

# Do Handheld Devices Facilitate Face-to-Face Collaboration? Handheld Devices with Large Shared Display Groupware

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# A short tour of Graduate Institute of Network Learning Technology & National Central University (NCU)



# A short tour of Graduate Institute of Network Learning Technology & National Central University (NCU)



Technology Enriched Classroom



Teleconference meeting room



# A short tour of previous and on-going research

應用資訊與創意內容 (資訊領域)

Smart Learning Environment Beyond 2020  
後2020之精巧學習環境



### Interactive Learning Classroom

Supporting interactive learning with handheld devices



Providing interactive workspaces with large shared displays



Supporting social presence and tele-presence



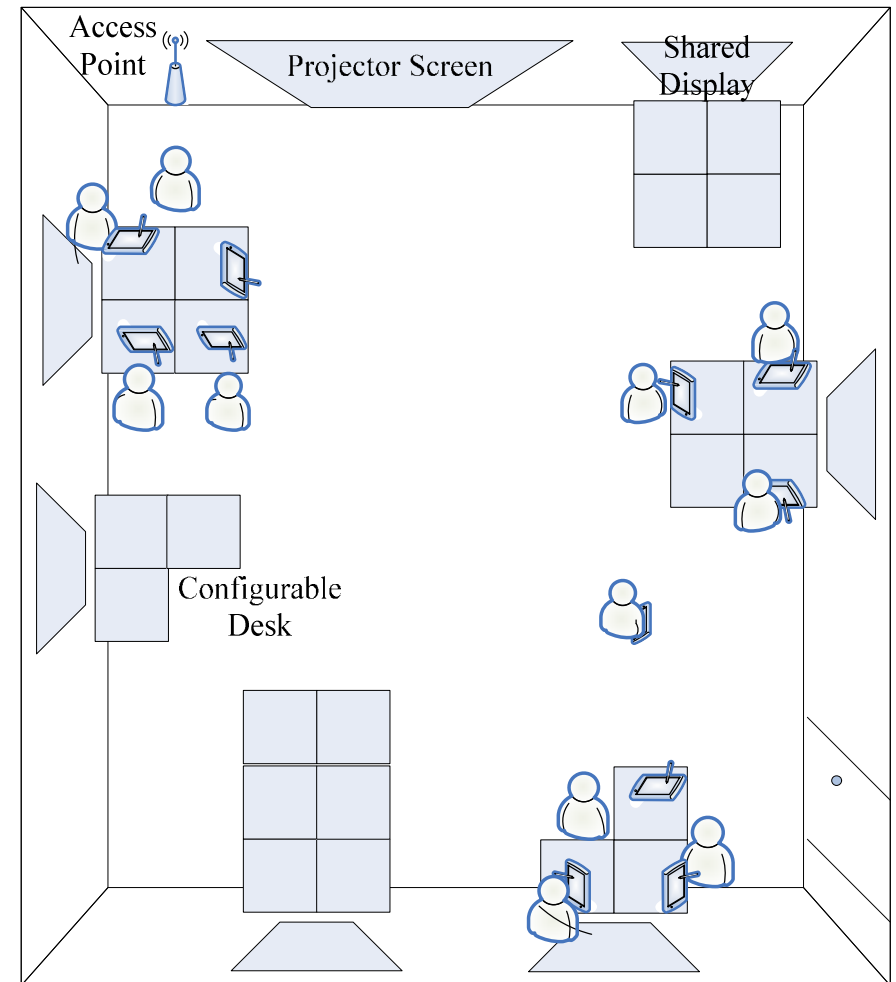
Providing interactive learning supports for students with special needs



- Technology enriched classroom
- Digital games and toys

# Technology Enriched Classroom

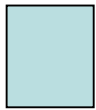
- 1:1 learning environment
- Each student
  - One handheld device such as laptop, PDA, and mobile phone
  - One desk (configurable working space)



# Technology Enriched Classroom

- 1:1 classroom
  - McDonald's Table
  - Configurable working space
    - 1:1 desks

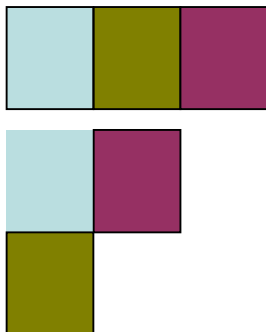
One Desk (Individual)



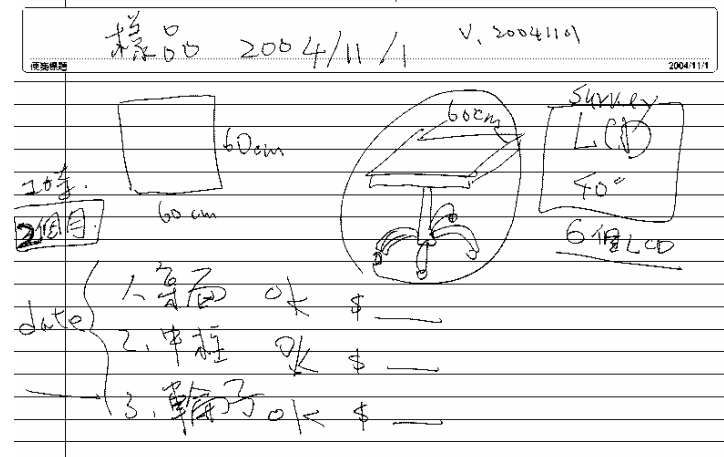
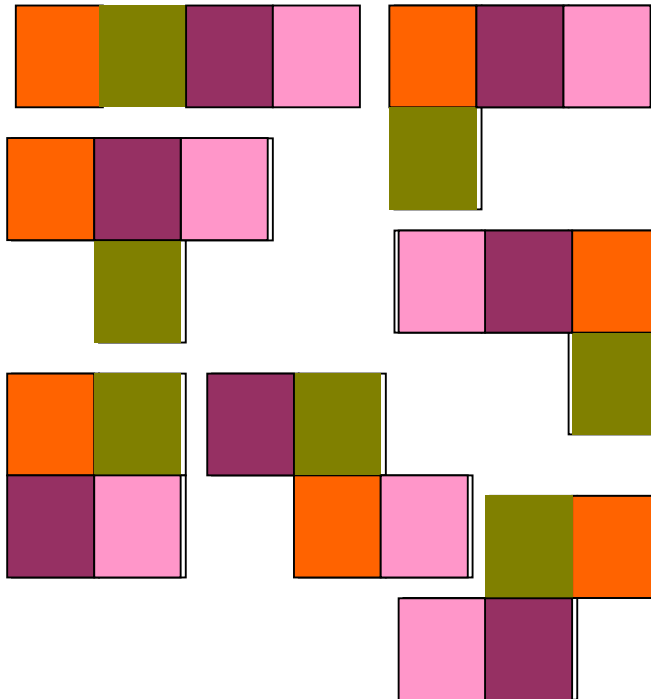
Two Desks



Three Desks



Four Desks





# Technology Enriched Classroom

- Collaboration support
- Formative assessment support
- Tele-presence and social presence support
- Content design for 1:1 learning



# Collaboration Support with Shared-Display

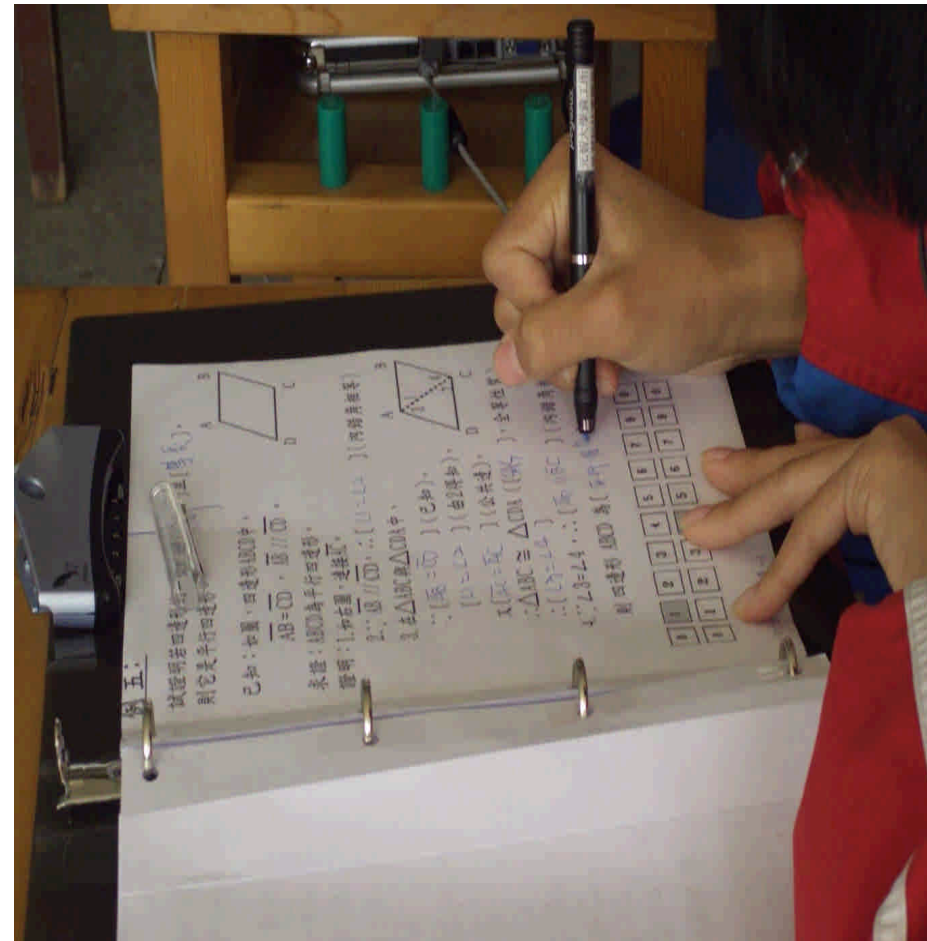
Collaborative learning scenario





# Formative Assessment Support

- Formative assessment Scenario
- Learning with paper-based textbooks instead of computers
- Automatic pen-stroke capture
- Teaching dynamically according to students' reaction



