포항공과대학교
산업경영공학과

Ergonomic Design
Technology Lab

Development of a Comprehensive Usability Testing and Analysis Protocol for Ergonomic Product Design

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- Research objectives
- 3-step approach
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Background

- Getting importance of user-friendly product development
  ⇒ Required **easy** of use, **comfortable** and **satisfactory** interface
  (Jordan, 1996; Abras et al., 2004; Courage and Baxter, 2005)

- Short-term lifecycle of product development & high competition
  ⇒ Required **quick**, **simple**, and **comprehensive** evaluation on product development companies (Hartson et al., 1996; Butler, 1996)

  ⇒ for quick evaluation: Subjective testing > Objective testing
  ⇒ for simple evaluation: Quantitative testing > Qualitative testing

Classification of usability evaluation methods

- **Type of information collection**
  - Qualitative evaluation vs. Quantitative evaluation
- **Type of collected data**
  - Subjective evaluation vs. Objective evaluation
- **Scope of evaluation**
  - Comprehensive evaluation vs. partial evaluation

Type of information collection

- **Qualitative evaluation**
  - Descriptive information of opinions or insights
  - Methodologies: interview, heuristic evaluation, observation, questionnaires, think aloud

- **Quantitative evaluation**
  - Quantified opinions
  - Methodologies: measurement, scaling (e.g. Borg's CR-10), scoring

Type of collected data

- **Subjective evaluation**
  - Participants' opinions, experimenters' insights
  - Methodologies
    - ✓ Subjective and qualitative: interview, questionnaires
    - ✓ Subjective and quantitative: Borg's CR-10 scale, 5-scale

- **Objective evaluation**
  - Participants' performance or ability (e.g. performance time, accuracy, error rate, motion, force)
  - Methodologies: ergonomic experiment with equipment

Scope of evaluation

- **Comprehensive evaluation**
  - Summative evaluation
  - Usually conducted on the final stage of product development phase
  - Evaluated most of elements or characteristics

- **Partial evaluation**
  - Formative evaluation
  - Usually conducted on the earlier stage or on special purpose
  - Evaluated focused elements, functions or benchmark tasks
  - e.g. keypad size of mobile phone

