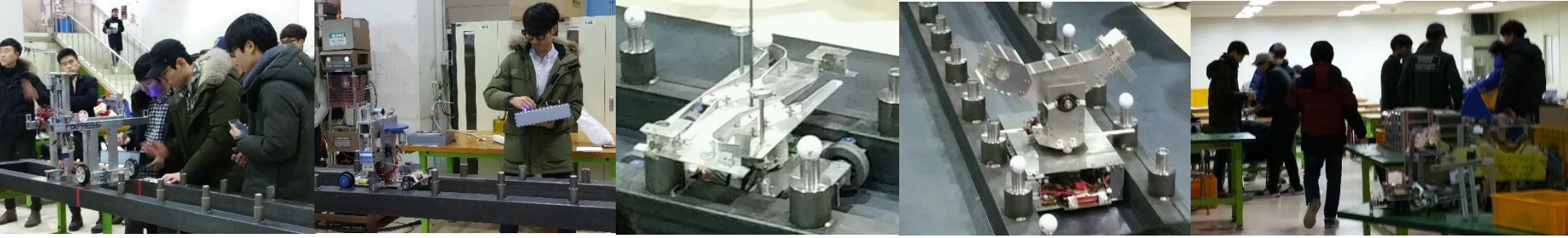

Development of Instructional Design Strategies for an Engineering Course Using Smart Support System for Creative Problem Solving

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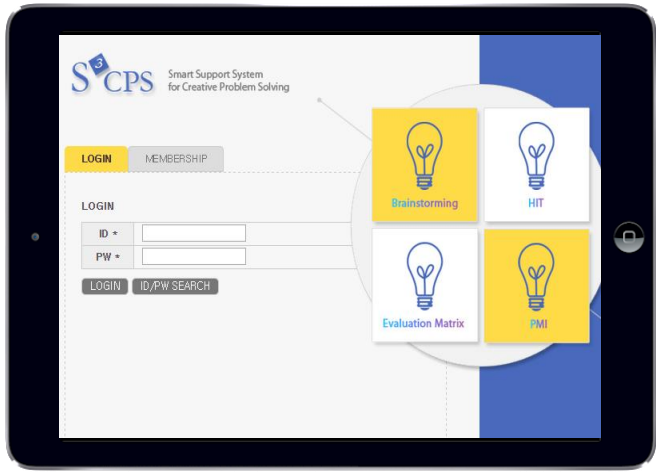
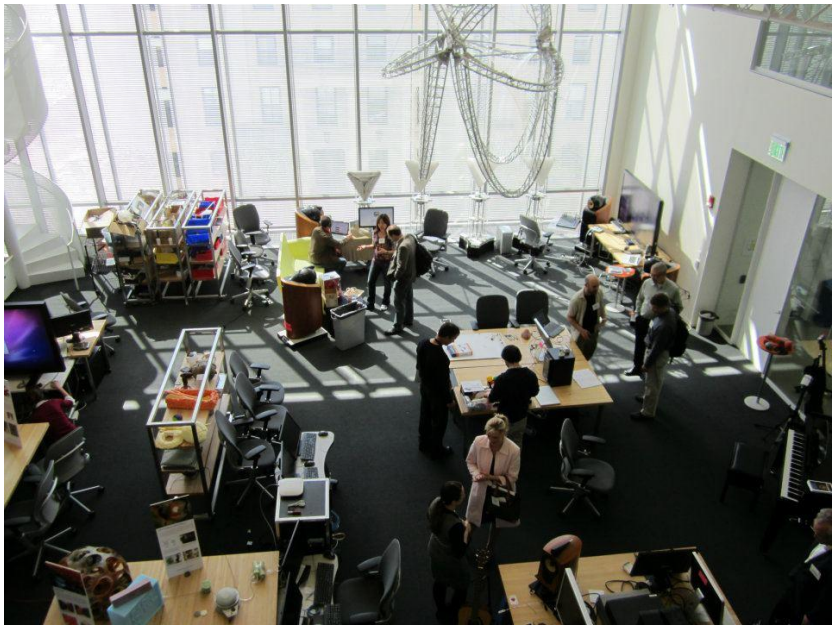
Seoul National University



Introduction

- **Constant emphasis for creativity in engineering education**

Design thinking workshop at d.school



MIT Media Lab

Sources: http://dschool.stanford.edu/fellowships/files/2014/09/fellows10.jpg
https://vault.cca.edu/file/4f4fabee-faa6-4296-81bc-40a5a28f8b3c/1/MIT%20Media%20Lab%20MA.jpg

Introduction

- **A variety of attempts to promote creativity in the engineering schools**

  - Techniques, models, courses, instructional methods, etc.
    (Kim, 2010; Lim, et al., 2011a; Khorbortly, & Budnik, 2014; Morin et al., 2014)