# Formative Assessment Support

Teacher

0 1 2 3 4 5 6 7 8 9

0 1 2 3 4 5 6 7 8 9

$s + p + 3 + p = 14$

$a = b$

$a_3 = 100 - 2p = p + 8 \times 8 = 8s$

$a_3 + 3p = 100$

$a_3 + p_3 = 100$

$a_3 + p_3 = c_3$

DBEE的周長。

$\overline{VB} = e, \overline{VC} = 10$ , 請求出四邊形DBEE的周長。

$\triangle VBC$  三邊中點, 且  $\angle B = 90^\circ$ ,

右圖中, D, E, F 分別為直線

三線堂觀

則  $a_3 + p_3 = c_3$ 。

直角  $\triangle VBC$ , 三邊長  $a, p, c$ ,

3. 求高商.

5-1 行四邊形, 25頁-5

Student page status

老師 ← Teacher

Students 宇軒 麗容 秀玲

雅君 欣婷 育儒 駿昇

View student page content

Choose stylus color

Blue Red Green

Eraser

White1 White2 White3

關閉

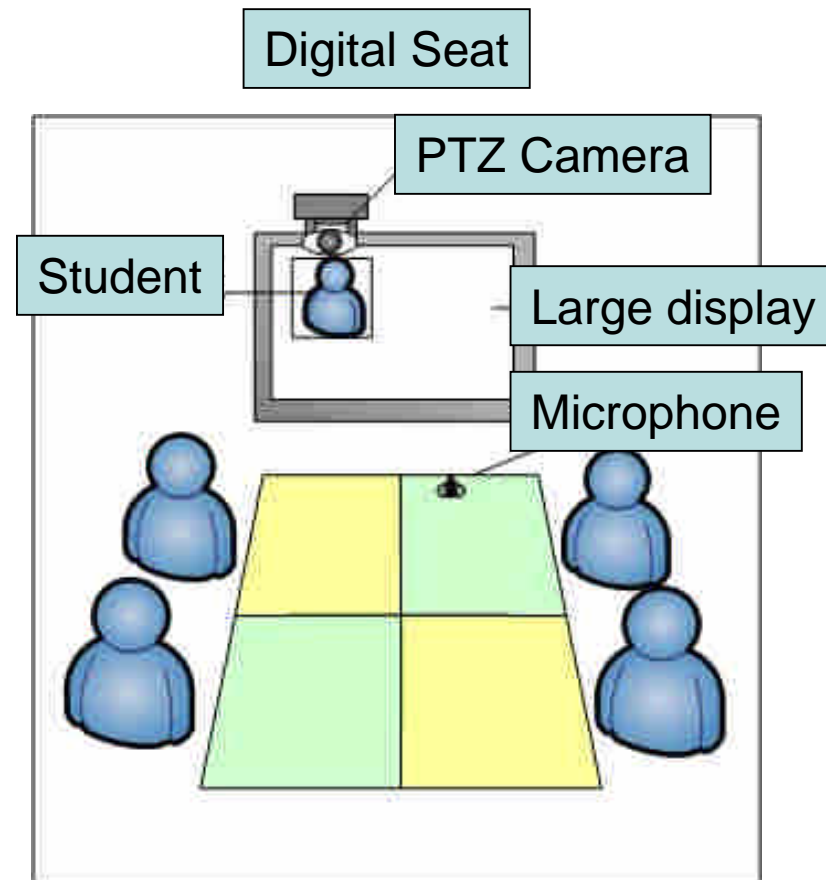
開始 CE HCTDemo Teacher 上午 10:38

# Formative Assessment Support



# Tele-Presence and Social Presence Support

- Distance learning scenario
- Classrooms without walls
  - Where students from any place over the world can join the class very naturally and lively
- Students remotely present themselves in the class through Internet
- Socially contact with other members (e.g. eye contact)
- Digital seats with large display to show student videos
- PTZ cameras for students



# Tele-Presence and Social Presence Support



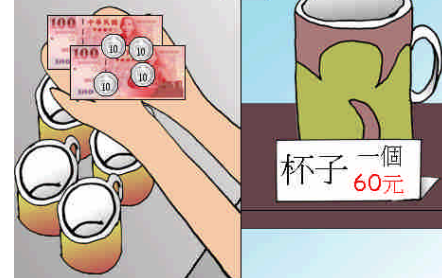
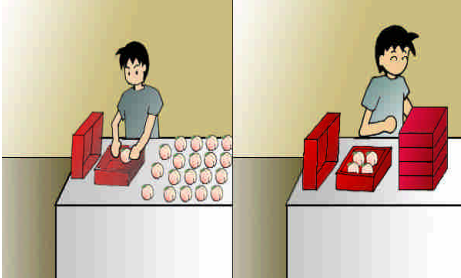
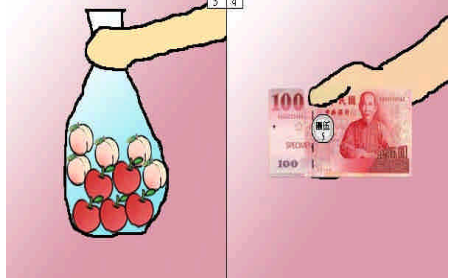
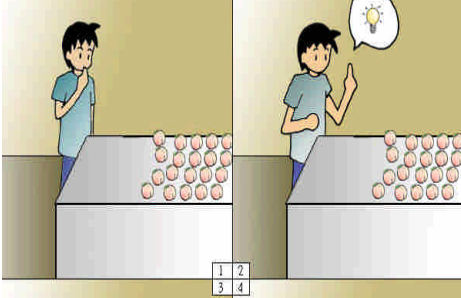
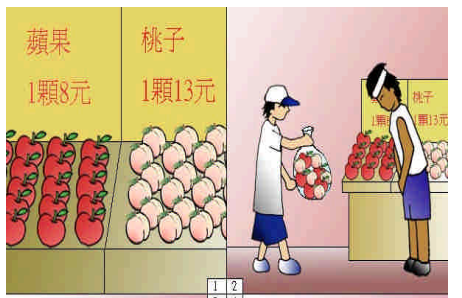
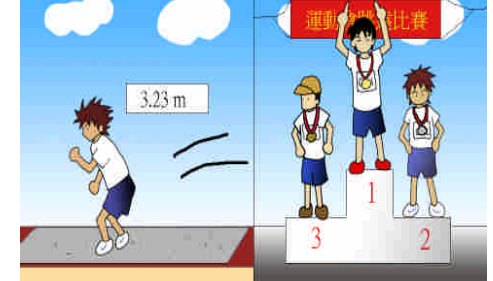
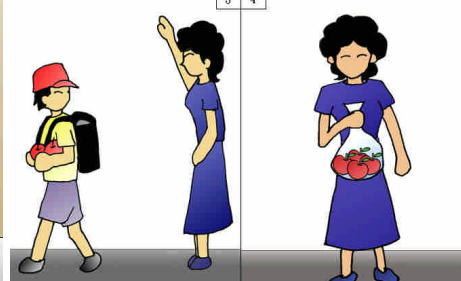
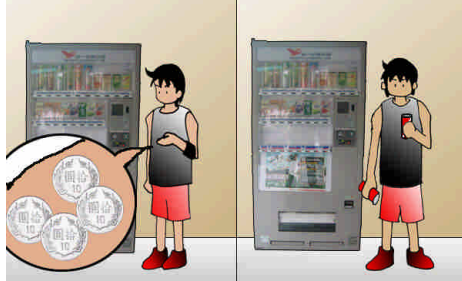
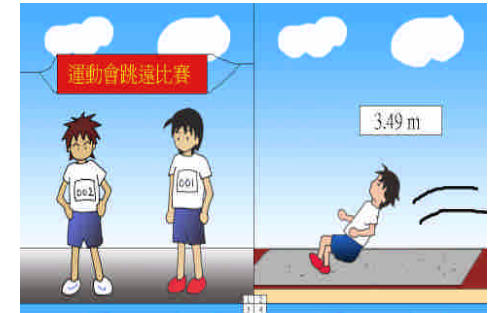
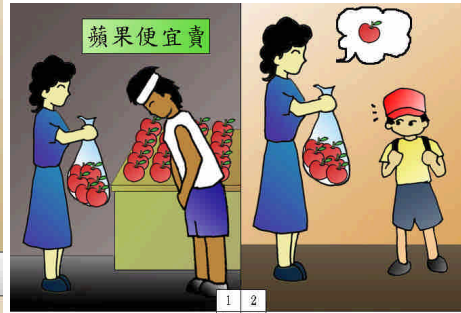
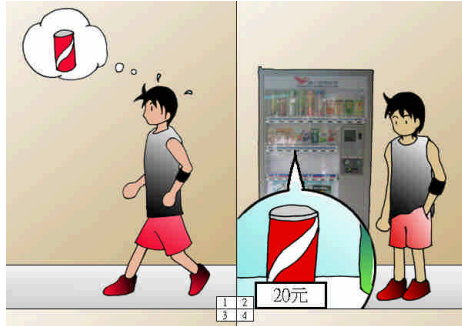




# The Content Design for one-to-one learning

- A collaborative learning Scenario
  - Small screen of handhelds
  - Authentic problems for children to learn
    - Real world problems, e. g. time management, comparison, commercial activities
    - Teaching or learning outside the classroom is not always economically feasible.
  - How should we design learning content on PDAs and bring the context of authentic problems into the classroom?

