and round
The leaf has a tapering point	3	1	1	4	The leaf has a hollow point
Perfectly smooth leaf edge	1	1	4	1	The leaf edge has deep indents

Trait (1) ←----Constructs (features of the plants)---→opposite(5)

Development of Repertory Grid-oriented Mindtools

- A PDA Mindtool is developed based on the repertory-grid approach
- Repertory grid approach can be an **effective knowledge construction tool** which helps the students to observe and classify the learning targets in the real world.

1st stage- creating the objective repertory grid by teachers

Trait Construct	Golden Chinese banyan	Arigated-leaf croton	Cuphea	Indian almond	Money Tree	Crown of thorns	Pink ixora	Opposite Construct
Leaf-shape long and thin	2	2	2	4	2	2	2	Leaf-shape flat and round
The leaf has a tapering point	3	1	1	4	2	1	3	The leaf has a hollow point
Perfectly smooth leaf edge	1	1	4	1	1	5	1	The leaf edge has deep indents
The leaf vein has few branches	2	3	2	2	3	3	3	The leaf vein has many branches

2nd stage- using the repertory grid for u-learning

- An interactive learning procedure is used to guide the students to observe and compare the features of the target objects in the authentic learning environment.

Step 1: Display the structure of the Objective repertory grid to individual students.

Step 2: Guide the students to observe and describe the main features of each learning object based on the Objective repertory grid structure.

The RG constructed by the student

Trait Construct	Lalang Grass	Arigated-leaf croton	Cuphea	Indian almond	Money Tree	Crown of thorns	Pink ixora	Opposite Construct
Leaf-shape long and thin								Leaf-shape flat and round
The leaf has a tapering point								…f …y
Perfectly smooth leaf edge								…f …as …s
… branches								…f …s branches

The student is asked to observe the "leaf shape" of "Liquidambar" by asking a question.

Tapering to a long point

Arrowhead-shaped point

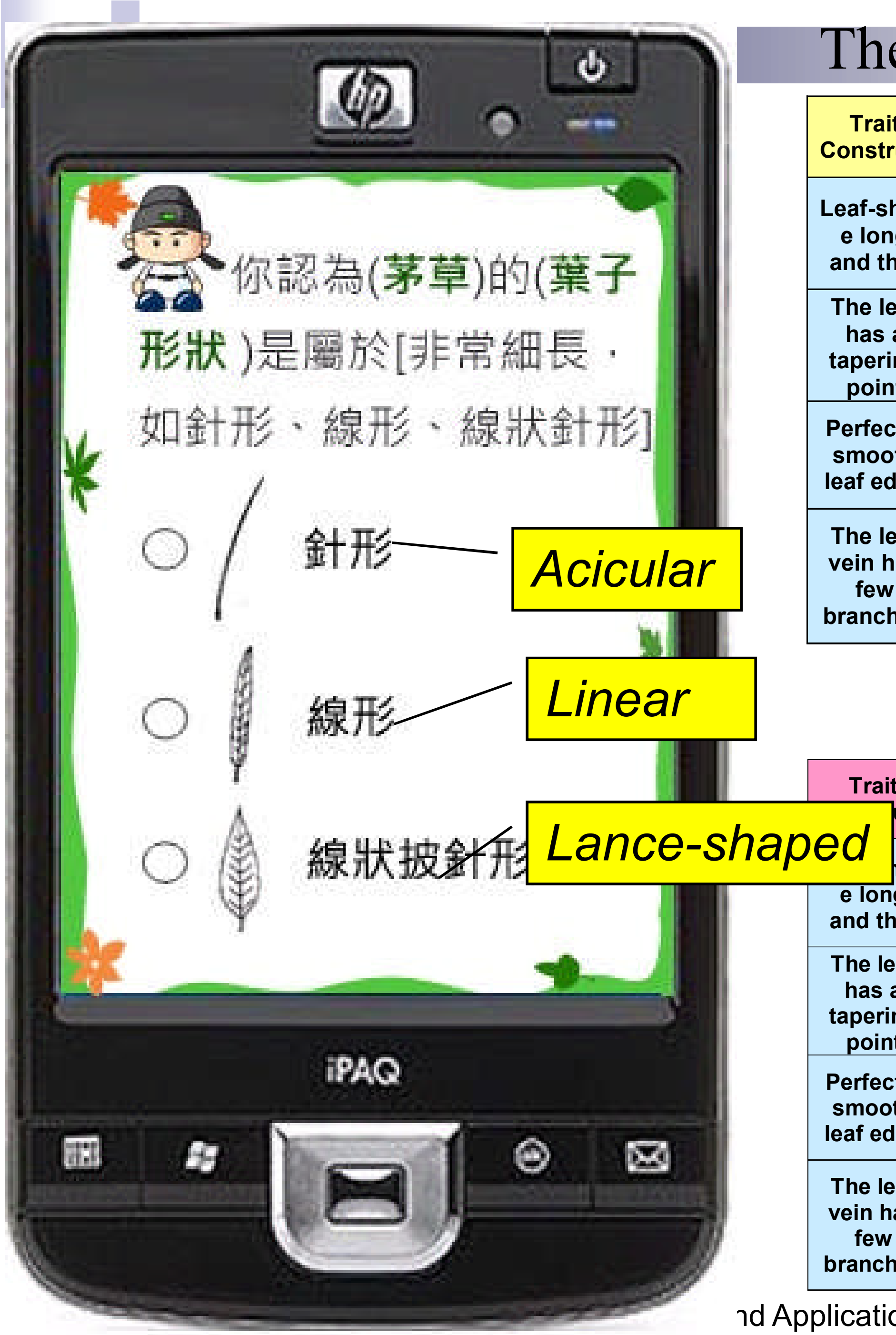
Stem attaches to tapering point

Round with a blunt tip

Leaf with a hollow point

The Objective RG

Trait Construct	Lalang Grass	Arigated-leaf croton	Cuphea	Indian almond	Money Tree	Crown of thorns	Pink ixora	Opposite Construct
Leaf-shape long and thin	1	2	2	4	2	2	2	Leaf-shape flat and round
The leaf has a tapering point	1	1	1	4	2	1	3	The leaf has a hollow point
Perfectly smooth leaf edge	1	1	4	4	1	5	1	The leaf edge has deep indents
The leaf vein has few branches	5	3	2	2	3	3	3	The leaf vein has many branches