Figure 1: The TRIZ Problem-Solving Method

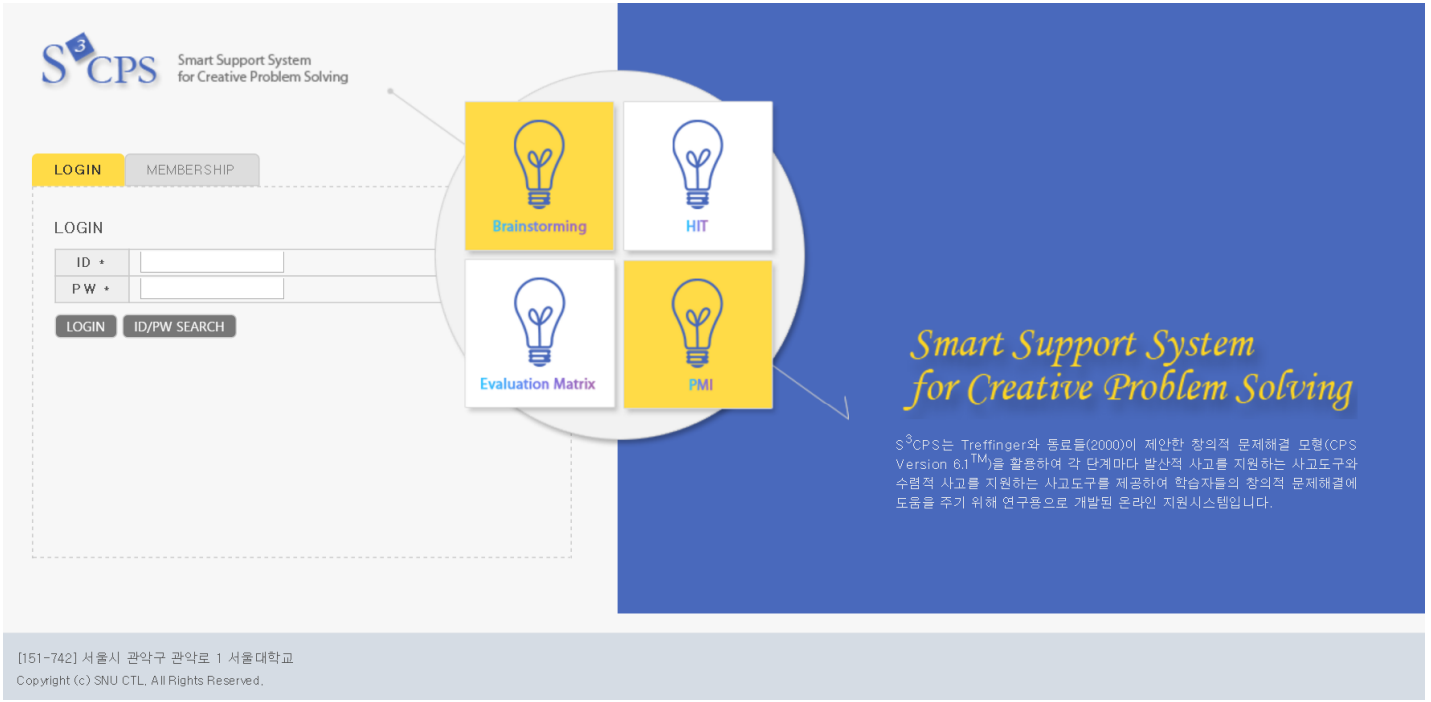
The arrows represent transformation from one formulation of the problem or solution to another. The gray arrows represent analysis of the problems and analytic use of the TRIZ databases. The purple arrow represents thinking by analogy to develop the specific solution.

Sources: https://www.mindtools.com/media/Diagrams/TRIZ.jpg
https://img.yumpu.com/46791295/1/358x269/supporting-creative-learning-mit.jpg

Introduction

- **Online environment is effective for facilitating creative problem solving**

  - Smart Support System for Creative Problem Solving(S^3CPS) developed to enhance students' creative problem solving ability (Lim et al., 2009)