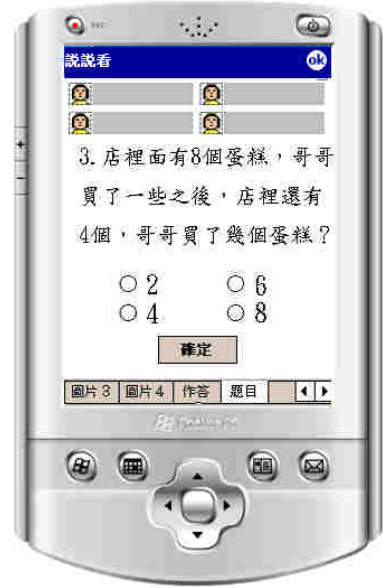
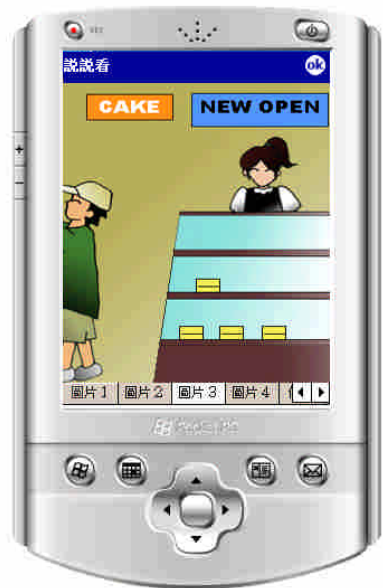
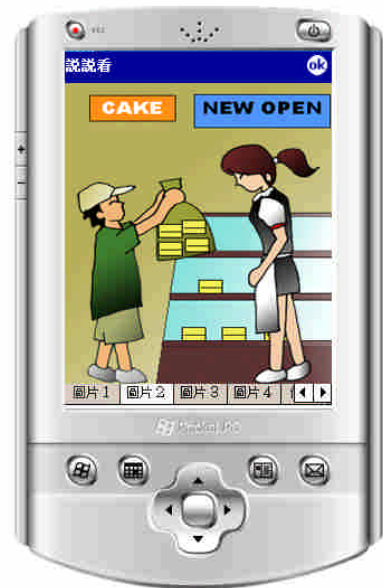
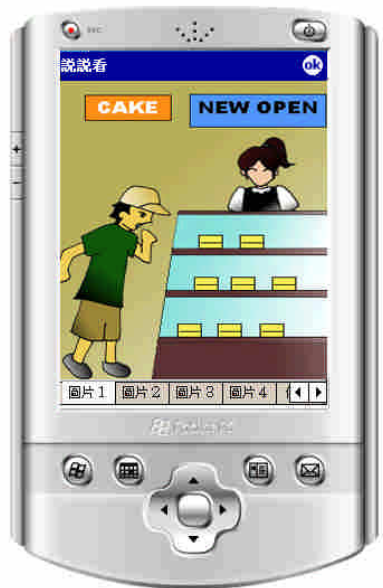
# Over 30 Four-frame comic strips



# The Content Design for one-to-one learning

- Benefits of comic strips
  - Being fit for PDA size
  - Reading difficulty (for some students with special needs)
  - Meaning making, Articulation and Collaboration
  - Teachers' adoption
    - Accessible at hands instead of complex technologies

# Problems embedded in comic strips



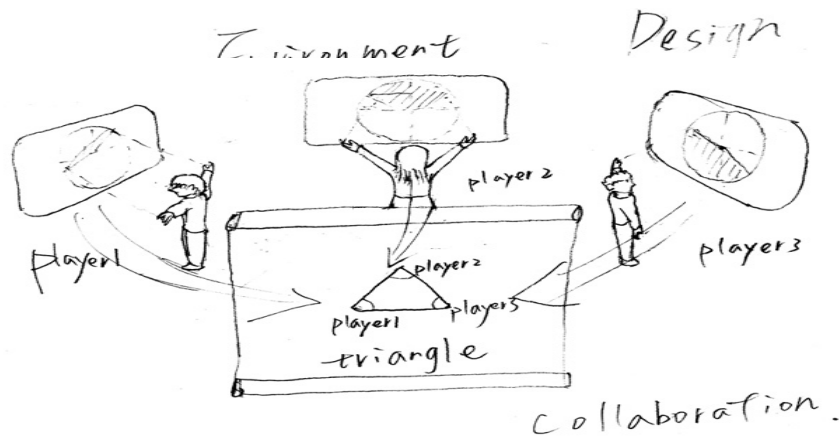
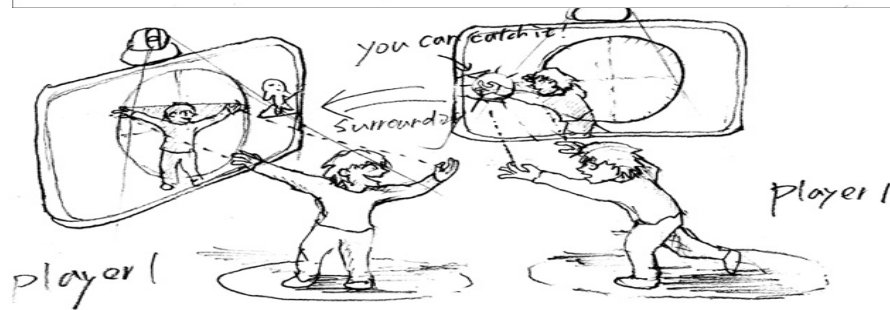
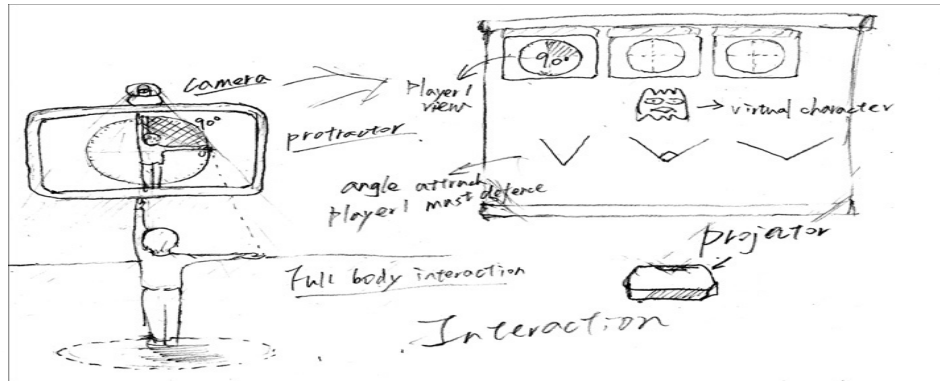




# Digital games and toys



# Full-Body Interaction Game



- Interacting with computers with bodies (with wristbands)
- Moving around the game environment (distributed servers)
- Collaboration for achieving group goals



# Story creation, sharing and telling

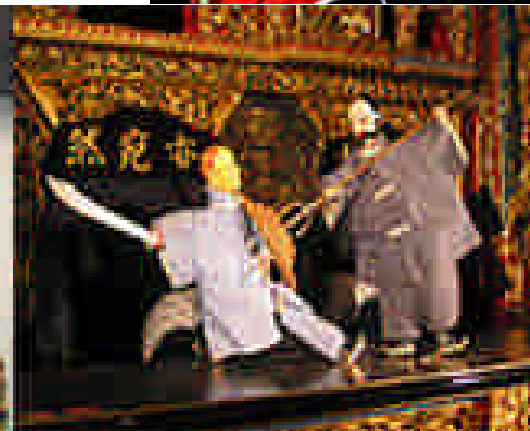
- Most stories live in only story books or in the mind of the person who tells it.



Died in 1998  
(aged 89)



Died in 2007  
(aged 107)



# Story creation, sharing and telling

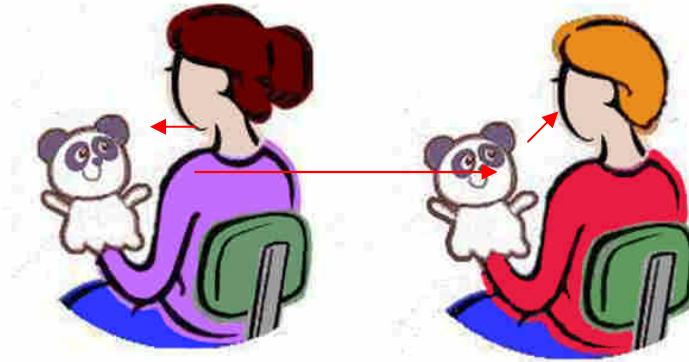
- Making stories to be created, shared, and presented in a lively way.