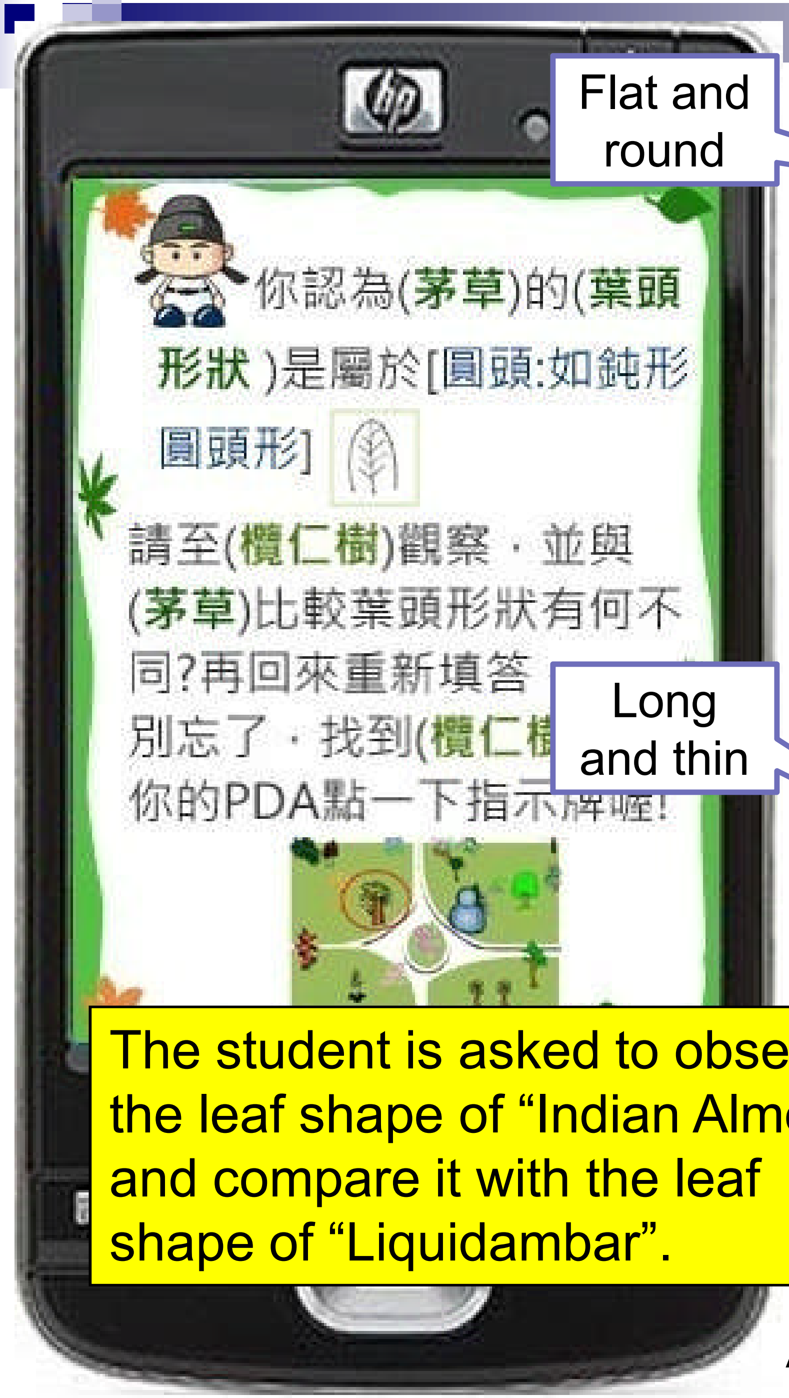
The RG constructed by the student

Trait Construct	Lalang Grass	Arigated-leaf croton	Cuphea	Indian almond	Money Tree	Crown of thorns	Pink ixora	Opposite Construct
Leaf-shape long and thin	1							Leaf-shape flat and round
The leaf has a tapering point								he leaf has a ollow point
Perfectly smooth leaf edge								he leaf dge has deep ndents
The leaf vein has few branches								he leaf ein has many ranches

The student has correctly answered the "leaf shape" of "Liquidambar" to be "long and thin", and is asked to describe more detailed features of the leaf shape.

The Objective RG

Trait uct	Lalang Grass	Arigated-leaf croton	Cuphea	Indian almond	Money Tree	Crown of thorns	Pink ixora	Opposite Construct
hap e long and thin	1	2	2	4	2	2,	2	Leaf-shape flat and round
The leaf has a tapering point	1	1	1	4	2	1	3	The leaf has a hollow point
Perfectly smooth leaf edge	1	1	4	1	1	5	1	The leaf edge has deep indents
The leaf vein has few branches	5	3	2	2	3	3	3	The leaf vein has many branches



Flat and round

Long and thin

The student is asked to observe the leaf shape of “Indian Almond” and compare it with the leaf shape of “Liquidambar”.

The RG constructed by the student

Trait Construct	Lalang Grass	Arigated-leaf croton	Cuphea	Indian almond	Money Tree	Crown of thorns	Pink ixora	Opposite Construct
Leaf-shape long and thin	4							Leaf-shape flat and round
The leaf has a tapering point								The leaf has a hollow point
Perfectly smooth leaf edge								The leaf edge has deep indents
The leaf vein has few branches								The leaf vein has many branches

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

The Objective RG

Trait Construct	Lalang Grass	Arigated-leaf croton	Cuphea	Indian almond	Money Tree	Crown of thorns	Pink ixora	Opposite Construct
Leaf-shape long and thin	1	2	2	4	2	2	2	Leaf-shape flat and round
The leaf a ...ing ...nt	1	1	1	4	2	1	3	The leaf has a hollow point
...ctly ...oth ...dge	1	1	4	1	1	5	1	The leaf edge has deep indents
...eaf has few branches	5	3	2	2	3	3	3	The leaf vein has many branches

Experiment Design

- **Subject: “Campus plants” unit of the Natural Science course**
- Experiment for Comparing u-Mindtool learning with u-Learning
  - 61 five-grade elementary school students

Comparing u-Mindtool learning with u-Learning

- Participants: 61 elementary school students
  - **Control group**: 29 students, PDA system with tour-based learning guidance and supplementary materials
  - **Experimental group**: 32 students, PDA system with the Repertory Grid-oriented Mindtool

