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A Case Study on the Implement of Teaching and Learning Models aiming at Training Creative Engineers: focused on the SICAT*

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The purpose of this paper is to apply the newly developed SICAT teaching and learning model to the actual scene of teaching and learning and draw a point of discussion for utilizing teaching and learning model, by uncovering the satisfaction of students and the inhibiting/facilitating elements when using the model. SICAT(Scientific Inquiry and Creative Activity with Technology; from here on SICAT), a teaching and learning model custom-built for engineering education, was developed, as more and more people paid attention to the demand for creative engineers. It was developed from the basis of PBL(Problem Based Learning), includes three sub-types which can be applied to the actual theory, design, and experimentation fields within engineering education. The three sub-types, which are ARDA(Analysis-Reasoning Activity & Discussion-Argumentation Activity), CoCD (Collaboration Activity & Capstone Design Activity), and ReSh(Reflection Activity & Sharing Activity), respectively support deductive and argumentation activities, creative design and collaboration activities, and retrospection and sharing activities. However, no research has been conducted to investigate whether or not there are inhibiting or facilitating elements in the application procedure, or what the rate of satisfaction for students is, when applying the SICAT model, which was newly developed to innovate existing engineering education, to the actual site of teaching and learning. Therefore, this research applied three

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types of SICAT teaching and learning models to the theory, design, and experimentation classes at the department of materials science and engineering at Hanyang University for eight weeks. After application, the students, teachers and tutors were surveyed and interviewed, and then the results analyzed in order to uncover inhibiting/facilitating elements and the rate of satisfaction. The satisfaction rate of students from the SICAT teaching and learning model was 3.78(in a perfect score of 5: The A type-3.65, The C type-3.80, The R type-3.90), and inhibiting/facilitating elements were drawn from the aspects of learning activities, support system. In conclusion, they can be contributed for implications of SICAT teaching and learning model universal use at engineering education in University.

Keywords : case study, teaching and learning model, Scientific Inquiry and Creative Activity with Technology (SICAT)

Introduction

The training of creative engineers is directly linked to re-procurement which is the key in leading future development and solving the problems of modern society. Universities in Korea and abroad are establishing Innovation Centers for Engineering Education, and are searching for ways to develop next-generation engineers using these centers as a foundation. However, the current engineering education systems have appeared to be unable to accomplish the training of creative human resources and satisfy the social demand for creative human resources(Bae, 2007).

The innovation of engineering education for the training of creative talent can be sought in various fields, but one focal starting point should be the instructional done in the field of education(Kwon et al., 2008a; Kwon et al., 2008b). As part of changing the teaching and learning methods at the scene of engineering education for the training of creative talent, the education technology research center and the fusion materials center at Hanyang University have developed SICAT(Scientific

Inquiry and Creative Activity with Technology), which is a teaching and learning model tailored to engineering education that aims at developing thinking skills and the abilities of talented next-generation engineers. The SICAT teaching and learning model is a concept model developed from the theoretical background of heuristics and PBL, which includes three lower category types for application in the actual teaching and learning scene. The purpose of this research is to apply the newly developed SICAT teaching and learning model to the actual scene of instruction and draw a point of discussion for utilizing the SICAT teaching and learning model, by uncovering the satisfaction of students and the inhibiting/facilitating elements when using the model.

Previous study on the SICAT teaching and learning model

SICAT teaching and learning model

The SICAT(Scientific Inquiry and Creative Activity with Technology) model is a concept model developed to train engineers with creative abilities(Kwon et al., 2009a; Kwon et al., 2009b). SI(Scientific Inquiry) is a learning process which supports the growth of problem-solving abilities and scientific inquiring, the basic requirements for talented engineers. CA(Creative Activity) is the creative activities conducted in the process of creative inquiry, and T(Technology) is the technological support given to the creative activities of the students that are conducted during creative inquiry and its process(Kwon et al., 2009a). Three lower category types(ARDA, CoCD, ReSh) have been developed for the SICAT teaching and learning model suited to theory, design, and experimentation lessons.