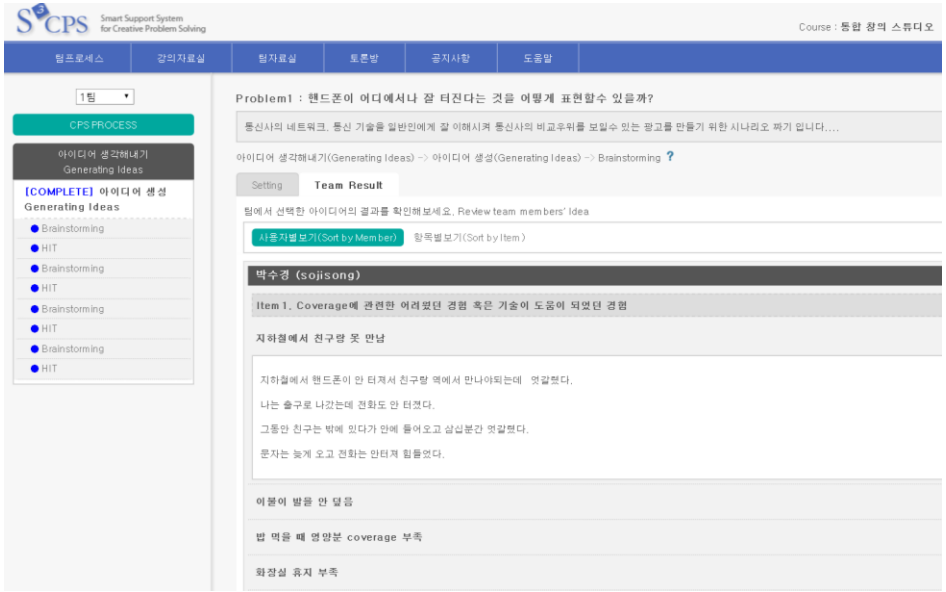


Smart Support System for Creative Problem Solving(S^3CPS)

Sources: http://s3cps.snu.ac.kr/

Introduction

- **Creative problem solving facilitated by online learning environment**
  - Applying Smart Support System for Creative Problem Solving(S3CPS) in vaious courses in 2009, 2011, and 2014(Lim et al., 2009, 2011, 2014)



Understanding Education(2009)

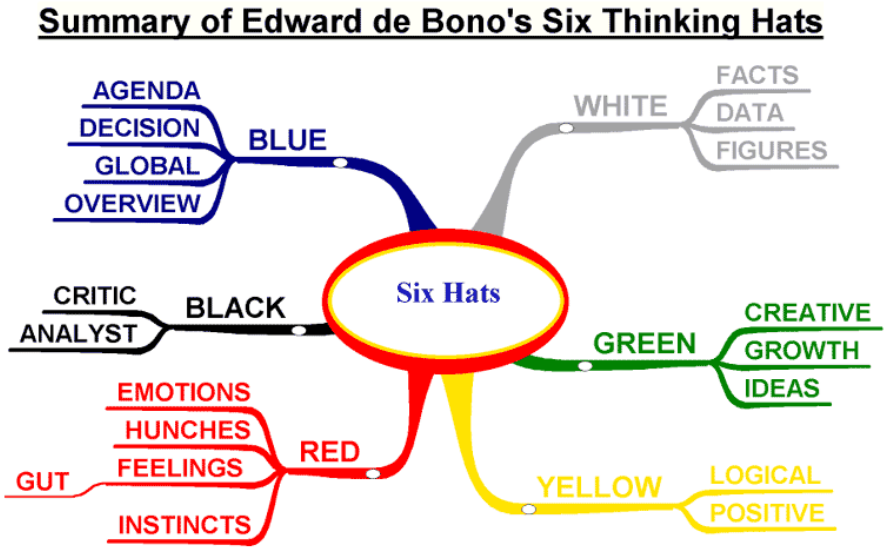
Integrative Creative Studio(2014)

Sources: 임철일, 윤순경, 박경선, 홍미영. (2009). 온라인 지원 시스템 기반의 '창의적 문제해결 모형'을 활용하는 통합형 대학 수업 모형의 개발. **교육공학연구, 25**(1), 171-203.; http://s3cps.snu.ac.kr/

Theoretical Background

- **Creative Problem Solving in Engineering Education**

  - Researches are mostly about instructional strategies and methods' and 'curriculum'(Lim et al., 2014a)



Six thinking hats strategy

Creative Engineering Design Course

Sources: http://1.bp.blogspot.com/_EWIxZ1rxIgE/S_Y_Mh2uwYI/AAAAAAAANqQ/91yKbTbgPvE/s1600/SixHats.gif
http://www.slideshare.net/LeeSeokchan/uml-9376164