Learning Achievements

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

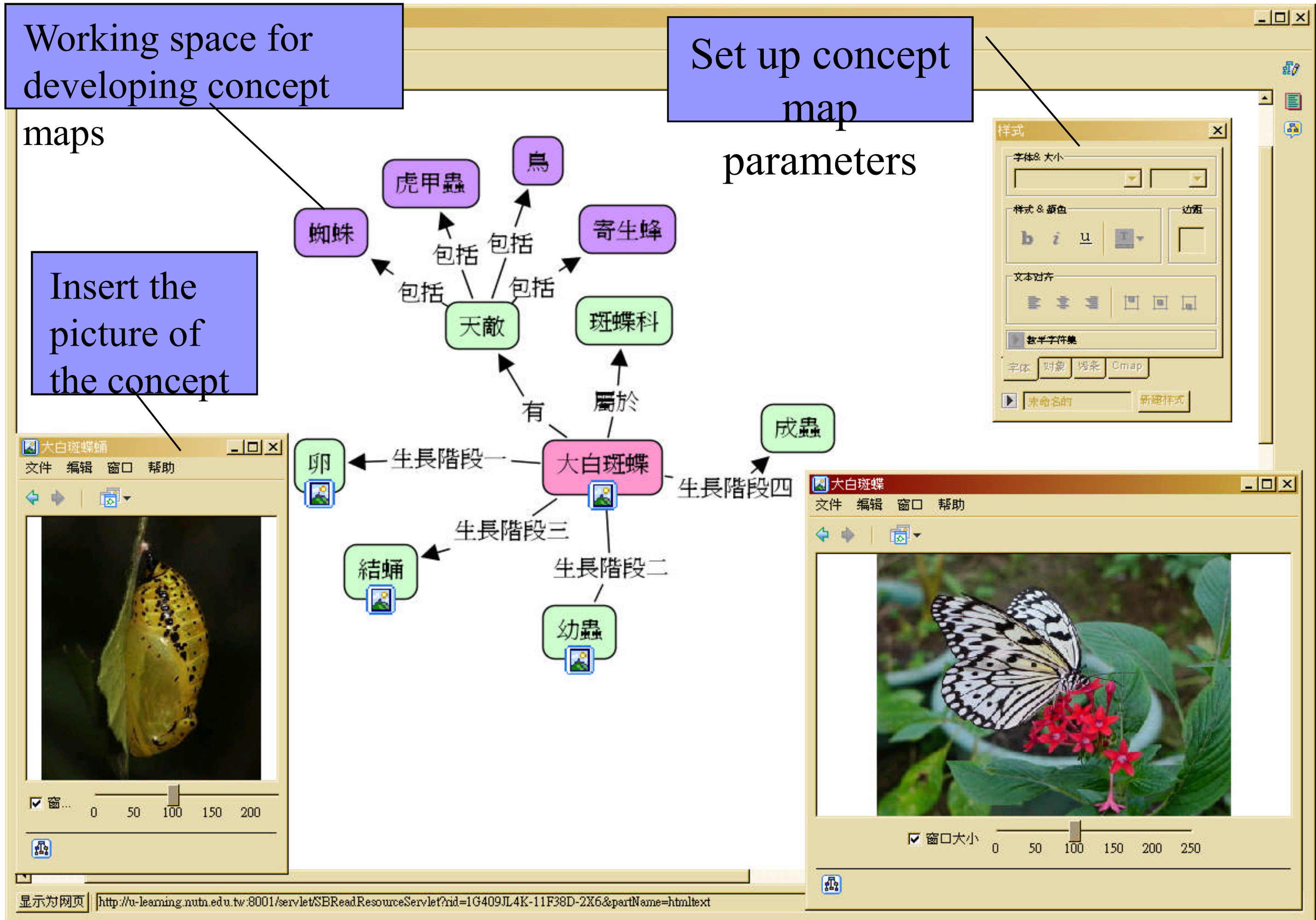
		N	Mean	S.D.	*t*
V1	control group	29	73.09	11.21	.591
V2	experimental group	32	71.14	14.56	

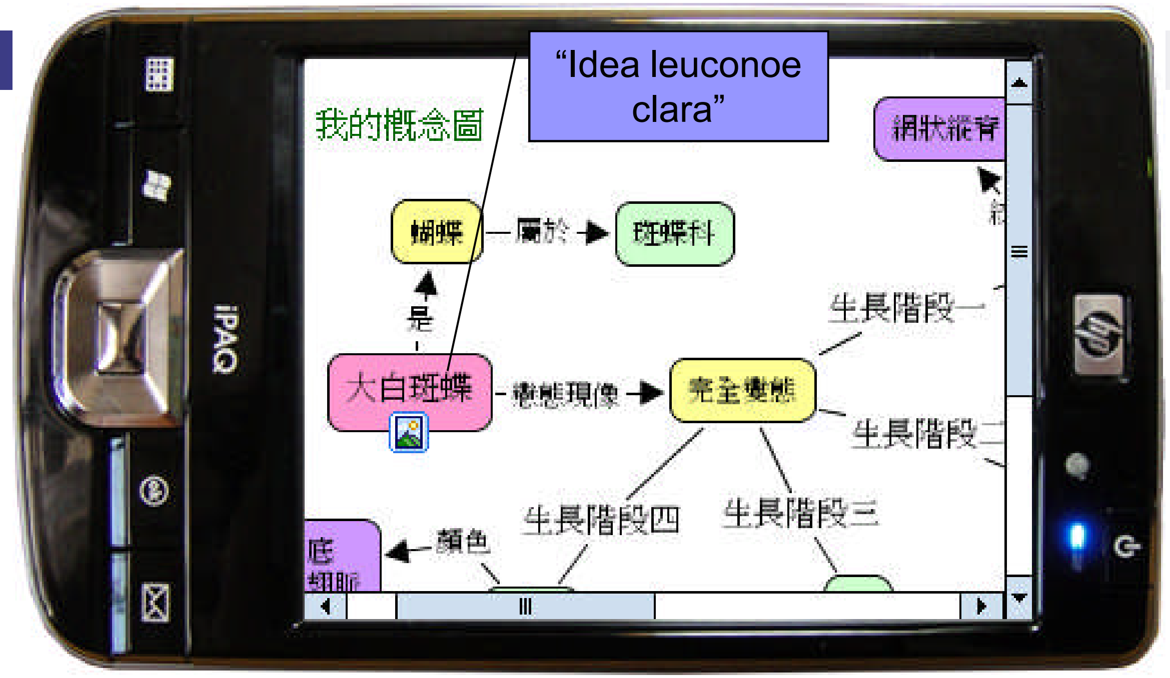
Table 2. Descriptive data, and ANCOVA of the post-test results