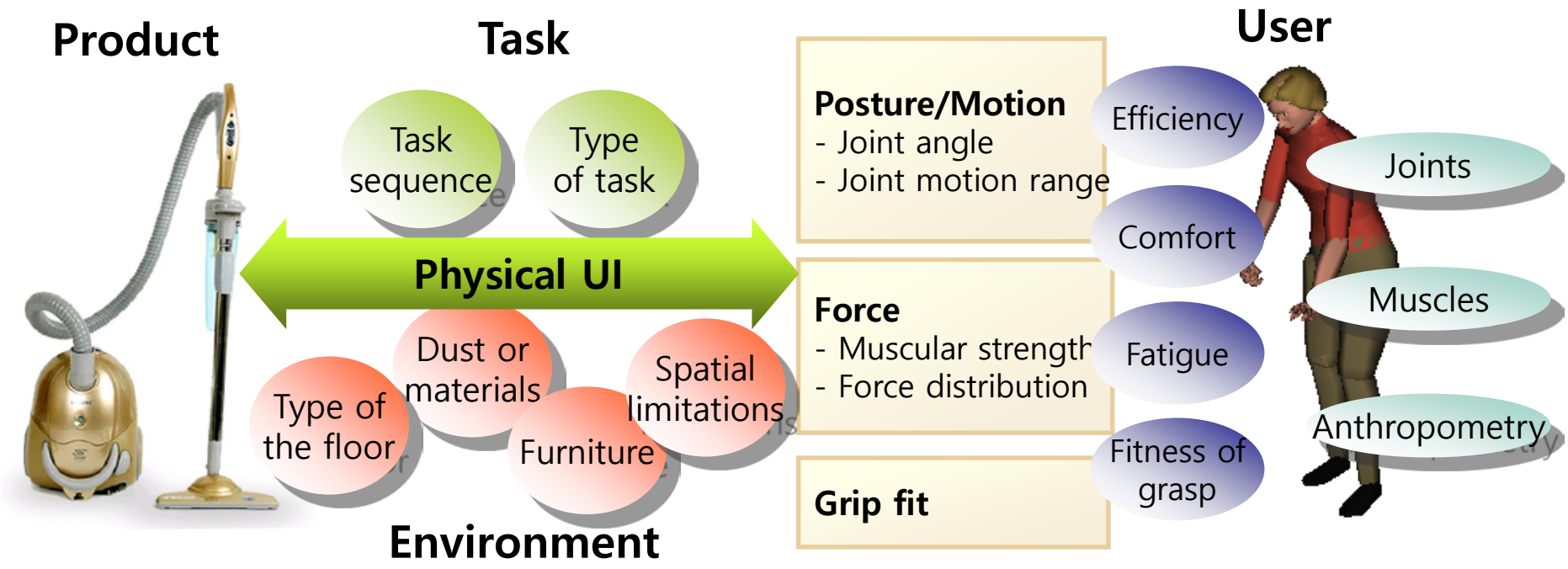
Better manners for practitioners

- **Type of information collection**
  - Qualitative evaluation vs. Quantitative evaluation
- **Type of collected data**
  - Subjective evaluation vs. Objective evaluation
- **Scope of evaluation**
  - Comprehensive evaluation vs. partial evaluation

for **quick**, **simple**, and **comprehensive** evaluation for practitioners

Product-User Interaction Model

- Need to consider 4 categories and those preferences



Objectives

- Developed a systematic protocol for **comprehensive** testing and analysis on product usability
- Conducted **subjective** and **quantitative** usability evaluation
- Applied to canister-type vacuum cleaner to examine its effectiveness

Approach

Step 1. Analysis of product characteristics

Step 2. Questionnaire development
and conducting usability testing

Step 3. Quantification of evaluation result
and analysis of usability problems

Approach

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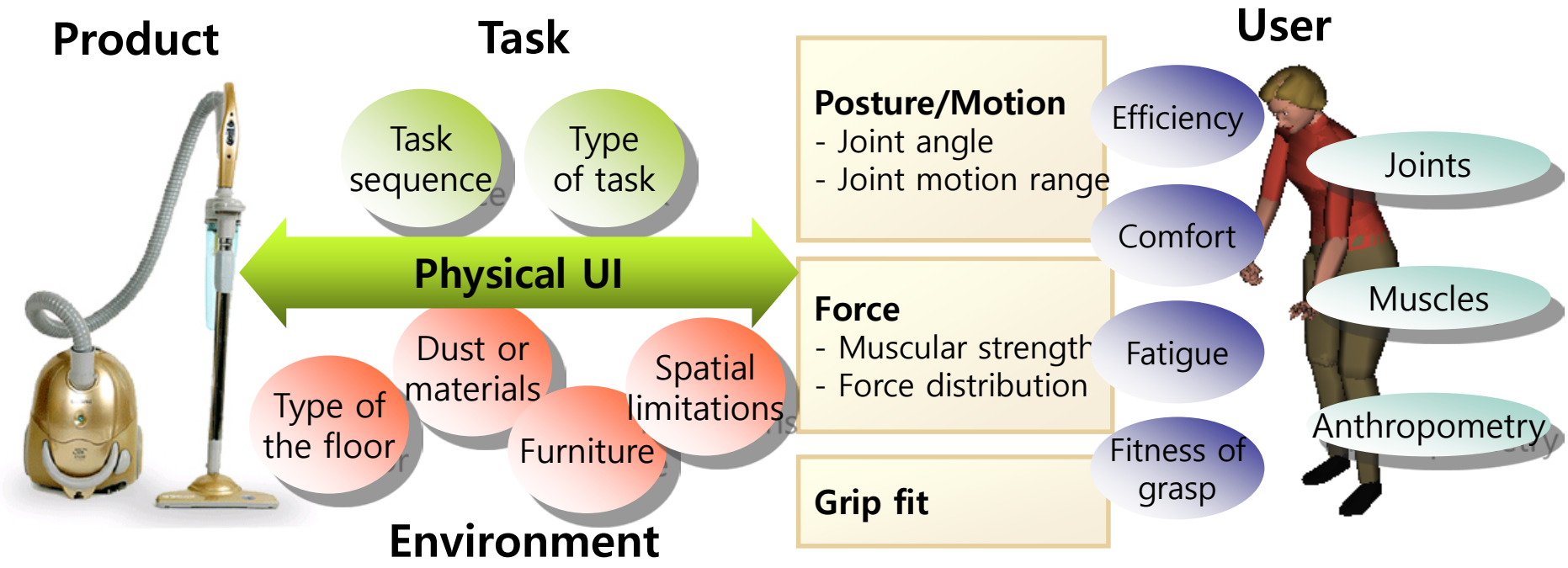
Step 1. Analysis of product characteristics