Theoretical Background

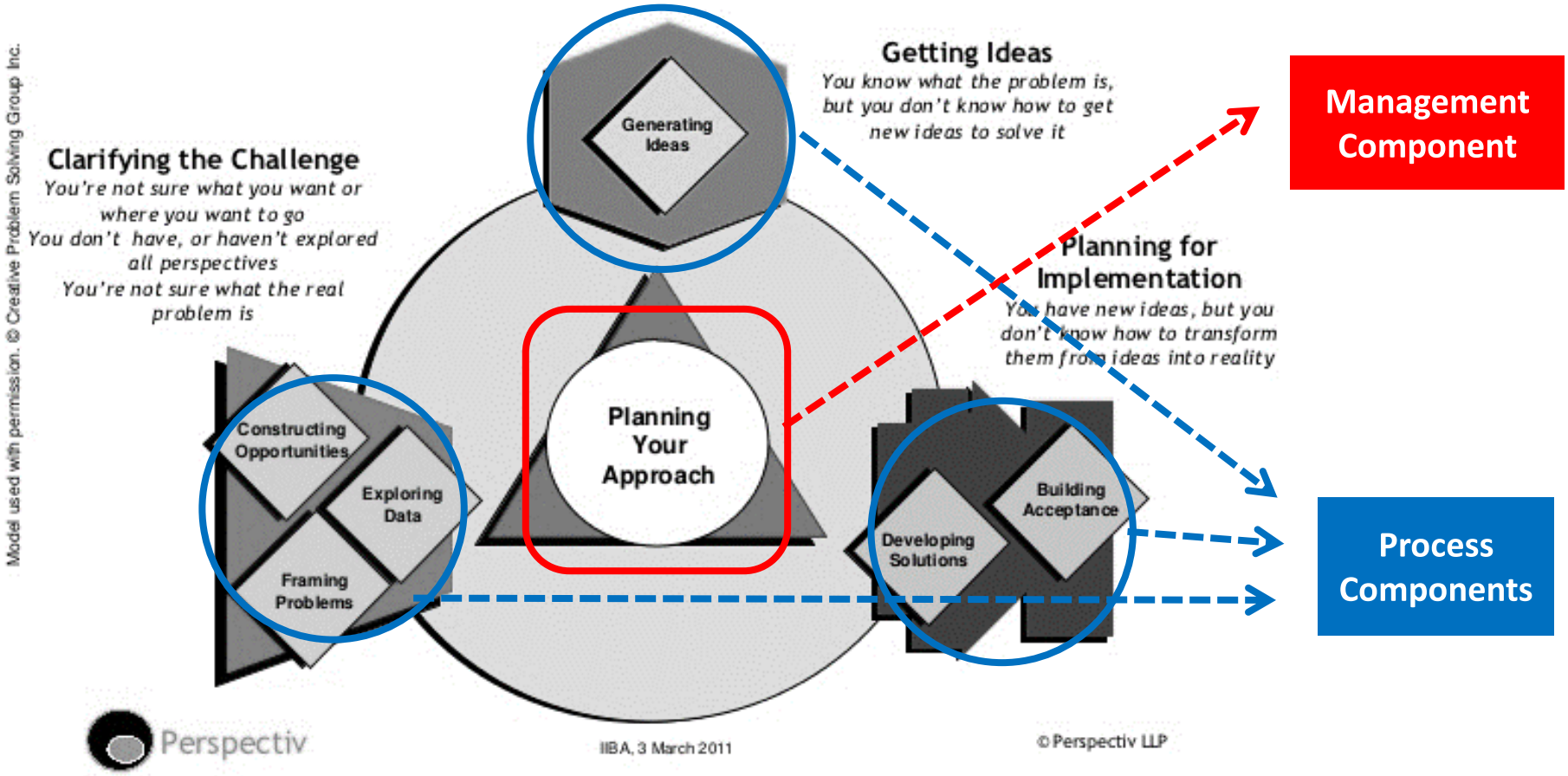
- **Team Projects in Engineering Education**

  - Team projects are actively used for the development of creative and fusing talents in engineering education.
  - Students learn teamwork skills, communication, cooperation skills and professional knowledge by carrying out team projects (Mills & Treagust, 2003)

Source : https://www.producteev.com/blog/5-helpful-tips-for-managing-a-project-or-team-remotely/

Theoretical Background

- **CPS Model and Smart Support System**
  - Creative Problem Solving(CPS) model: CPS 6.1^{TM} version (Treffinger et al., 2000)



http://image.slidesharecdn.com/iibarollsroyce3mar2011fl-cpsv45distributed-110309180735-phpapp02/95/facilitative-leadership-creative-problem-solving-41-728.jpg?cb=1300515833

Theoretical Background

- **Smart Support System for Creative Problem Solving(S^3CPS)**
  - An online support system developed based on CPS model (Lim et al., 2009)
  - Creative problem solving by the repeated use of divergent and convergent thinking tools

Thinking tools of S3CPS

Divergent thinking tools

- **Brainstorming**

Convergent thinking tools

- **HIT**
- **PMI(Plus, Minus, Interesting)**
- **Evaluation matrix**

Methods

- **Design and development research**
  - **Product and tool research** of design and development research (Richey & Klein, 2014)
  - Developing **instructional design strategies** for an engineering course using S^{3}CPS