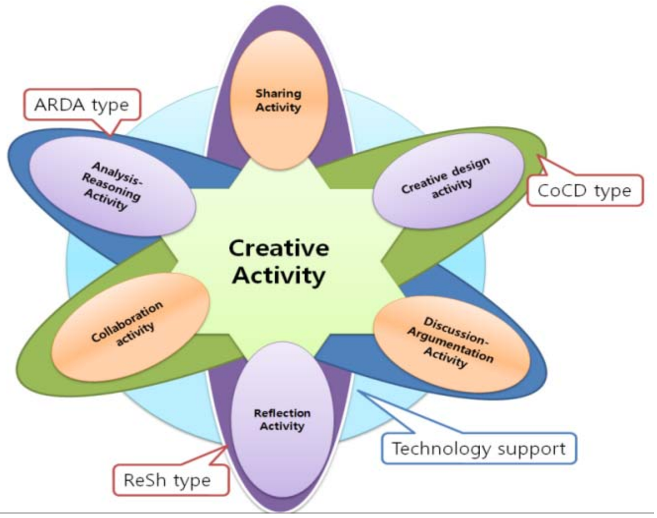

Figure 1. Three types of SICAT Model (ARDA, ReSh, CoCD type)

Analysis on the three sub-types of the SICAT Teaching and learning Model

① ARDA(**A**nalysis-**R**easoning Activity & **D**iscussion-**A**rgumentation Activity) Type: Mainly supports Analysis-Reasoning Activities and Discussion-Argumentation Activities. This focuses on support strategies for logical discussion activities that are based on examples, so it is suitable to the theory-based classes conducted in engineering education. Students go through a learning process according to the The A type application, while getting involved in reasoning activities, argumentation activities and discussions.

② CoCD(**Co**llaboration Activity & **C**apstone **D**esign Activity)type: Mainly supports collaboration activities and capstone design activities. This focuses on support strategies for creative thinking and cooperation, so it is suitable to the design-based classes that are being conducted in engineering education. By a learning process according to the The C type application, students get involved in capstone design activities which include gathering and distributing various ideas and also collaboration activities which allow problem solving through collaboration with teachers, tutors and other students.

③ ReSh(**Re**flection Activity & **Sh**aring Activity) type: This type mainly supports reflection activities and sharing activities. Because this type focuses on reflective thinking and supporting a strategy for sharing activities, it is suitable for experiment-based classes that are being conducted in engineering education. By means of monitoring, Students are involved in reflection activities as well as sharing activities in online communities by methods like keeping a reflection journal on their individual learning, the learning process of the team and its results.

Method

Research time and participants

The A type, C type, and R type SICAT models were applied respectively to the theory, design, and experimentation classes that were conducted at the department of materials science and engineering at Hanyang University. The subjects that were applied according to each The A typere as follows:

Table 1. Research Subjects

Type	Name of subject	Type of instruction	Students
ARDA	Thin film Engineering	Theory	senior (48 persons)
CoCD	Capstone Design in Materials Science(URIP)	Capstone Design	Freshman (16 persons)
ReSh	Engineering experiment using Experiment materials(optic characteristics of materials)	Experimentation	Junior (37 persons)

Research outline

① Analysis on the SICAT teaching and learning models developed for training creative engineering talent and also for its three sub-types.

② The A type, C type, and R type of the SICAT teaching and learning model was applied respectively to the theory, design, and experimentation classes conducted at the department of materials science and engineering at Hanyang University.

③ After each type was applied, the students and teachers of each class were surveyed with a 5-point scale questionnaire and open-ended questions.

Research procedure

① The A type

○ Subject: Thin film Engineering

○ Participants: 46 persons (8 teams, 5-6 persons in a team)

○ Period: Monday and Tuesday during 1st week in April to 2nd week of May

○ Learning place: R 101 of the 1st Engineering building (offline)
Online community BBS in EzHub at Hanynang university (See Appendix 1)

○ Schedule

Time	Research content	Student's activities
Orientation	Guide to students, teacher, tutors about the purpose and process outline of this research	
March, 24	<The 1st classroom observation> · Individual assignment representation for argumentation activities : How to obtain the uniform thickness of the thin films in evaporation chamber?	· Organizing team (8 teams, 5-6 persons in a team)

March, 27 ~ April, 6	· Individual assignment guide (31, May) · Monitoring of online argumentation activities and students' activities facilitation	· Individual assignment guide at online BBS · Leave feedback comments about others' assignment more than 3 times (See Appendix3)
April, 14	<The 2nd classroom observation> · Review and discussion result on Individual argumentation activities · Team project guide	· Team project guide (deadline: 4, May) assignment mode: PPT
April, 15 ~ May, 10	· Monitoring of online argumentation Activities and students' activities Facilitation	· Leave feedback comments about other team's assignment more than 3 times (deadline: May, 8)
May, 11 ~ May, 12	· Review and discussion result on Team project	· Interview(46 students, tutors, teacher) · Submission final assignment (deadline: May, 13)
Follow-up activities (Analysis)	· Feedback comments(online) · Interaction on class(offline) · Interview results	