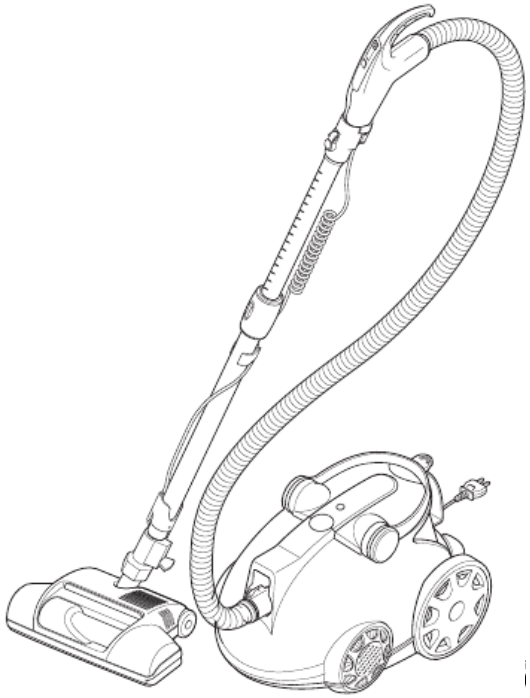
- Product-User Interaction Model
- Analysis of each categories and those preferences



Characteristics of PRODUCT

- Hierarchy of product component (illustrated for vacuum cleaner)

Category	Component	Category	Component
Body	Body case	**Wand and Brush**	Telescopic wand
	Carriage handle		Wand handle
	Control buttons		Hose
	Display		Control buttons
	Dust bin		Connector
	Wheels		Brush



Characteristics of TASK

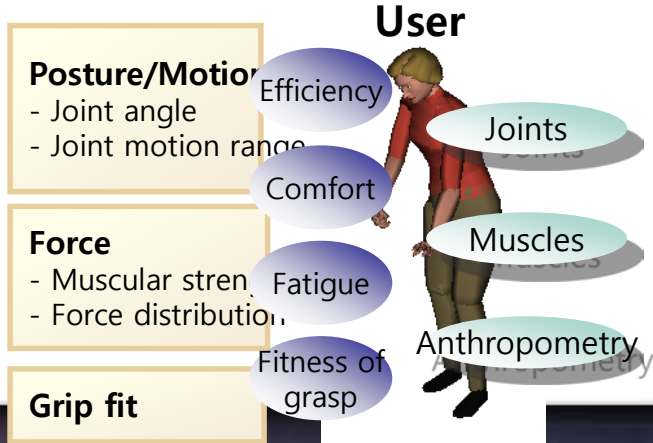
- Hierarchy of task

Category	Task	Subtask	
Infrequent task	Preparation	Power supply	
		Brush installation	
		Brush exchange	
Interactive task	Operation	Movement	Use of carriage handle
			Use of wheels
		Button control	Power on/off
			Suction power control