Variable		N	Mean	S.D.	Adjusted Mean	Std.Error.	*F value*	*p*
post-test	Experimental group	32	52.69	13.45	52.185	2.236	7.533*	.024
	Control group	29	44.31	13.68	44.652	2.346		

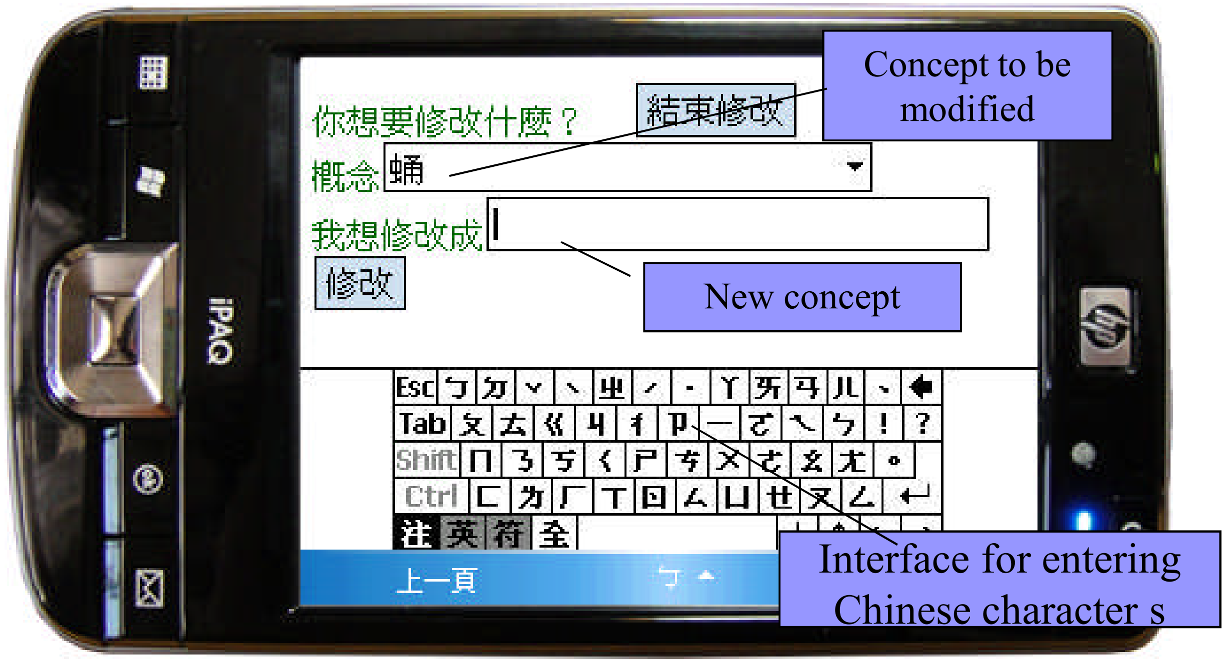
*p<.05

A Concept map-oriented Mindtool for u-learning





“Idea leuconoe clara”
我的概念圖
蝴蝶
屬於
斑蝶科
是
大白斑蝶
完全變態
生長階段一
生長階段二
生長階段三
生長階段四
顏色

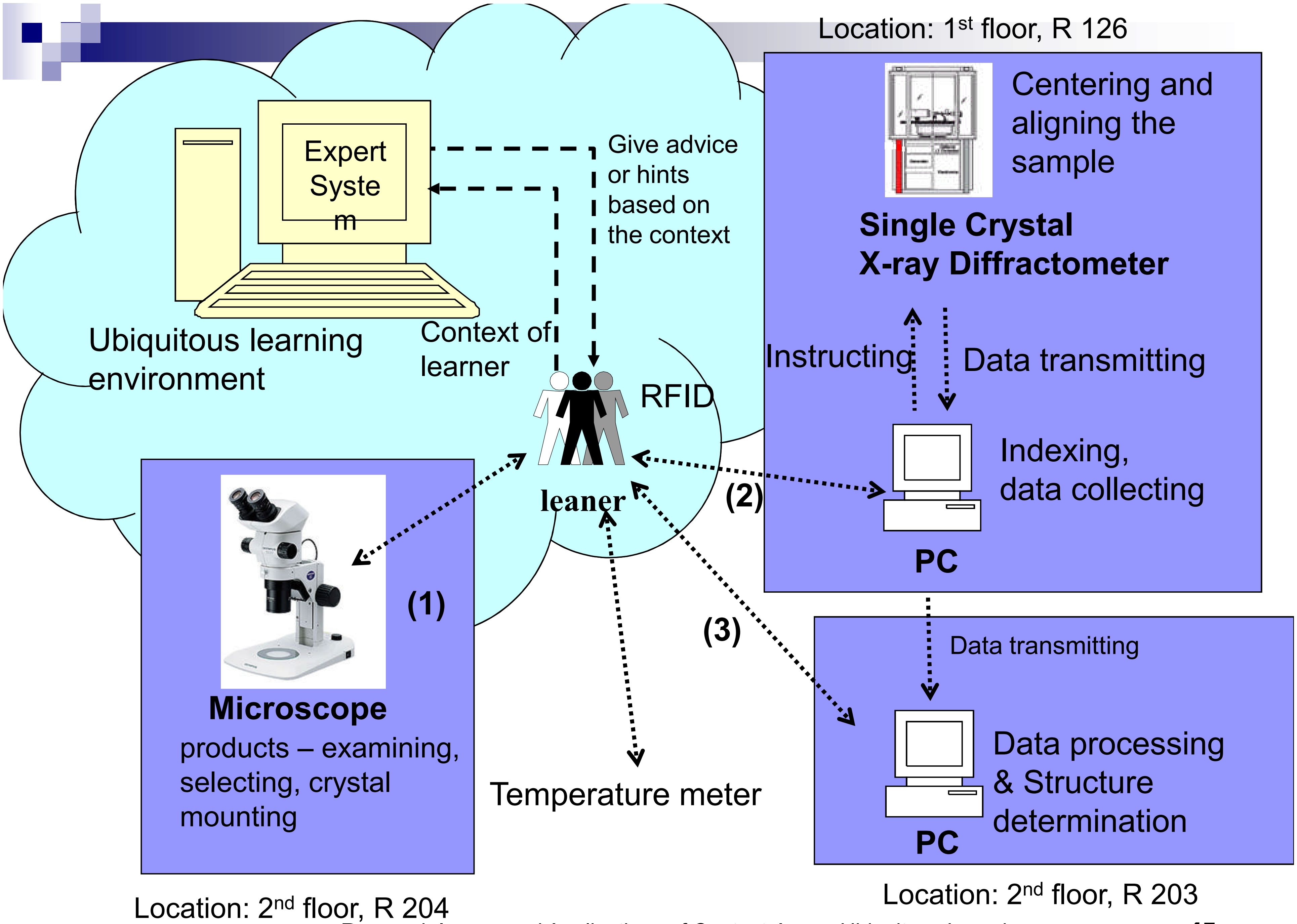


Concept to be modified
你想要修改什麼？
結束修改
概念
蛹
我想修改成
修改
New concept
上一頁
Interface for entering Chinese character s

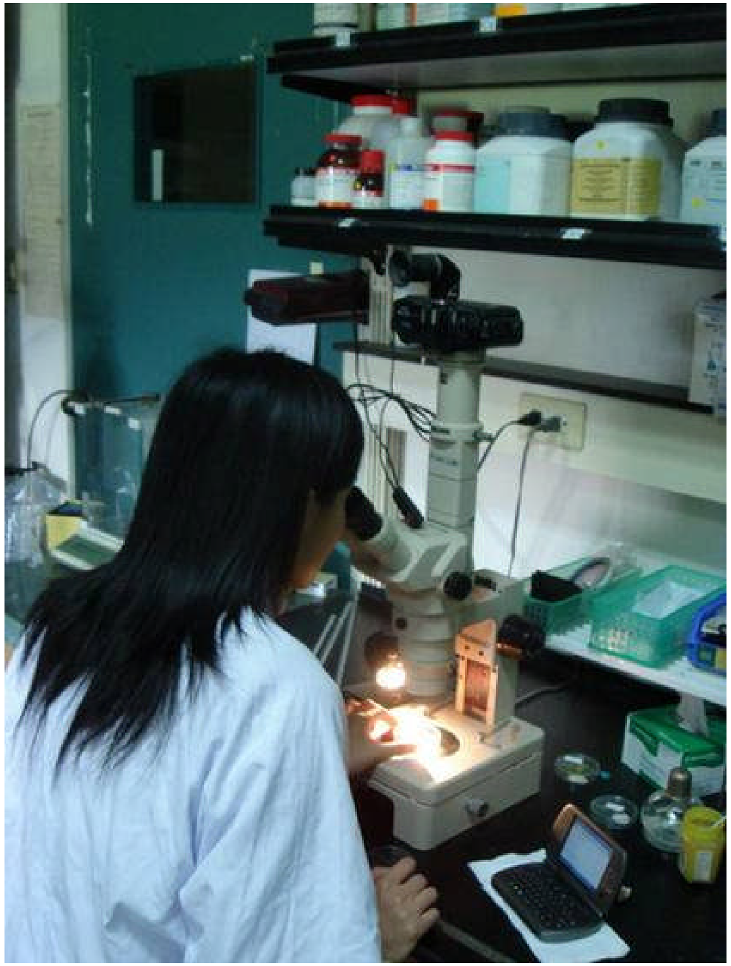
Context-Aware U-Learning for complex experiment procedures

Background and Motivation

- Development of a context-aware u-learning system for training the "Single-Crystal X-ray Diffraction" procedure in a Chemistry course.
- It is the most effective method for analyzing 3D structure of compound materials.
- The learners are graduated or PhD students.
- It is time-consuming to train a new researcher (usually 6 months to 1 year)
- The operations could be dangerous, and hence the learner requires full-time guidance during the training process