Primary study (Spring semester of 2015)

Design strategies for applying S^{3}CPS in engineering course developed	Effectiveness of design strategies examined through surveys and interviews

Secondary study (Fall semester of 2015)

Modified design strategies & specific guidelines developed and applied	Intensive interviews to improve design strategies

Source : https://www.producteev.com/blog/5-helpful-tips-for-managing-a-project-or-team-remotely/

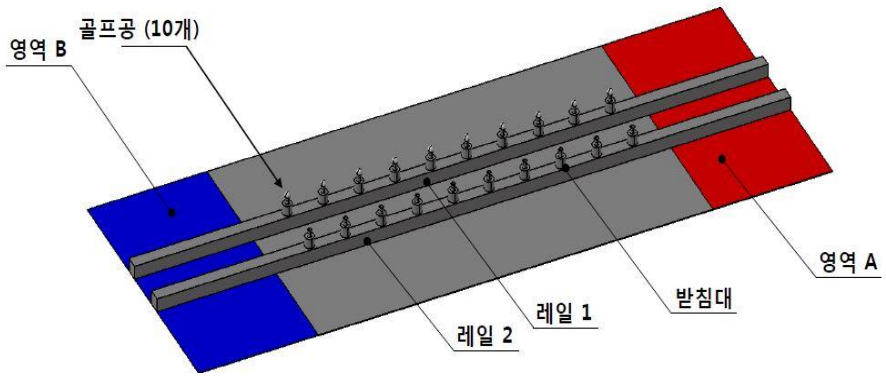
Methods

- **Research site and context**

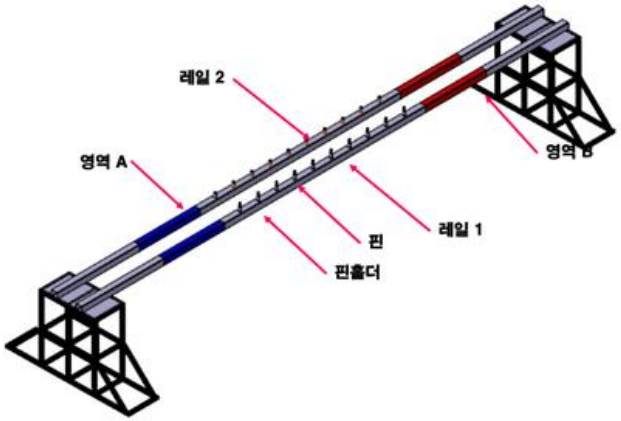
- ‘Design, Production & Practice’ course offered by department of Mechanical and Aerospace Engineering at S University in spring and fall semester of 2015

- Learning goal: to experience systematic process of designing and developing robots with optimum functions and conditions

- 112 students in the primary study and 108 students in the secondary study participated (Each students assigned to a team of 6-8 students)



Team assignment in spring semester



Team assignment in Fall semester

Results

- **Analysis**

- The contents, syllabus and schedule of the course were analyzed and most effective way to apply the CPS process components was determined before applying the system.

- S^3CPS was considered to be effective at **conceptual design stage** in the course.

Simplified procedure of conceptual design stage

Results

- **First Smart Support System-based Design Strategies and their Application**
  - Four instructional design strategies were developed by researchers from previous studies

Partial use of the smart support system

- For conceptual design stage where students come up with various ideas and select the optimal design alternative