Characteristics of USER

- Usability measures

Category	Component
Comfortable posture	The extent to which **comfortable postures** are maintained while operating the product
Efficient motion	The extent to which **motions are efficiently used to operate** the product
Natural motion	The extent to which **natural motions** are used to operate the product
Effective use of force	The extent to which **forces** used to operate the product are acceptable
Fit to the hand	The extent to which the **handle or grip fits to the size and shape** of the hand
Ease of use	The extent to which a user **easily operates** the product



Characteristics of ENVIRONMENT

- Environment

floor

bed

upon furniture

under furniture

gaps

Relationship among characteristics

- As conducting usability test by tasks, **related characteristics** are also evaluated
- Task x Component

Task			Component					
			Body				Wand	
			Body case	Control buttons	Display	Carriage handle	Telescopic wand	Brush
Preparation	Power supply		O					
	Brush installation						O	O
	Brush exchange						O	O
Operation	Movement	Use of carriage handle	O			O		
	Button control	Power on/off		O	O			
		Suction power control		O	O			

Relationship among characteristics

- Task x Usability measures

Task			Usability measures				
			Comfortable posture	Efficient motion	Natural motion	Fit to the hand	Ease of use
Preparation	Power supply			O	O		
	Brush installation		O	O			O
	Brush exchange		O	O			O
Operation	Movement	Use of carriage handle				O	
	Button control	Power on/off			O		O
		Suction power control			O		O

Approach

Step 1. Analysis of product characteristics

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Step 2. Questionnaire development

- Based on analysis of characteristics of TASK, PRODUCT, and USER categories and its relationship

Compo-nent	Task	Usability questions	Product Model		
			Model A	Model B	Model C
Brush	Brush installation	The extent to which brush is connected to tube at a single trial WITHOUT ERROR	Low High ① ② ③ ④ ⑤	Low High ① ② ③ ④ ⑤	Low High ① ② ③ ④ ⑤
		The extent to which brush is EASILY connected to tube	① ② ③ ④ ⑤	① ② ③ ④ ⑤	① ② ③ ④ ⑤
	Brush exchange	The extent to which release button on brush is pressed by applying PROPER FORCE	① ② ③ ④ ⑤	① ② ③ ④ ⑤	① ② ③ ④ ⑤
		The extent to which brush can be EASILY disconnected from tube	① ② ③ ④ ⑤	① ② ③ ④ ⑤	① ② ③ ④ ⑤

Step 2. Questionnaire development

- Task x Component

Task			Component					
			Body				Wand	
			Body case	Control buttons	Display	Carriage handle	Telescopic wand	Brush
Preparation	Power supply		O					
	Brush installation						**O**	**O**
	Brush exchange						**O**	**O**
Operation	Movement	Use of carriage handle	O			O		
	Button control	Power on/off		O	O			
		Suction power control		O	O			

Step 2. Questionnaire development

- Task x Usability measures

Task			Usability measures				
			Comfortable posture	Efficient motion	Natural motion	Fit to the hand	Ease of use
Preparation	Power supply			O	O		
	Brush installation		**O**	**O**			**O**
	Brush exchange		**O**	**O**			**O**
Operation	Movement	Use of carriage handle				O	
	Button control	Power on/off			O		O
		Suction power control			O		O