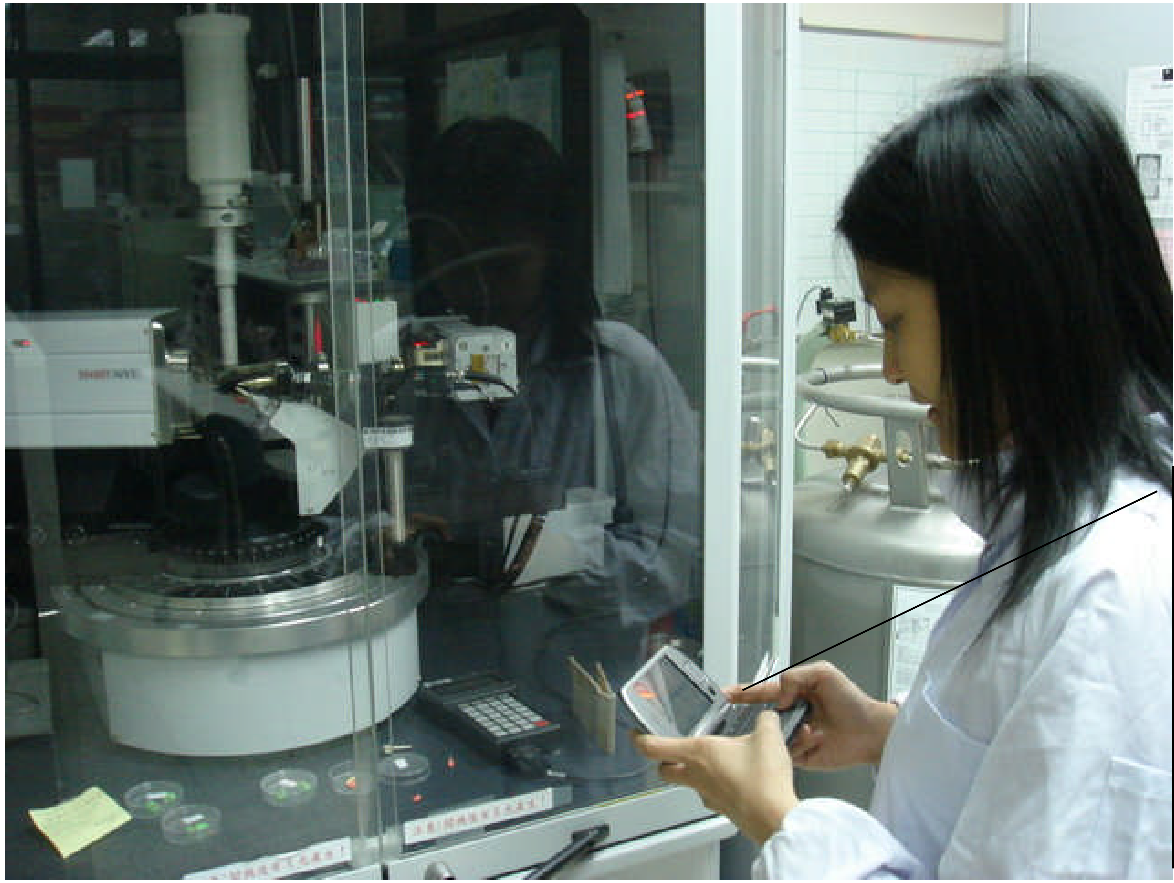

Location: 1st floor, R 126
Expert System
Give advice or hints based on the context
Context of learner
Ubiquitous learning environment
RFID
leaner
Centering and aligning the sample
Single Crystal X-ray Diffractometer
Instructing
Data transmitting
Indexing, data collecting
PC
(1)
(2)
(3)
Microscope
products – examining, selecting, crystal mounting
Temperature meter
Data transmitting
Data processing & Structure determination
PC
Location: 2nd floor, R 203
Location: 2nd floor, R 204

Stage 1: Select a crystal of **good quality and suitable size** through an optical microscope and mount the crystal on the top of the glass fiber.



The expert system will hint the learner to complete the procedure and check if the selected crystal is usable.

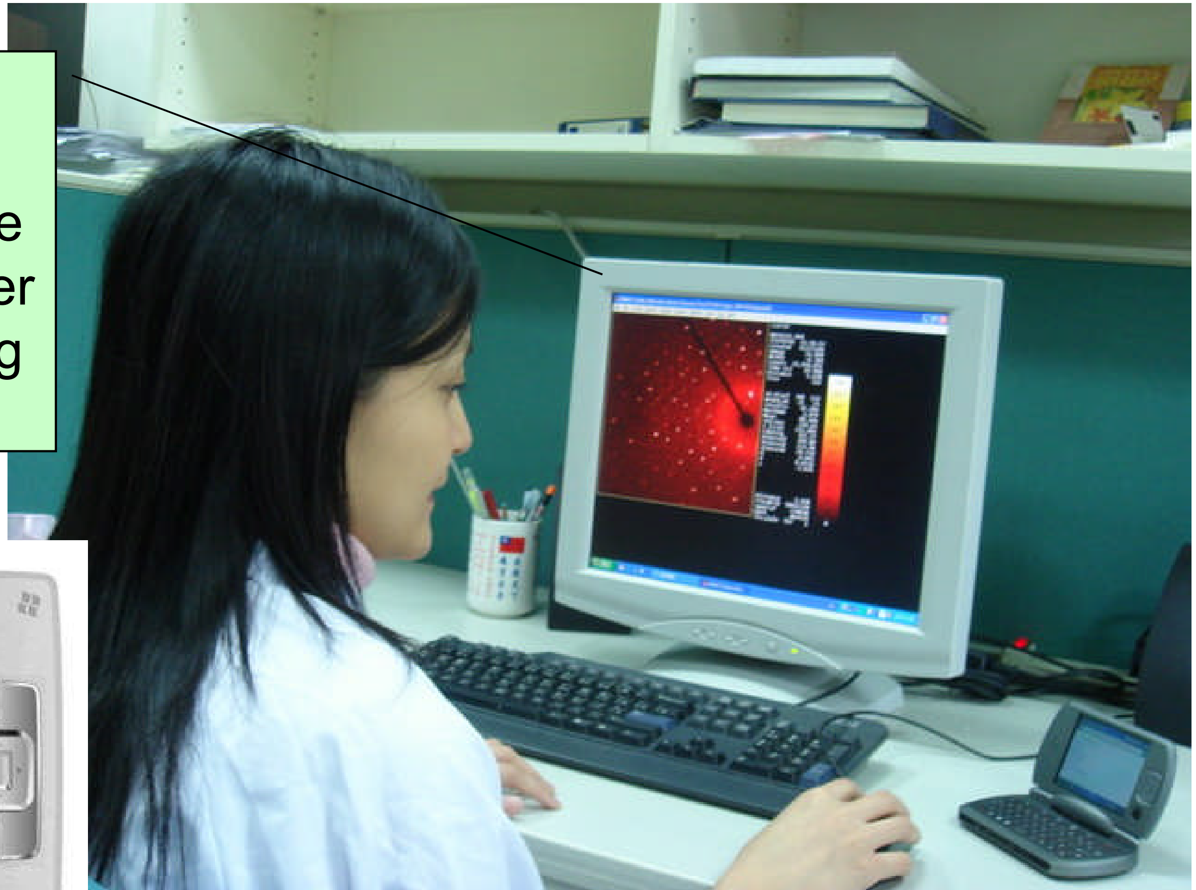
Stage 2: Analyze the crystal by operating the X-ray diffractometer to find the cell constants within acceptable deviation.



This stage is very complex since there are several rules to be followed and various parameters to be considered.

Stage 3: Determine the 3D structure of the crystal-line solid using a special program

The outputs of the program include the shape, the exact distance between atoms, and other parameters for describing the structure.