Storytelling puppet

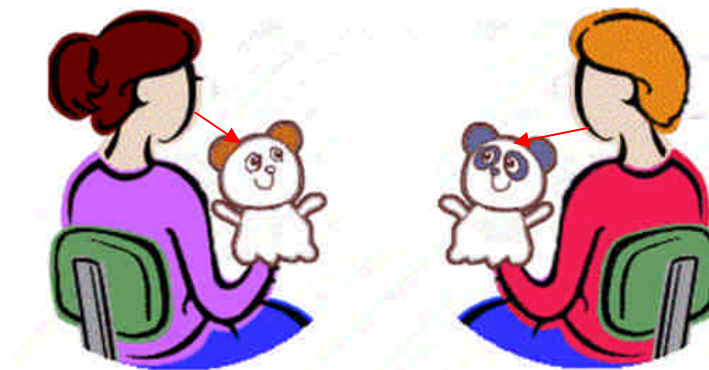




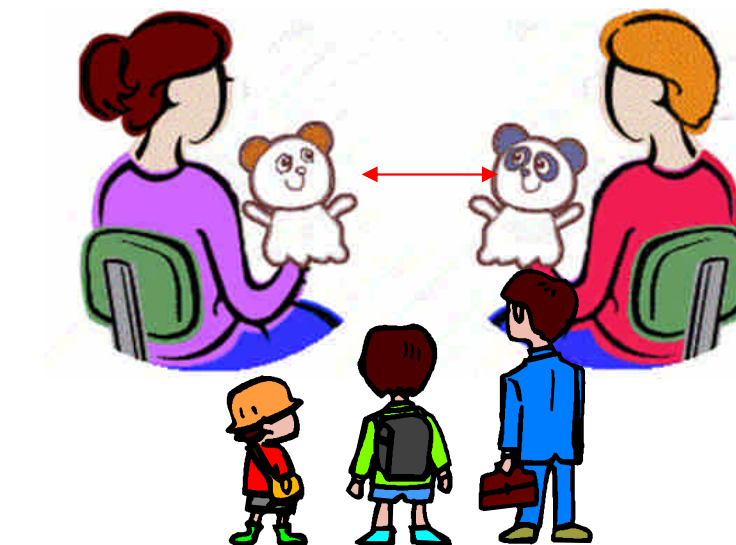
Story Sharing



Collaborative  
Story Creation



Story Telling



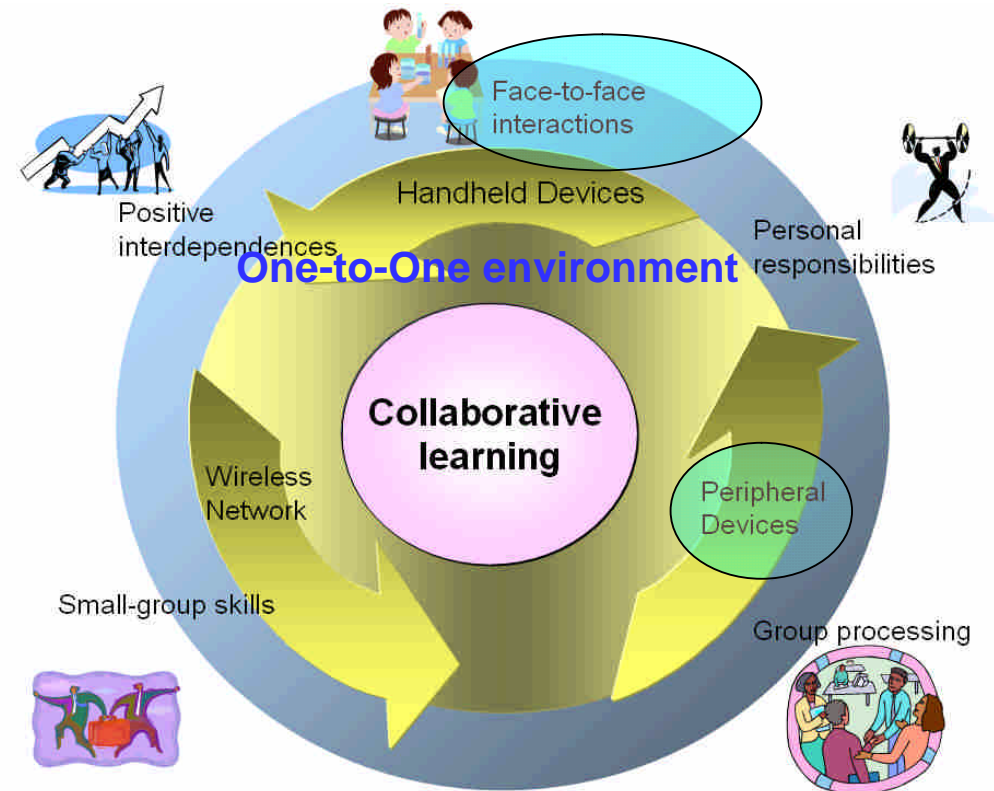




Do Handheld Devices Facilitate  
Face-to-Face Collaboration?  
Handheld Devices with Large  
Shared Display Groupware

# Collaboration with Handheld Devices

- Key guidelines to successful cooperative learning (by Johnson and Johnson)
- One-to-one (1:1) environment can facilitate cooperative learning since students can bring handheld devices fitted with wireless communication capabilities into classrooms. (G1:1 website)
  - PDAs, Tablet PCs and Wireless network can enhance face-to-face interactions.
  - Peripheral devices: Camera, Display, Printer



# Collaboration with Handheld Devices



- The screens of handheld devices, being designed for individual-user mobile application, limit promotive interaction among groups of learners.
- The lack of shared displays may lead to **loss of eye-contact and unawareness of visual focus**. (by Scott et al. 2004)
  - Students can not conveniently **share information and discuss** with non-adjacent partners.

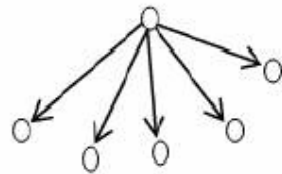
# Some design considerations

- Gibson (1977) affordances: ‘opportunities for action’  
Kirschner and Kreijns (2003)
- Norman (1999) related **affordance and constraints**
  - “Physical constraints make some actions impossible: there is no way to ignore them. Logical and cultural constraints are weaker in the sense that they can be violated or ignored, but they act as valuable aids to navigating the unknowns and complexities of everyday life. As a result, they are powerful tools for the designer.”
- The environment with different technological settings will **provide different educational affordance** in collaborative learning context.

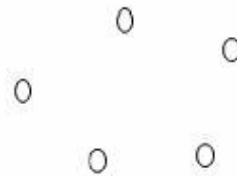
# Some design considerations

- Handheld devices facilitate **personal work, coordination** and provide **mobility** for new scenario of collaborative learning.
- On the contrary, the large display devices create **a workspace for student groups to cooperate and work** on complex tasks.
- The **discussion behavior in the small group meeting**:
  - The desire for projectors or large displays represents a logical and cultural constraint (pp. 41, Norman, 1999) indicated that “the current choice is an intelligent fit to human cognition, but there are alternative methods that work equally well.”
- **Bridging the two different devices**

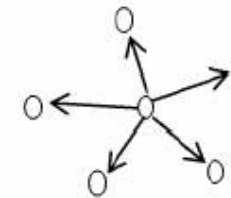
# Some design considerations



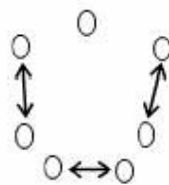
Unresponsive



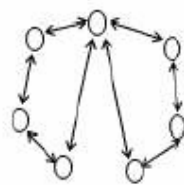
Unsocial



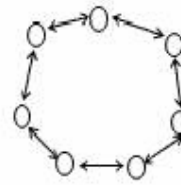
Dominant leader



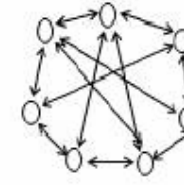
tête-à-tête



Fragmented, cliquish



Stilted



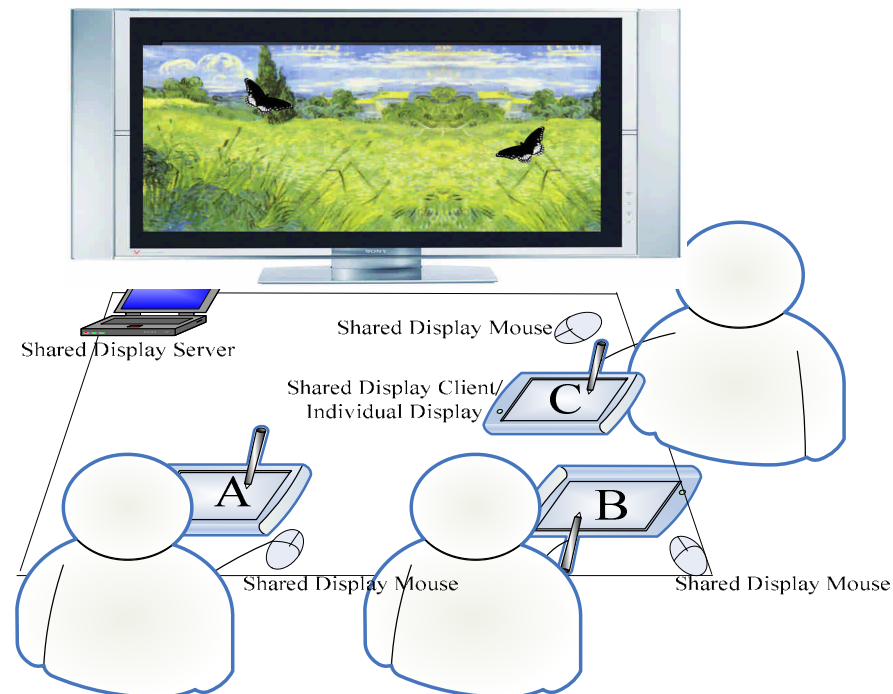
Ideal

Milson's group communication patterns (1973)