② The C type

○ Subject: Capstone Design in Materials Science 1(URIP)

○ Participants: 16 persons of sophomore (5 teams, 3-4 persons in a team)

○ Period: 10 a.m. Saturday during May to June

○ Learning purpose

: develop motor using permanent magnet and product a car based on this work

○ Schedule

Time	Research content
Orientation	Guide to students, teacher, tutors about the purpose and process outline of this research
March, 14	• Organizing team and ready for collaborative activities
March, 15 ~ April, 3	• 1st team activity : principle, features, category, use of Permanent magnet through team collaborative learning
April, 4	• Presentation and share between teams on 1st team activity • The 1st classroom observation
April, 5 ~ May, 8	• 2nd team activity - Capstone design through basic concept and idea for final product
May, 9	• Presentation and share between teams on 2nd team activity • The 2nd classroom observation
May, 16	• 3rd team activity : Capstone design with design, production and revision of permanent magnet
May, 23	• Presentation and share between teams on 3rd team activity • The 3rd classroom observation
May, 30	• 4th team activity : Final capstone design with product a car based on permanent magnet developed
June, 6	• Presentation and share between teams on 4th team activity • The 4th classroom observation
Follow-up activities (Analysis)	1. Learning result measurement 2. Student's satisfaction measurement 3. Teacher activities based on ADD-SICAT-ER 4. Survey on instructional activities

③ The R type

○ Subject: Engineering experiment using Experiment materials (optic characteristics of materials)

○ Participants: 30 persons (6 teams, 5 persons in a team)

○ Period: Wednesday and Thursday of 1^{st}-3^{rd} week on May

○ Schedule

Time	1st week	2^{nd} week	3^{rd} week
Student's activities	Theory lecture: Optic characteristics of materials	Experiment 1: IR, UV/VIS evaporation measurement	Experiment 2: Observation laser driving and waveguide/nonlinear feature in Specimen material
Reflection comment	· Identify research problem from theory lecture · Preview of next step · Complete reflection comments to others (over 3 times)	· Reflection on Experiment 1 · Complete reflection comments to others (over 3 times)	· Reflection on Experiment 2 · Complete reflection comments to others (over 3 times) (See Appendix3)
Reflection question	· Make reflection questions to check self's level on experiment	· Make reflection questions to check self's level on experiment	· Make reflection questions to check self's level on experiment
Reflection Response evaluation			· Self-evaluation on reflection activities during 3 week (See Appendix3)

Results

After application, the students, teachers and tutors were surveyed and interviewed, and then the results analyzed in order to uncover inhibiting/facilitating elements and the rate of satisfaction.

The satisfaction rate of students from the SICAT teaching and learning model was 3.78(in a perfect score of 5: The A type-3.65, The C type-3.80 and The R type-3.90).

Results on The A type

① Student's satisfaction of The A type

Student's satisfaction of The A type represented average 3.65(in a perfect score of 5). In detailed, reasoning activities were acquired through the assignment that the result was the highest responses to 4.08. Also the application of this type has been helpful to perform this learning task with 3.96. However, the appropriate evaluation process and method were the lowest to 3.42.

② Facilitators and Inhibitors of The A type

According to survey result of students and a teacher on The A type application, facilitators and Inhibitors are as Table 2:

Table 2. Facilitators and Inhibitors of The A type

Facilitators	Inhibitors
Increase of self-regulated learning experience	Increase on instructional level of difficulty
Increase of online/offline collaboration and interaction	Increase of student's pressure on dual learning(online/offline)
Opportunity to expand higher level thinking	Preparation of requirements on learning environment (class hour and size, technical support system and etc)
Discussion culture formation with argumentation reasoning	

■ Facilitators of The A type

First of all, students experienced more self-regulated learning than previous method. In detailed, students were able to look for their own thinking and reasoning and get a opportunity to claim own argumentation results. Teachers could get students to perform activities and solve problems creatively designed. Secondly, Increase of online/offline collaboration and interaction was shown. With using online and offline learning space, either directly or indirectly through an exchange of views and opinions of their argumentation and argumentation about the activities of others opinions was possible. In other words, it overcame the limitations of the offline classroom. The third, students could get more opportunity to expand higher level thinking. It was helpful to find what the core problem has been recognized. The teacher responded that argumentation and reasoning activities in the engineering education were necessary same to research on learning content. In the end, Discussion culture was formed naturally with argumentation reasoning activities. Students could be easily familiar with discussion culture if they are taken encouragement by cooperation through group work.