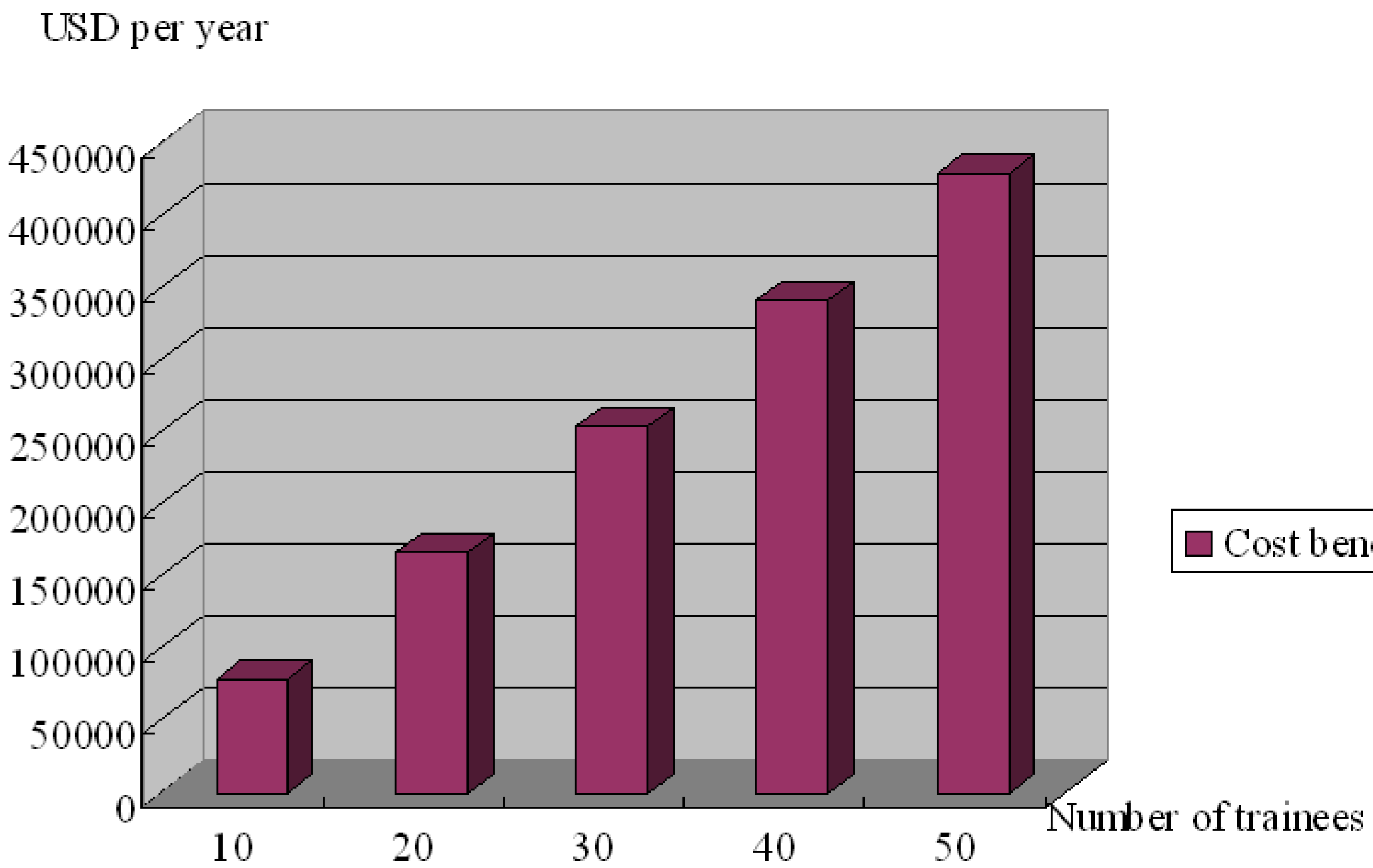
Benefits of the context-aware u-learning approach

- based on the responses from 5 researchers who had 6 months experiences and the system logs of 5 new learners

	Traditional Approach (mean, S.D.)	**U-learning Approach** (mean, S.D.)	**t**
Average number of experiments conducted per week	1.9 (0.55)	8 (2.38)	-5.59**
Number of mistakes made per experiment	2.3 (0.65)	0.32 (0.08)	6.75***
Average time needed to deal with faults in an experiment	2.5 days (0.66)	0.45 days (0.15)	6.77***
Time for fully understanding the operating procedure	5.5 months (1.49)	2 months (0.45)	5.04**

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

Estimation about cost benefit for using the approach



Save 80,000 USD per year for training 10 researchers

Other applications of U-Learning

Learning activity in the Ecology Garden of southern Taiwan

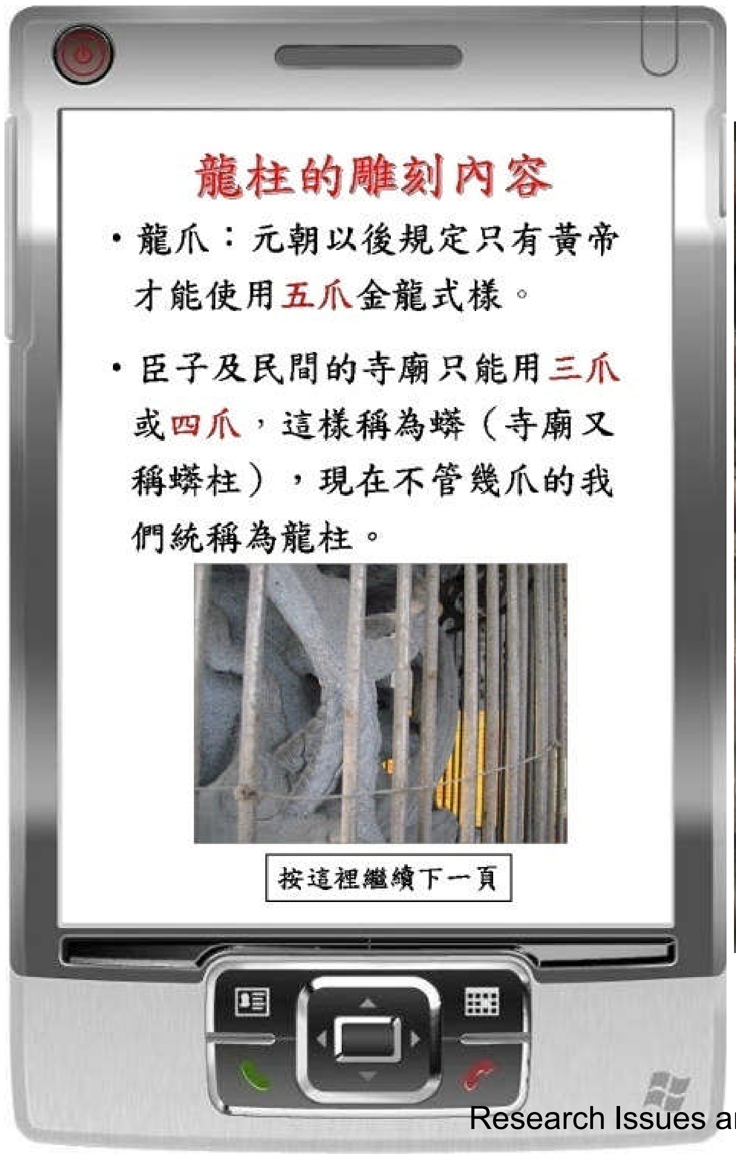
Mangroves, Black-Face Spoonbills and Fiddler Crabs