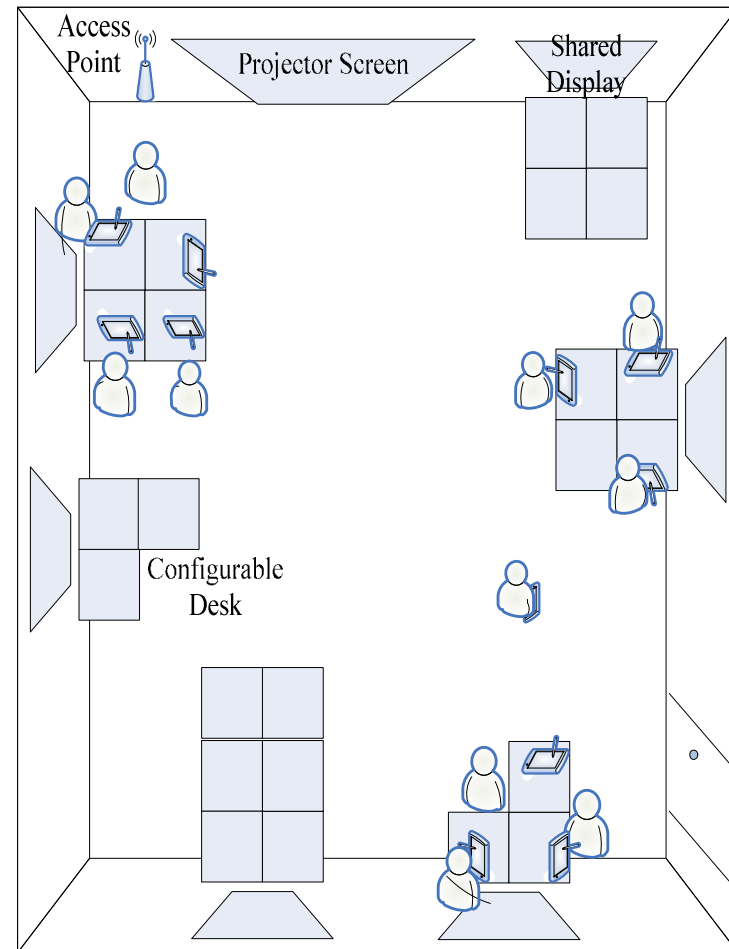
# The Research Question

- How peripheral equipment such as **projectors and LCD screens in classrooms** can augment handheld devices to support efficient and lively collaborative learning ?



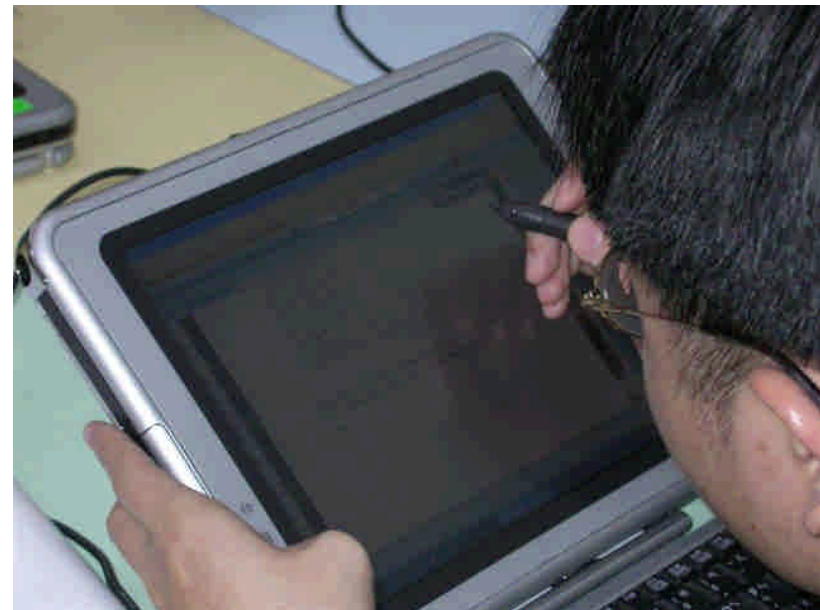
# One-to-one collaborative classroom

- This study developed a **one-to-one collaborative classroom**.
- The classroom contains **six workspaces**.
- Each group workspace was equipped with a **LCD shared displays**.
- Students can **freely move to a workspace** and login the shared display groupware at the workspace.
- Students not only work within their handheld devices but also **share complicated diagrams, procedures and statements** using shared display groupware.



# Collaborative Learning Scenario with Shared Display

- Students collaboratively learn in **Thinking-Pairing-Sharing (TPS)** (Lyman, 1981) learning activity **using Tablet PCs**.
  - Thinking Stage: Student used Tablet PCs to **complete their individual answers**
  - Pairing-Sharing Stage: students shared their individual answers with their group partners and **complete a common group answer**.



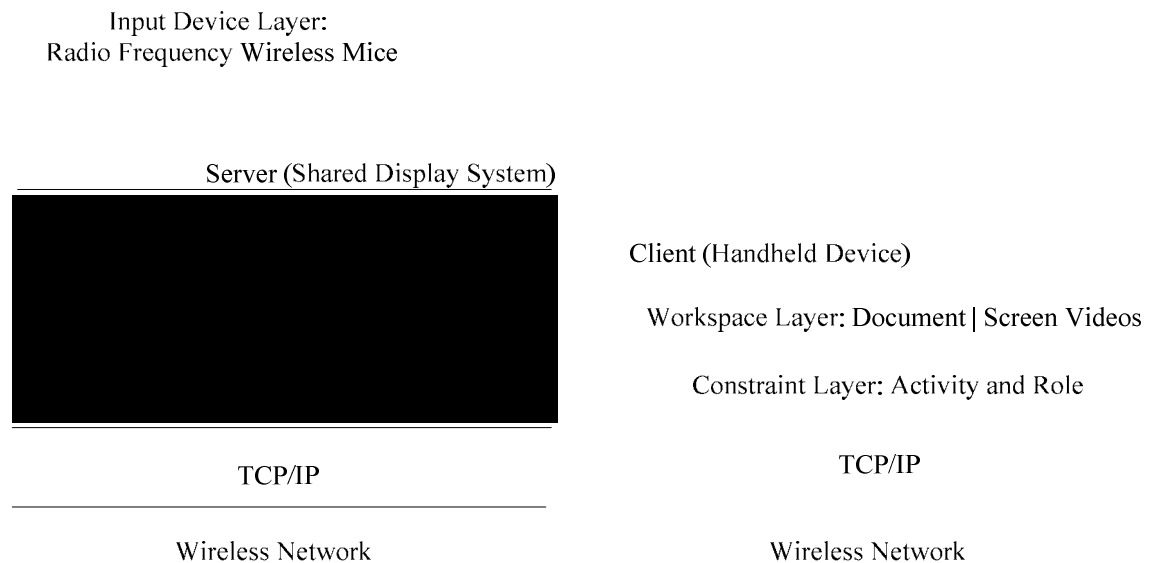
# The Shared Display Groupware

- Shared display groupware can facilitate collaboration by promoting shared understanding of the workspace and increasing awareness of partner actions.
  - mobile note taking and meeting (Paek et al. 2004)
  - promoting informal cooperation
  - Presentation (Errod, 1999)
  - Learning (Scott et al. 2004)
  - Collaboration (Divitini, 2004)



# The Shared Display Groupware

- Client-Server Architecture
- TCP/IP connection on Wireless network
- Three Layer



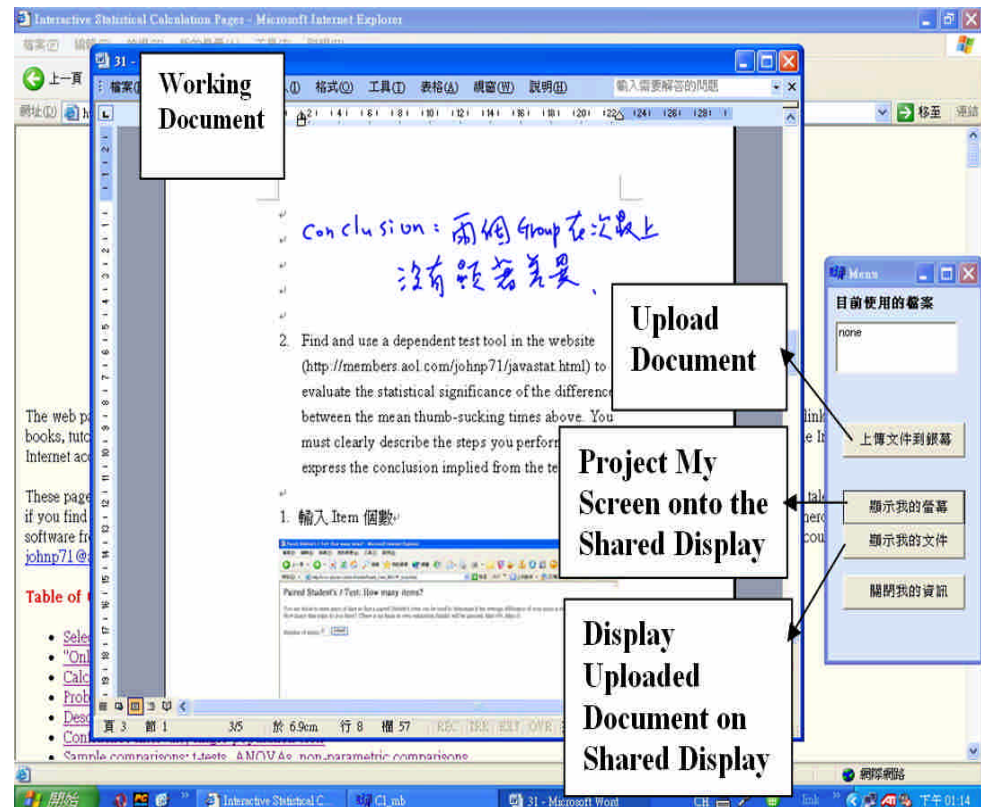
# The Shared Display Groupware

- Constraint Layer
  - Enforcing activity constraints
    - The shared display groupware cannot display individual answers until all students have uploaded their individual answers