■ Inhibitors of The A type

It could increase on instructional level of difficulty. The teacher responded that especially lower level students felt difficult to find the process and draw conclusions. Moreover, it was shown increase of student's pressure on dual learning, online/offline as well as previous theory learning/ another activity. One more, students and a teacher also should get preparation of requirements on learning environment such as class hour, participations, technical support system and etc.

Results on The C type

① Student's satisfaction of The C type

Student's satisfaction of The C type represented average 3.80(in a perfect score of 5). In detailed, creative design activities has been helpful to improve comprehensive judgment that the result was the highest responses to 4.20. Furthermore, the application of this type has been contributed to perform learning purpose with 4.10. However, same as The type A, the appropriate evaluation process and method were the lowest to 3.32.

② Facilitators and Inhibitors of The C type

According to survey result of students and a teacher on The C type application, facilitators and Inhibitors are as Table 3:

Table 3. Facilitators and Inhibitors of The C type

Facilitators	Inhibitors
Alignment theory and practice on learning theme	Difficulties of learning theme choice according to higher level of difficulty
Facilitation of team activities facilitation with collaboration	Insufficiency of evaluation and learning preparation depends on student's level
Facilitation of team activities through collaboration	

■ Facilitators of The C type

It was ideal instruction with combination theory and practice. In addition, it could be facilitation of team activities facilitation with collaboration. Creative design activities conducted in teams were similar to the actual engineering of the project and students were interested in especially team activities. Finally, students were able to acquire that facilitation of team activities through collaboration. It was more that the existing class that all team members together could participate and share ideas to get the best idea.

■ Inhibitor of The C type

There would be shown difficulties of learning theme choice according to higher level of difficulty.

It needed much time and student's flow to investigate and then complete assignment. The teacher told that a class of the junior or senior would be more suitable. Also, evaluation and learning preparation depended on student's level would be Insufficient.

Results on The R type

① Student's satisfaction of The C type

Student's satisfaction of The R type represented average 3.90(in a perfect score of 5). Relatively the responses on level of instructional difficulty and usability of engineer's competency development were the lowest to 3.79. Questions of evaluation were not conducted because instructional mode of the Type R with omnibus style is not similar to the Type A and C.

② Facilitators and Inhibitors of The C type

According to survey result of students and a teacher on The R type application, facilitators and Inhibitors are as Table 4:

Table 4. Facilitators and Inhibitors of The R type

Facilitators	Inhibitors
Easy online access for reflection activity	Pressure and responsibility of reflection/sharing activities
Ability to parallel with reflection and sharing activities	Limitation of asynchronous interaction
Increase of online interaction	

■ Facilitators of The R type

It was easy online access for reflection activity. Students left some comments online not too long as emoticon were also permitted. There was ability to parallel with reflection and sharing activities. Students could check, share and ask information related to instruction easily with other students, tutor, and the teacher. In the end, student's online interaction and more active participation was definitely increased.

■ Inhibitors of The R type

The one of inhibitors represented students' pressure and responsibility of reflection/sharing activities. Students needed more time to participate in reflection/sharing activities comparing to ordinary other class. Also, the word, 'reflection' was unfamiliar to students. Moreover, online BBS had Limitation of asynchronous interaction. It would be better that the number of students participated could be lessened.

Conclusion

The satisfaction as well as inhibiting/facilitating elements of SICAT model could be shown again with the aspects of student, teacher, and support system respectively as the below Table 5. In conclusion, they can be contributed for implications of SICAT teaching and learning model universal use at engineering education in University.

The First of facilitators, it should be emphasized on self-regulated learning to ultimately improve the accessibility of engineering talent. It is necessary as following teacher aspect that engineering classed are similar to actual team performance in the field of engineering. A class with fully higher thinking and creative ideas of teachers would make students easily to be accustomed with the field. In terms of support system aspect, it should be focused on alignment with online/offline and individual/team learning designed.

There are some implications from inhibitors as well. Students get unnecessary burden on learning activities actively so it needs to help them to overcome it with more sophisticated learning method. According to this point, teacher should Support with long-term instructional design and plan depended on student's level as well as various instruction evaluation tool. Finally, in terms of support system aspect, more advanced technical system also should be prepared such as class hour and size, technical support requirement and etc.