Selective use of the divergent and convergent thinking tools

- Brainstorming, Evaluation Matrix and PMI

Opportunity for practice before regular usage of the system

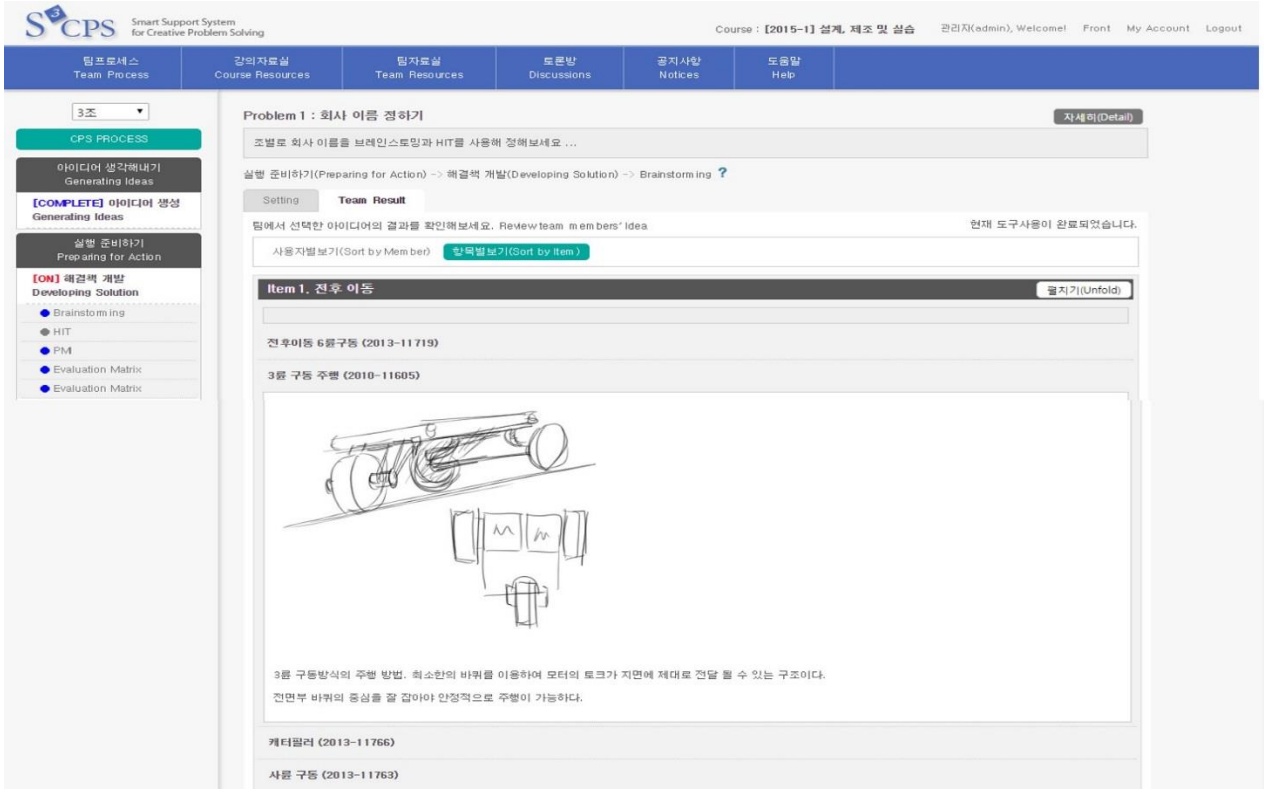
- Team-naming activity

Sufficient instruction for the system and tools

- Orientation to the system, a user's manual and guidance materials provided

Results

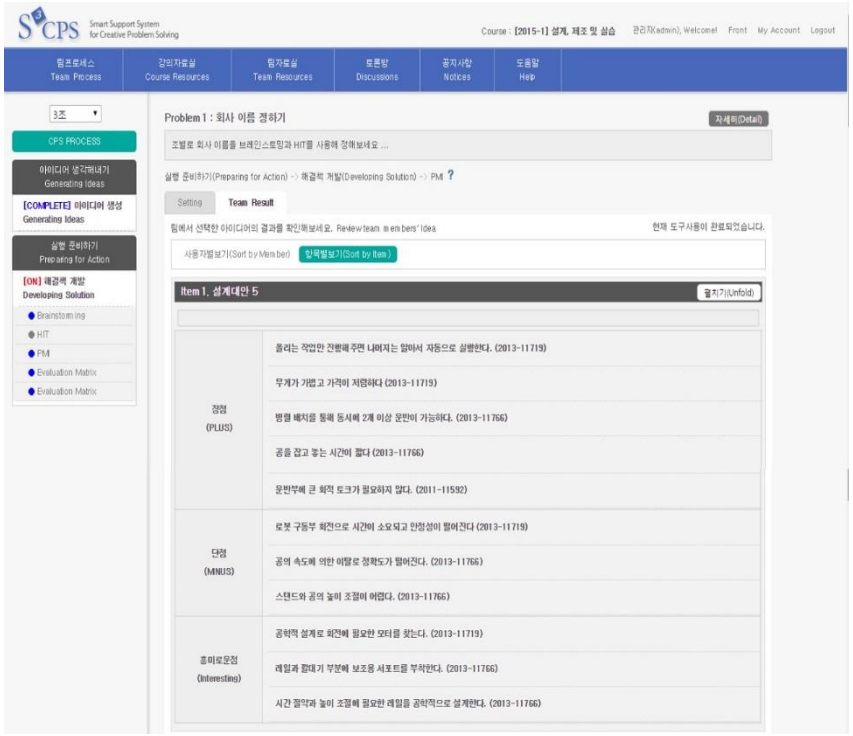
- **Example of divergent thinking tools**