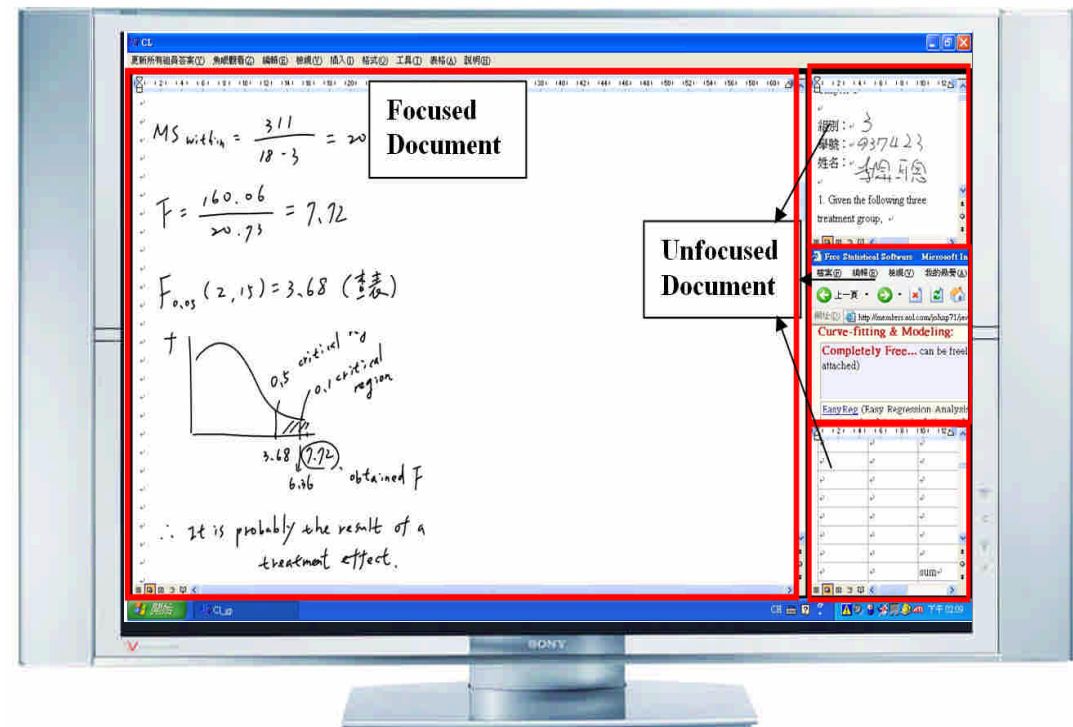
# The Shared Display Groupware

- **Workspace layer**
  - uploading individual answers in individual handheld devices and displaying the documents on the shared display.
  - supporting simultaneous screen video projection from individual handheld screens to the shared display via the wireless network.

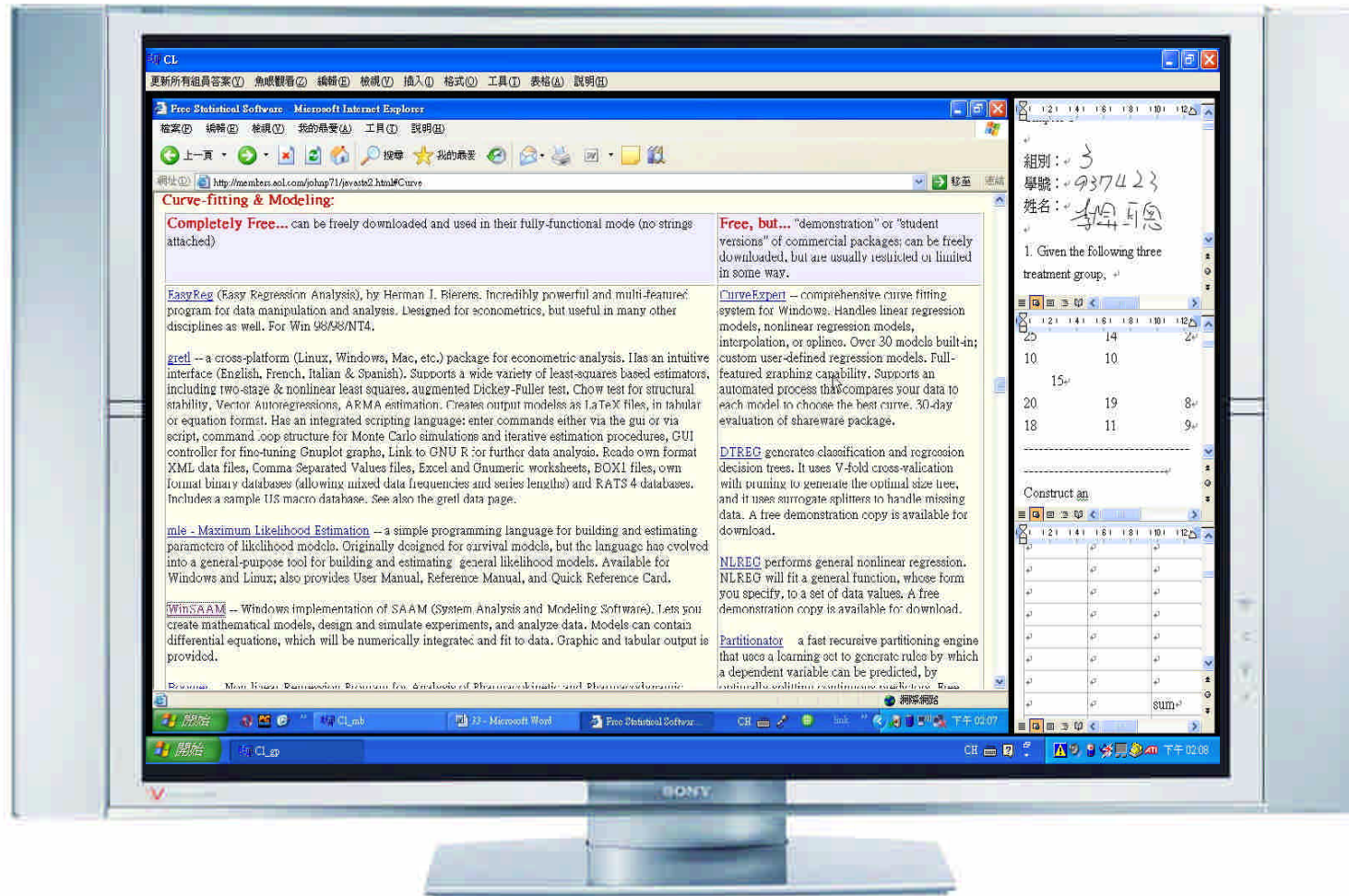


# The Shared Display Groupware

- **Presentation layer**
  - displaying the workspace properly to support group collaboration
  - displaying all the individual answers of students with equal size
  - too crowded to allow students to clearly view all the displayed answers.
  - using fish-eye layout in which only the focused document is enlarged while others are shrunk on the shared display.

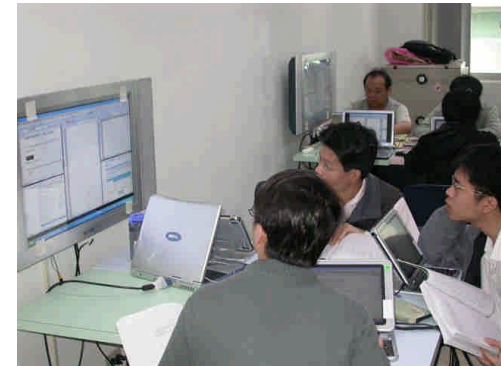
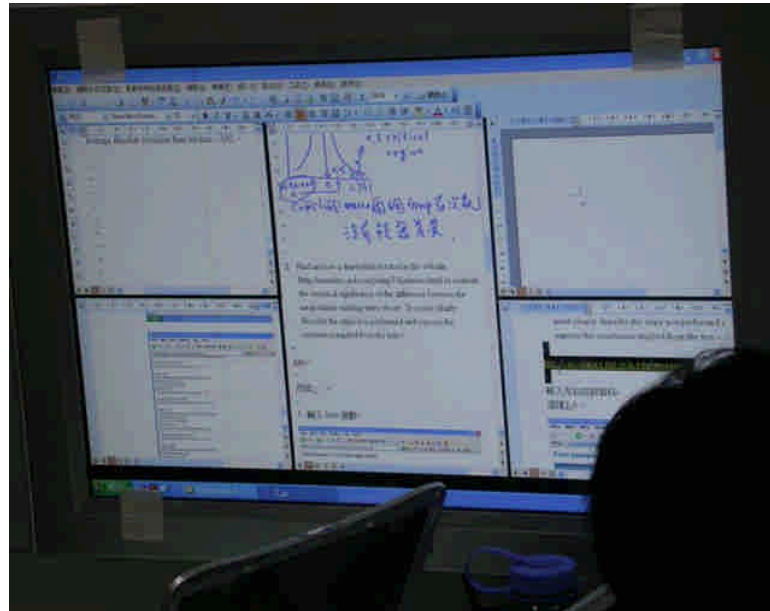
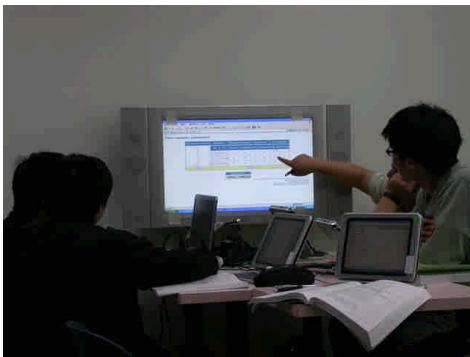