The innovative future of engineering education could make develop engineering talent capability to strengthen facilitators and complement inhibitors of SICAT model as mentioned as the previous. The following of this research needs to represent more practical application idea customized situated context of engineering instructional design to improve feasibility of SICAT model.

Table 5. Implications from Facilitators a 1

	Implications from Facilitator	Implications from Inhibitors
Student aspect	Pursue self-regulated learning with increase of learning access	Lessen students' pressure on new learning method and Increase efficiency
Teacher Aspect	Develop Higher and creative thinking with team practical application	Support with long-term instructional design and plan depended on student's level and instruction evaluation
Support System aspect	Focus on combination with online/offline and individual/ team learning	Prepare more advanced technical system

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<Appendix 1>

[Figure 1] Online community in Ezhub of 1

<Appendix 2>

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▸ 목록

코멘트 (5개)

현구(00012002006015) 2009/03/31

자전은 구형 면의 한 접점을 기준으로 원운동(공전)을 하는 것을 말하는 것인가요??

박형웅(00012003009921) 2009/04/04

자전은 원자들이 증착 될 기판을 말하는 것입니다. 쎄타와 파이가 같을 경우 수식적으로 균일하게 만들 수 있지만, 기판 자체는 곡률을 가지지 않으므로 이것이 자전하게 된다면 더욱 균일한 박막을 얻을 수 있을것이라 생각하였습니다. 물론 완전 저의 생각은 아니고 삼성전기측의 특허 내용을 읽고 그 모티브를 소개 한 것입니다.

박형웅(00012003009921) 2009/04/04

또한 source기준으로 low angle과 high angle사이에 증착되는 정도가 다를것이므로 로딩된 전체 기판을 공전시킨다는 아이디어를 제시하였습니다.

현구(00012002006015) 2009/04/05

좋은 생각인것 같네요~^^ 하지만 위치마다 증착 시간과 자전과 공전의 회전 속도가 또하나의 변수로 작용하겠군요 ㅠㅠ

김동호(00012003009794) 2009/04/05

시편의 크기에 의한 중심부와 가장부분의 차이까지 고려하여 일정한 두께로 증착하기 위해서는 회전축을 중심으로 회전하여야 할 것이라는 생각까지는 했었는데 글로만 전달하려고 하니 저는 도무지 자신이 없었는데... 참고자료를 찾기 위해서 시간을 많이 투자하셨겠네요. 그림이 있으니 훨씬 이해가 쉽게 되었습니다.

[Figure 1] Online argumentation activities

<Appendix 3>

07 황일선 2009/05/23 11:22 답글 | 신고 | 삭제

진짜 평소에 공부를 열심히 해야겠다는걸 이번 실험을 통해서 절실히 느꼈어-_-;;;

B조 윤준호 2009/05/23 11:34 답글 | 신고 | 삭제

잔광효과가 큰이유가 떨어지는 시간이 오래 걸리다는것 보다는 여러개가 꾸준히 떨어지는 것 일지도 모르겠네요..

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07 최수교 2009/05/23 15:50 답글 | 신고 | 삭제

아직도 너무 어려운 점이 많아 ㅠㅠ. 마지막 문단에 흡수도에 대한 얘기는 나는 다르게 생각했었는데 그 생각이 틀린 것 같아. 근데 정확하게 어떻게 되는건지를 모르겠네.

07전희영 2009/05/24 00:51 답글 | 신고 | 삭제

밴드갭 에너지 이상의 에너지를 가지는 빛을 쏘아주어도 흡수도가 가장 큰 파장(에너지) 영역이 일정한 이유는 정말 이해가 잘 안되네;; 혹시 물체의 고유 영점 에너지랑 격자 구조와 관련 있는 것은 아닐까?

[Figure 3] Reflection comment

신동욱교수님 실험실에서의 3주 수업도 이제 끝이 났네요. 얻어가는 것도 많았고, 아쉬운 점도 있었지만 특히 마지막주인 이번 실험은 친절하게 세세한 내용마저 다 알려주시려 하신 조교님 덕에 여태까지의 모든 실험수업 중 개인적으로 가장 유익했고 만족한 수업이었던 것 같네요.

마지막 실험이 약간 아쉬웠지만 전체적으로 3주 실험의 커리큘럼은 대체적으로 새로운 시도였다고 생각합니다. 이후에는 좀더 많은 내용과 효율적인 시간운용으로 더 좋은 결과 있기를 바랍니다.

[Figure 4] Reflection response evaluation

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