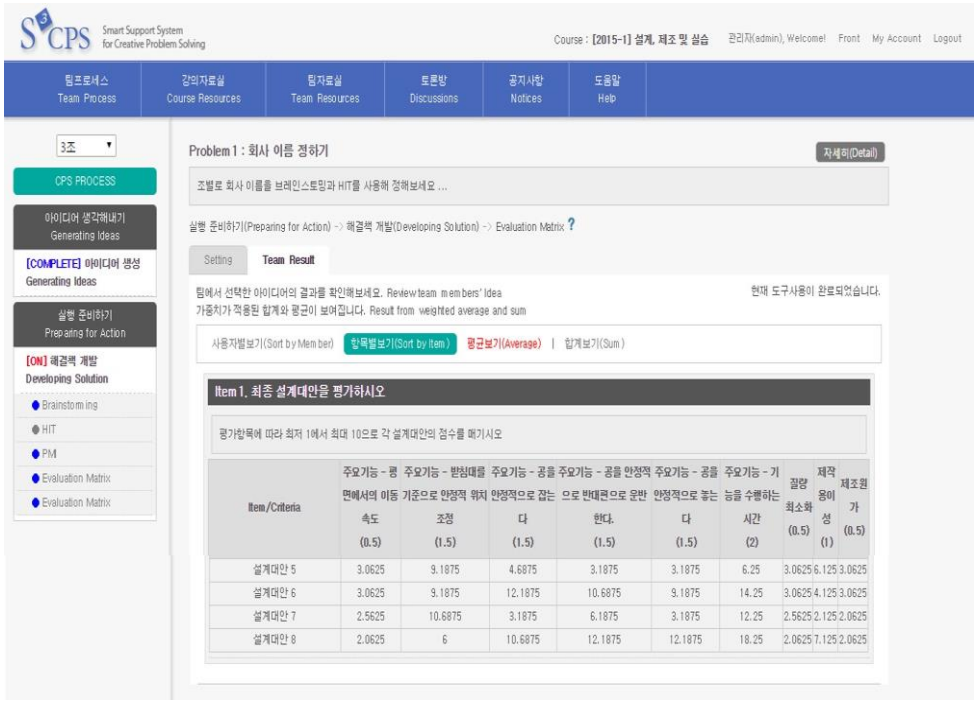
Brainstorming

Results

- **Example of convergent thinking tools**



PMI(Plus, Minus, Interesting)



Evaluation Matrix

Results

- **First Smart Support System-based Design Strategies and their Application**
  - S^3CPS applied in the first 6 weeks of the course following the first design strategies
  - The Application methods are as follows:
    - **Optimize the utilization** of the smart support system by considering the characteristics and conditions of the lecture to designing the course.
    - **Be flexible** in using various thinking tools of the smart support system according to the task and procedure of the team project.
    - **Provide opportunities** to be fully acquainted with the system's thinking tools to accustom the students to using the system.

Results

- **Effects of the First Smart Support System-based Design Strategies**
  - In-depth interviews and an open-ended student survey to confirm the effects
  - **Effects on creative problem solving activities**

Thinking Tools		Effects	Opinions
Divergent	Brainstorming	+	generating various ideas
			having plenty of time
		-	delays in thinking activities
			repetition of ideas
Convergent	PMI	+	objective evaluation
		_	delays in thinking activities
	Evaluation Matrix	+	clear presentation of evaluation results
			reliability of evaluation
		-	lack of discussion in decision making

Results

- **Effects of the First Smart Support System-based Design Strategies**
  - In-depth interviews and an open-ended student survey to confirm the effects
    - **Effects on *team project performance***

Effects	Opinions
+	improvement in team participation and cohesion
	efficient and systematic project management
	well-organized and convenient way of documentation
-	demotivation of communication
	inconvenience due to duplicated tasks

Results

- **Second Smart Support System-based Design Strategies, Implementation Guidelines and their Application**
  - Complementation of previous design strategies derived through primary implementation and previous research review

Provide a blended learning environment

- Enable divergent and convergent thinking at physical and virtual space

Operate team-based projects

- Many engineering courses run by project basis
- Team-based projects recognized as effective for enhancing creativity

Provide a authentic engineering task

- Design assignments and activities reflecting the characteristics of engineering

Offer an online support system for creative problem solving

- Provide space and network for varied communication
- Support the problem solving process by setting the CPS stage fitting to the project and using divergent and convergent tools

Provide appropriate guidance for system and class management

- Introduce the system and thinking tools
- Provide the chance of practical exercise for adjustment

Results

- **Second Smart Support System-based Design Strategies, Implementation Guidelines and their Application**
  - Detailed guidelines of the implementation following to the course procedures based on general design strategies

Course Procedure	Detailed Guidelines of Implementation	
	Online Activities	Offline Activities
I. Preparation Stage	- Registration of online system	- Introduction of team project assignment - Introduction of CPS model and system - Introduction of team arrangements and activities
II. Practice Stage	- Electing team leaders - Team naming(exercise activity)	- Propose of exercise activity (team naming) - Introduction of the procedure of exercise activity