# The Shared Display Groupware



# The Shared Display Groupware

The sharing activity with shared display groupware



# A Comparative Evaluation

- Thirteen graduate students enrolled in a *Statistics and Data Mining Techniques* course
- Comparing student reactions in three settings
  - Tablet-PC-Only setting,
  - Network-File-Sharing setting (Tablet PC with network file sharing) setting,
  - Shared-Display (Tablet PC with shared display) setting



# A Comparative Evaluation

- Tablet-PC-Only Setting
  - Students used **only Tablet PCs** to complete and share their individual answers and complete a common answer.





# A Comparative Evaluation

- Network-File-Sharing setting
  - Students can view the answers of others on their own Tablet PCs through the wireless network and application programs.

The screenshot shows a Tablet PC interface with a document containing handwritten answers and mathematical calculations. The top menu bar is highlighted with a red box. The document content includes:

1. Under what circumstances would a researcher hope to attribute a difference...  
 $H_0$ ? When would  $H_1$  be a more welcome explanation?  
•  $H_1$ : 虛無假設, 表示沒有顯著差異  
•  $H_0$ : 對立假設, 表示有顯著差異

2. The 120 students who responded to the academic cheating survey showed a mean age of  $\bar{X} = 22.7$  and a standard deviation of  $s = 15.2$ . The mean age of the student body population was 25.7. Use Equation 6.1 to compute the test statistic  $t$  for these data.  
• 
$$\frac{22.7 - 25.7}{\frac{15.2}{\sqrt{120}}} = \frac{-3}{1.387} = -2.162$$

3. Use Equation 6.2 to compute  $\chi^2$  for the data presented in Comprehension Check 6.21.  
• 
$$\frac{(18 - 5.564)^2}{5.564} + \frac{(40 - 35.334)^2}{35.334} + \frac{(175 - 88.738)^2}{88.738} + \frac{(90 - 82.028)^2}{82.028}$$
  
• 
$$+ \frac{(25 - 35.334)^2}{35.334} + \frac{(2 - 5.564)^2}{5.564} = 33.894$$

4. Use Equation 6.2 to compute  $\chi^2$  for the data presented in Table 6.1.  
• 
$$\frac{(101 - 72)^2}{72} + \frac{(19 - 48)^2}{48} = \dots$$

A red box highlights the text "Others' answers" in the center of the screen.



# Communication Behavior -- Tablet-PC-Only



- Students naturally communicated with their partners who **sat closest to them**.
- Students must **crowd together** to view the Tablet PCs of their partners.
- [Video](#)
- Students did not share common **visual focus** while discussing.
- They have to **guess others' visual focus**.

# Communication Behavior

-- Network-File-Sharing



- Students view the answers of others **on their own Tablet PCs**.
- Students must **turn to others' Tablet PCs** to know the locations their partners are referring to.
- Video
- Students frequently used **"location indicators"** such as "LEFT" and "RIGHT" while explaining their answers.
- They have to **guess others' visual focus**.

# Communication Behavior

-- Shared-Display



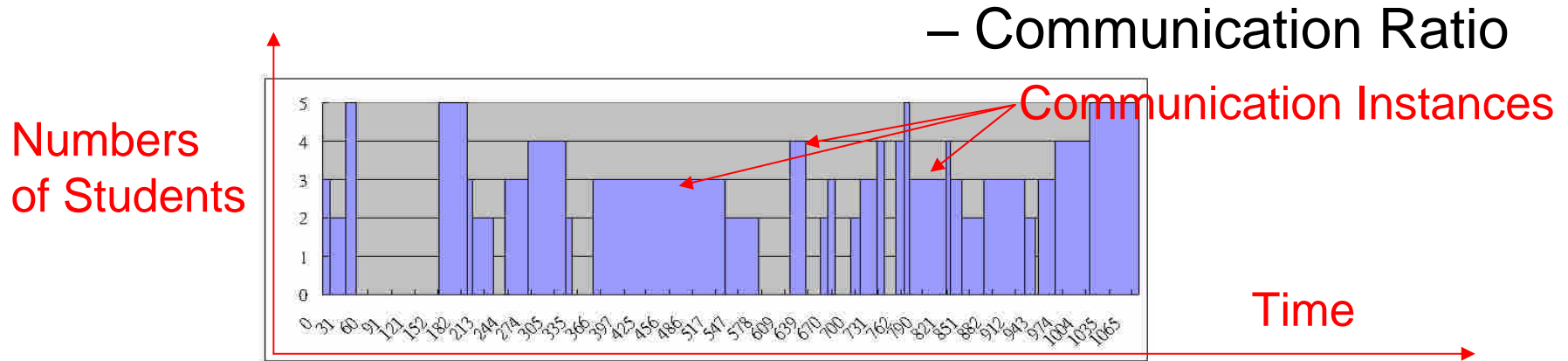
- Students frequently **used their hands** to refer to individual answers on the shared displays
- Students were **attracted to the shared displays.**
- [Video](#)
- They continued watching the shared displays and listening to the expressions of their partners.

# Shared-Display with PDAs



- Students used PDAs to search statistical tools on the Internet.
- Students then used Virtual Network Computing (VNC) software to manipulate statistical tools on the shared display.
- Students frequently used their hands to refer to the information on the shared displays.
- [Video](#)

# Quantitative results



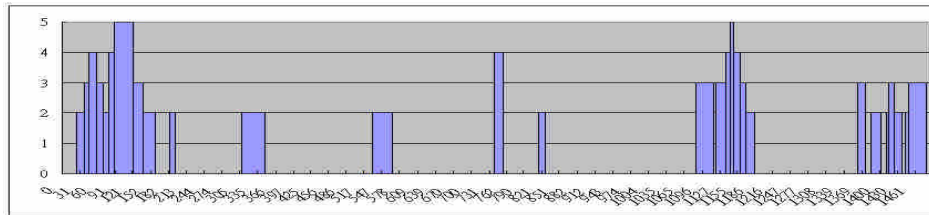
- Videos were analyzed and codified into **communication sequence diagrams**
  - Each bar in the diagrams represents a communication instance
  - Y-axis indicates how many students involved in a communication instance
  - X-axis indicated how long many seconds does a communication instance last.
- **Participation ratio** represents the level in which **all group members were attracted to the group discussion activity**.

$$\sum_{\text{Communication Instance } i} \frac{\text{Period}(i) * \text{Participated}(i)}{\text{Period}(i) * \text{group size}}$$

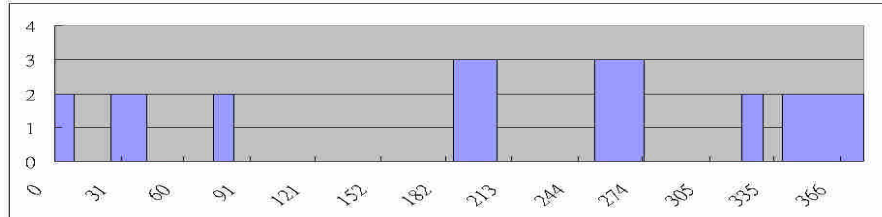


# Quantitative results

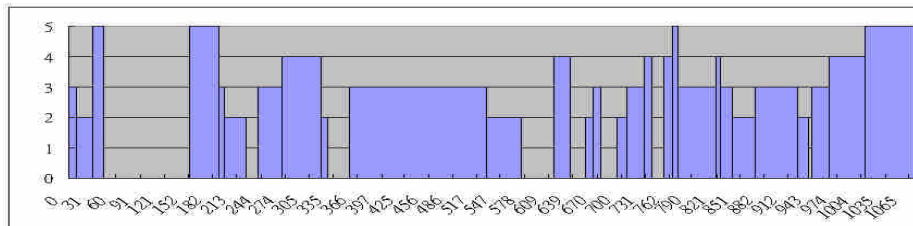
## Tablet-PC-Only setting



## Network-File-Sharing setting



## Shared-Display setting



- In the Shared-Display setting, students demonstrated **higher communication ratio**, because students continued watching the shared displays and listening to the expressions of their partners.
- However, in network-File-Sharing setting, students spent most of time on checking others' answers on their own Tablet PCs, and demonstrated **lower communication ratio**.

# Quantitative results

## Communication Ratio

	Group 1	Group 2	Group 3
Tablet-PC-Only	0.573	0.762	0.932
Network-File-Sharing	0.585	0.509	0.745
Shared-Display	0.634	0.87	0.93

# Quantitative results– Hand pointing behavior

- Students displayed more frequent pointing behavior in the environments with shared displays.
- The result reflects that shared displays enable students to interact with one another actively.