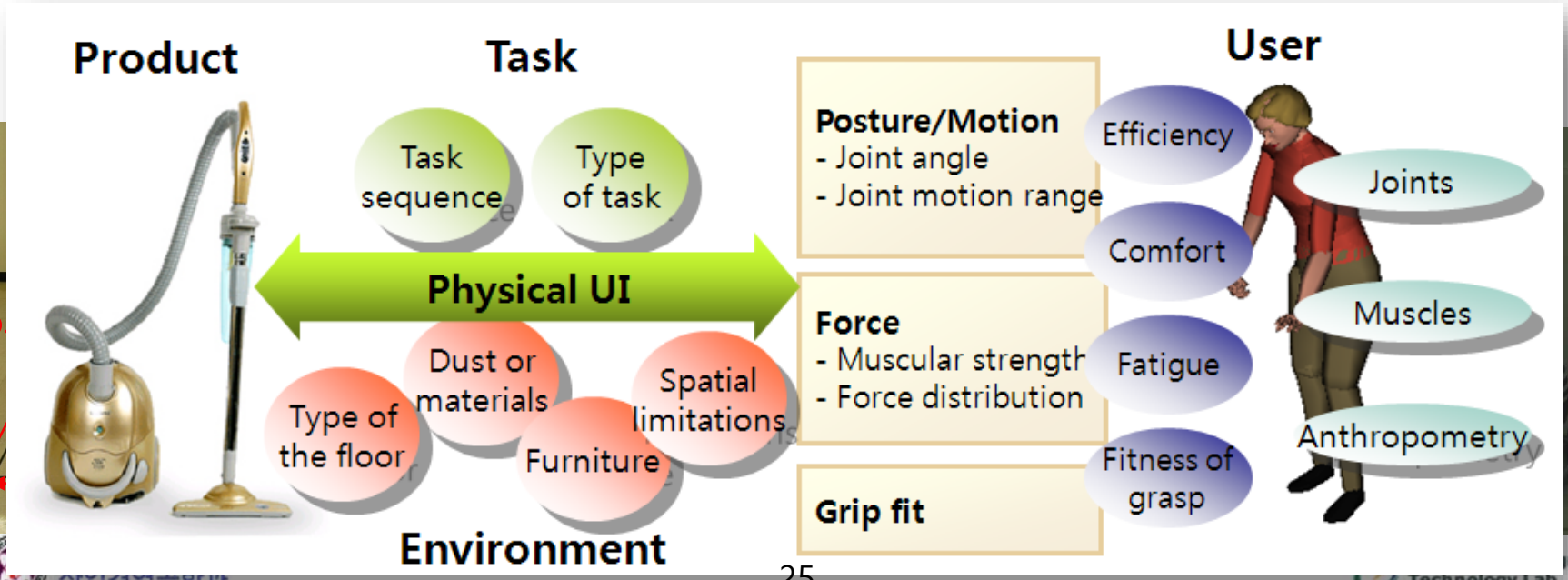
Step 2. Questionnaire development

- Based on analysis of characteristics of TASK, PRODUCT, and USER categories and its relationship
- Quantitative results

Compo-nent	Task	Usability questions	Product Model		
			Model A	Model B	Model C
Brush	Brush installation	The extent to which brush is connected to tube at a single trial WITHOUT ERROR	Low High ① ② ③ ④ ⑤	Low High ① ② ③ ④ ⑤	Low High ① ② ③ ④ ⑤
		The extent to which brush is EASILY connected to tube	① ② ③ ④ ⑤	① ② ③ ④ ⑤	① ② ③ ④ ⑤
	Brush exchange	The extent to which release button on brush is pressed by applying PROPER FORCE	① ② ③ ④ ⑤	① ② ③ ④ ⑤	① ② ③ ④ ⑤
		The extent to which brush can be EASILY disconnected from tube	① ② ③ ④ ⑤	① ② ③ ④ ⑤	① ② ③ ④ ⑤

Step 2. Conducting usability testing

- **Evaluation room** set up: based on analysis of ENVIRONMENT
- Participants evaluated every TASK related components and usability measures (PRODUCT) (USER)



Approach

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Step 3. Quantification of evaluation result