Results

Course Procedure		Detailed Guidelines of Implementation	
		Online Activities	Offline Activities
III. Implem-entation Stage	Exploration of Working Principles	② Arrangement and registration of one's own idea	① Suggestion of ideas and feedback ③ Re-discussion on ideas
	Invention of Design Alternatives		Invention of 6-8 design alternatives incorporating the working principles
	Analysis of Pros and Cons of Design Alternatives	① Registration of evaluation items for design alternatives ② Evaluation of each design alternative	③ Discussion on evaluation results of d esign alternatives ④ Selection of 3~4 design alternatives
	Discussion of Pros and Cons of Design Alternatives	② Arrangement and registra -tion of opinions	① Discussion on pros, cons & improvement plans for selected design alternatives ③ Re-discussion on the ideas
	Evaluation of Final Design Alternative	① Evaluation of design alternatives	② Selection/modification of the optimal design alternative through discussion

Results

Course Procedure	Detailed Guidelines of Implementation	
	Online Activities	Offline Activities
IV. Evaluation Stage	- Evaluation of students' online activities by teaching assistants	- Presentation of the outcome by each team - Evaluation of team presentation by lecturer and teaching assistants

- Second design strategies and guidelines of implementation were applied to the same range and period as the previous ones.
- Existing orientation, manuals and instructional materials were restructured reflecting the new design strategies and guidelines.

Results

- **Improvement of the Second Smart Support System-based Design Strategies and Implementation Guidelines**
  - Pros, cons and improvement points of the strategies and guidelines and the learners' actual methods of progress recognized through interviews with students

- **Pros**

- helpful to proceed a systematic project and record and arrange its processes
- making free time through remote working, confirming the proceeding situation through the system, providing an alternative to offline meetings, promoting participation and proper evaluation

Type	Reaction of Learners	Frequency
Pros	It was helpful for the systematic procedure of project.	4
	It was a help for recording and arranging process.	3
	It enabled to make spare time through remote processing.	2
	The real-time confirmation through system was possible.	1
	It became an alternative in case offline meeting was difficult.	1
	It gave a help to promote the participation of team members.	1
	It was useful for proper evaluation.	1

Results

- **Improvement of the Second Smart Support System-based Design Strategies and Implementation Guidelines**

- **Cons**

- online communication cumbersome and difficult to understand
- it takes much time in online and offline activities in parallel
- progression of evaluator-centered procedure, occurrence of duplicated tasks, low effectiveness comparing with offline methods, inconvenience due to unfamiliar system

Type	Reaction of Learners	Frequency
Cons	There was a limitation of online communication in itself.	4
	It took much time to proceed step by step online and offline.	4
	It accompanied unnecessary process.	2
	Duplicated tasks occurred.	2
	It was not that effective when the offline meeting was available.	2
	It was inconvenient to use due to unfamiliar system.	2

Results

- **Improvement of the Second Smart Support System-based Design Strategies and Implementation Guidelines**

- **Improvement points**

- flexible adjustment of processing time according to the class in progress
- selective implementation of detailed activities appropriate to actual situation

Type	Reaction of Learners	Frequency
Improvement Points	Flexible adjustment of processing time according to the class in progress.	1
	Selective implementation of detailed activities appropriate to the situation.	1

Results

- **Improvement of the Second Smart Support System-based Design Strategies and Implementation Guidelines**

- **Actual way of progress**
- Most learners carried out several stages at once.
- Offline activities were implemented mainly for each procedure and then recorded online.

Type	Reaction of Learners	Frequency
Actual Method of Progress	They carried out several stages at once.	6
	They implemented offline activities for each procedure mainly and then recorded the result online.	4
	They used additional online document tool and messenger.	2
	They followed the implementation guidelines as it were.	1

Conclusion

- **Effects of design strategies**

- They were shown to be helpful for participation of learners, the proposal of various opinions, systematic process of project and structuration of data.

- **Limitation of design strategies**

- It could be relatively time-consuming while delivering message in online communication in addition to the traditional offline methods.
- Some learners could feel uncomfortable in using the online system.

Conclusion

- **Implications**

- Careful determination of the mode and range of application is needed through a thorough analysis of contexts of the class and learners.
  - In this study, offline gathering of students were active in the class.
  - Students' need for the online system was relatively smaller.

- It is desirable to let learners selectively and flexibly apply instructional design strategies and detailed implementation guidelines.
  - It would be more effective to utilize the guidance and tools in accordance with the situation and needs of each team rather than passively follow the suggestions of researchers.

THANK YOU