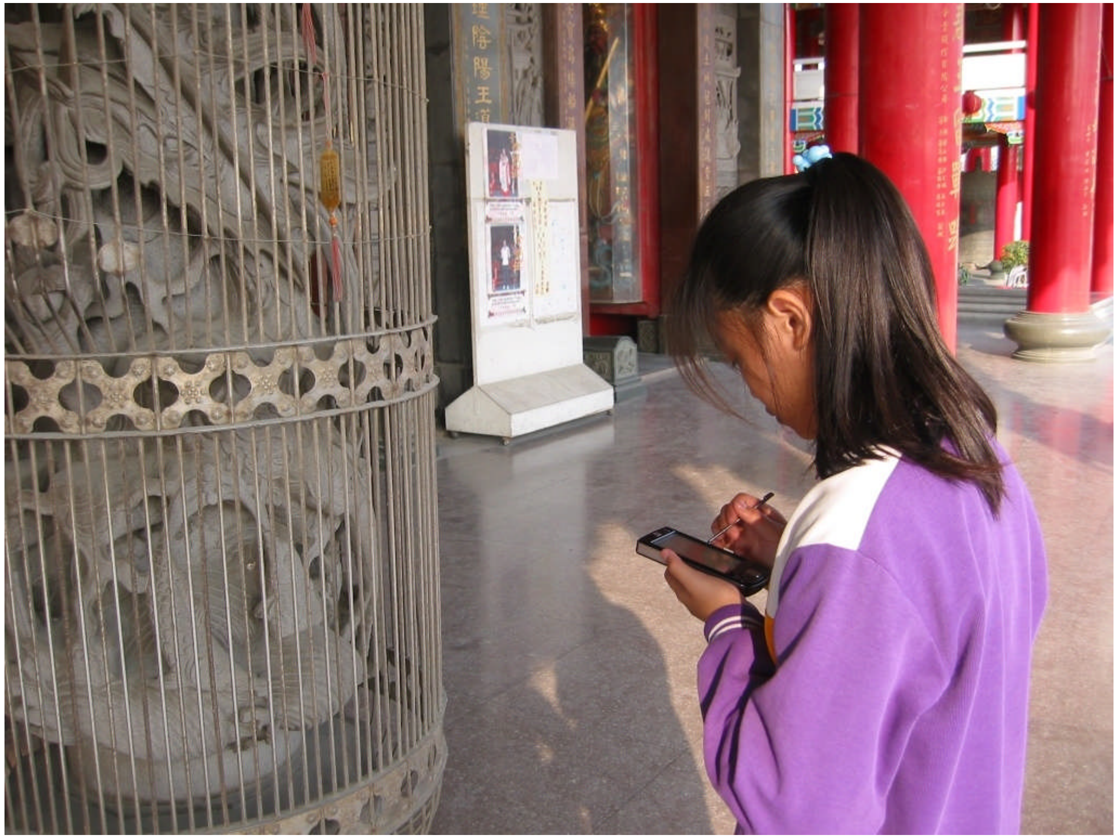
Ecology Park in National University of Tainan

U-learning for Local culture courses

Learning task 1- observe learning targets

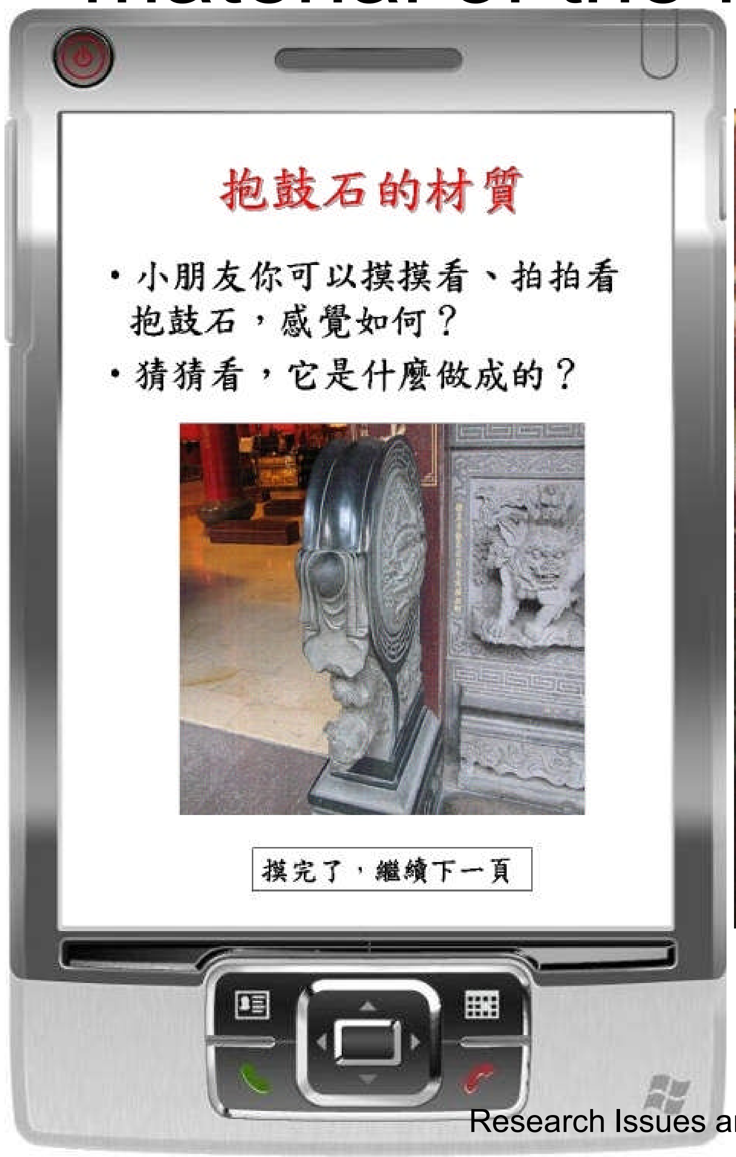
Learning task 2- read the ancient records





Learning task 3- search for supplementary materials for target objects

Learning task 4- to touch and feel the material of the learning targets



Conclusions

- The popularity of mobile, wireless communication and sensing technologies has brought us some new aspects for perceiving education.
- Many issues need to be investigated
  - Design new learning activities
  - Analyze the real-world learning behaviors
  - Develop new learning strategies or tools

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Thank you