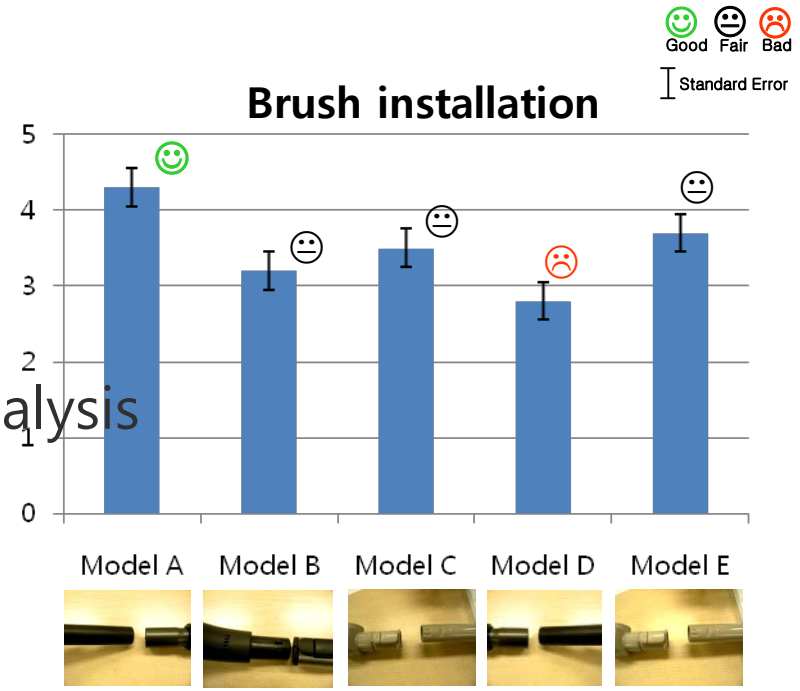
- Evaluation conducted by component, task, and usability measure
- Qualitative results calculated by usability measure, task, and component

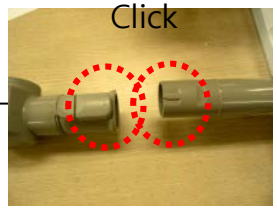
Compo-			Product Model				
Component	Task	Usability measure	Model A		Model B		C
			Score	Task score	Score	Task score	
Brush	Brush Installation	Comfortable posture	3.2	3.1	3.9	3.7	High ④ ⑤
		Efficient motion	3.2		3.7		④ ⑤
		Easy of use	2.9		3.5		
	Brush exchange	Comfortable posture	3.5	3.5	4.2	3.9	④ ⑤
		Efficient motion	3.4		3.7		④ ⑤
		Easy of use	3.6		3.8		

from tube

Step 3. Analysis of usability problems

- **Quantitative result of components** were established
- **Qualitative design guidelines** were suggested by benchmarking analysis



Category	Design criteria	Description	Image
Preferred	**Weight**	Model A (290 g) is lighter than Models B, E (513 g), D (610 g) and C (545 g)	-
	Visual information	Arrows to indicate connecting location and direction	
	Auditory feedback	Sound feedback when pipes are connected properly	
Requiring improvement	**Use of force**	Models B, C, D, and E require larger force to connect pipe with brush	-

Discussions

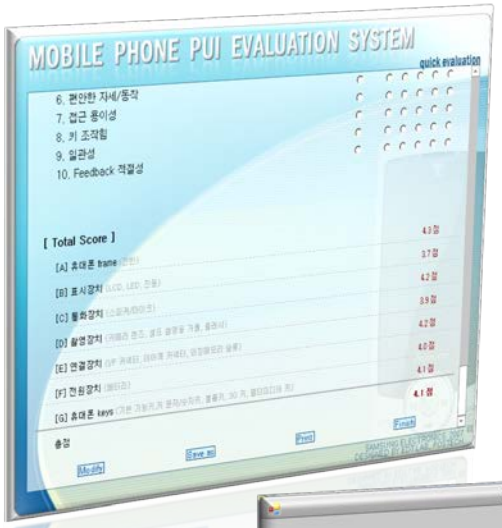
- **Advantages**
  - **Comprehensive evaluation** by using Product-User Interface Model
  - Analysis of characteristics of TASK, PRODUCT, USER, and ENVIRONMENT and its relationships
    ⇒ Systematically applied to make questionnaire and analyze of testing result

- **Limitations**
  - Just considered **qualitative comparisons of evaluated products**
    ⇒ Need to find optimal values of design criteria
  - Not considered importance between components or tasks
    ⇒ Applied this concept as **weight of scores** on the next research

Future study

- Need **faster** analysis and **easier** interpret results
  ⇒ We have developed several types of evaluation systems

Web-based type



Stand-alone type