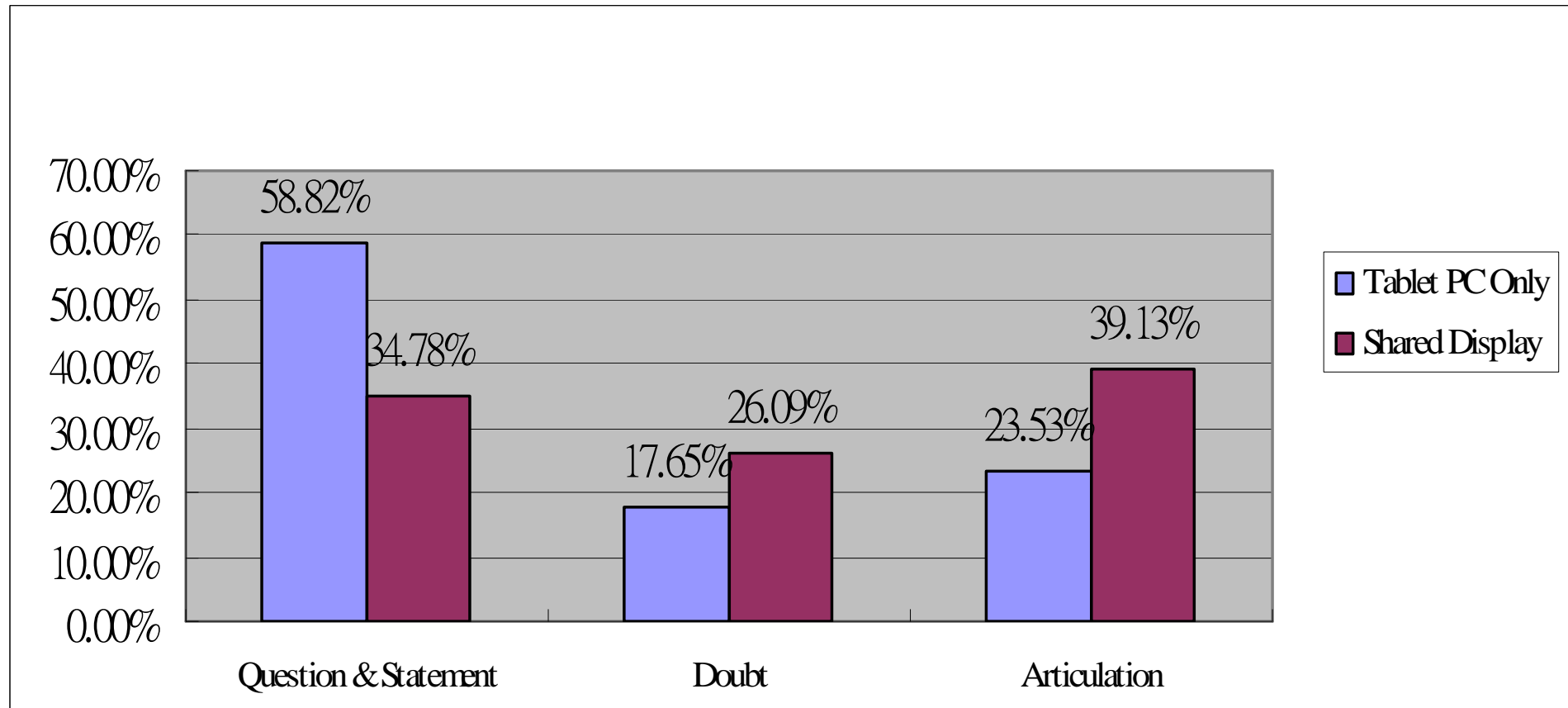
	Group 1	Group 2	Group 3
Tablet-PC-Only	19	6	8
Network-File-Sharing	2	7	0
Shared-Display 1	12	42	10
Shared-Display 2	25	40	13

# Quantitative results– Eye Contact behavior

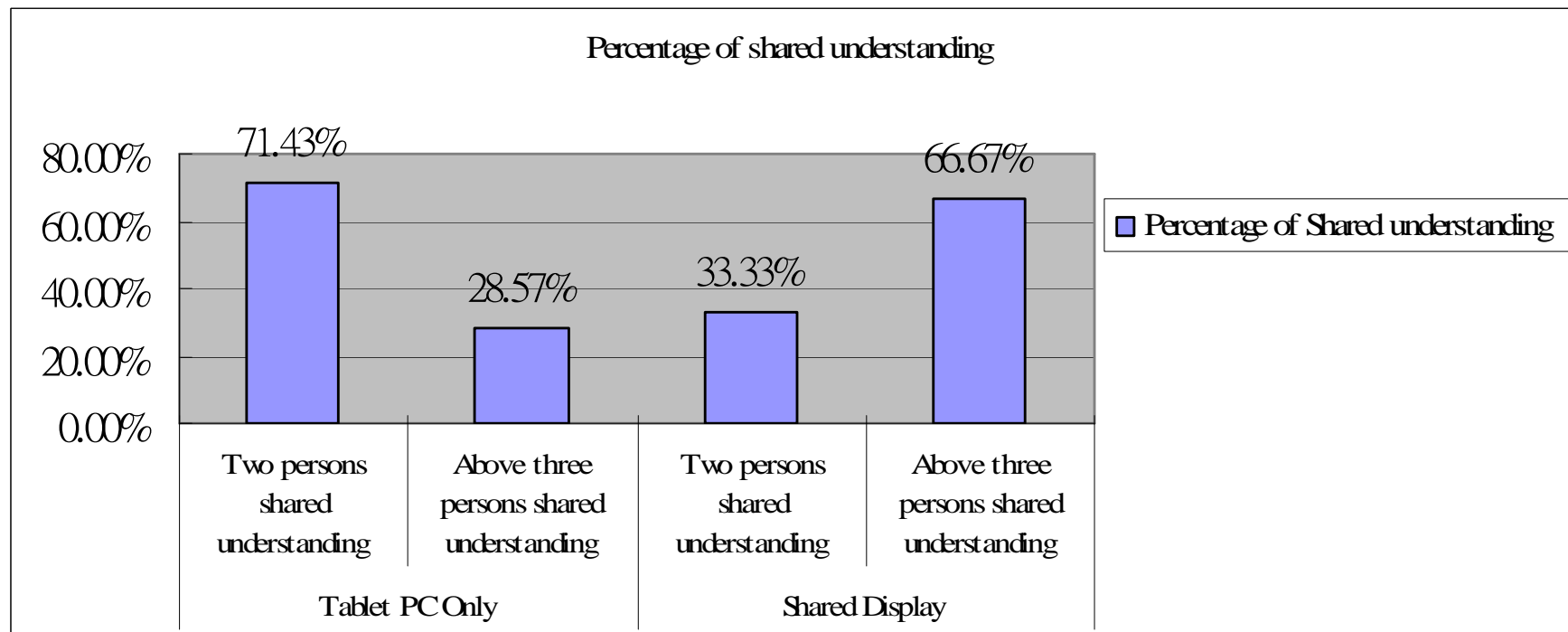
- **In the Tablet-PC-Only environment:** Students demonstrated high eye contact frequency since they had to take note of the visual focus of their partners and refer to information in the Tablet PCs of other individuals.
- **In Network-File-Sharing environment:** Most students focused completely on their own Tablet PCs and did not notice the non-verbal signals of their partners.
- **Shared-Display environment:** Students were attracted to the shared displays and continued watching the shared displays

	Group 1	Group 2	Group 3
Tablet-PC-Only	79	73	77 High
Network-File-Sharing	20	34	7 Low
Shared-Display 1	31	66	23
Shared-Display 2	32	31	16 Low

# Divergence Analysis



# Shared Understanding Analysis





# Quantitative results– Student Questionnaire

- A questionnaire revealed that the Shared-Display scores significantly exceed the Tablet-PC-Only scores and Network-File-Sharing scores.
- The questionnaire result indicates that shared displays are effective in improving communication in collaborative learning activities.

<b>I am aware of the visual focus of my partner.</b>	<b>4.29</b>	<b>-3.24</b>	<b>&lt;.01</b>
	<b>2.36</b>		
<b>I know what my partner is referring to in individual answers.</b>	<b>4.07</b>	<b>-3.27</b>	<b>&lt;.01</b>
	<b>2.5</b>		
<b>My partners know where I refer to in individual answers.</b>	<b>3.93</b>	<b>-2.85</b>	<b>&lt;.01</b>

# Concluding Remarks

- Resources demanded
  - In addition to the resources available around their workspace such as textbooks and notebooks, students demonstrated [the demand of accessing resources on the Internet](#) as a support for complete group tasks during discussion
  - There is a strong demand to support students to discuss and [shared their experiences in accessing the Internet](#) as they collaboratively worked on open-ended questions.
- Workspace transfer during group work
  - private-to-private: from a private space (a handheld device) to another private space ([file sharing or screen projection on personal devices through networks](#))
  - private-to-public: from a private space to public space ([from a laptop screen to a projector or shared-display](#))

# Concluding Remarks

- The proposed shared display groupware attracted group members to **enhance communication patterns**.
- The groupware also **promotes a shared understanding** of the workspace and increases awareness of the actions of partners.
- The shared displays enable group members to participate closely in shared activities and **establish ideal communication patterns achieving effective collaboration**.

# Interaction Technology and Learning (ITL Lab)

- 5 PHD. Students
- 11 Graduate Students