Proposal of an Educational Design to Improve High School Science Students' Motivation to Enroll in a University's Department of Science and Engineering

Yuto Omae, Katsuko T. Nakahira, and Hirotaka Takahashi
Nagaoka University of Technology
Niigata, Japan
e-mail: y_omae@stn.nagaokaut.ac.jp, katsuko@vos.nagaokaut.ac.jp, hirotaka@kjs.nagaokaut.ac.jp

Abstract—**Many Japanese students pursuing science and engineering majors drop out of the program due to a lack of motivation to learn. One reason is students' declining interest in science or engineering, mainly because their career goals are vague. Helping students make better choices when choosing a university/department by increasing their motivation is an effective way to improve this situation. One approach is to provide stimuli that increase students' interests and provide them with a feeling of satisfaction. Changing the educational environment is one way to provide these stimuli. We assume that students' motivation to study science and technology will increase if we contribute to constructing these environments. In this paper, we propose an educational design including micro-insertion to improve students' motivation.**

Keywords-educational design; perception; motivation; micro-insertion; teaching science.

I. INTRODUCTION

One goal of the Japanese government policy is to realize a "scientific and technological nation," due to the shortage of energy resources. Thus, the Japanese government has conducted many projects for training human resources of technology-focused public educational institutions (e.g., Super Science High School and Science Partnership Program [1][2]). As a result of these projects, the ratio of an enrollment to university in the department of science and engineering was 20% [3]. However, the dropout rate in this department is higher than that in Liberal Arts [4]. The major reasons that students drop out of the program are classified as "positive reasons (e.g., studying abroad, changing interests, aiming at acquisition of qualifications)" and "negative reasons (e.g., loss of motivation, insufficient credits, and student apathy)" [4]. The existences of the dropout students from the department of Science and Engineering become disincentive for the above purpose in Japan. As a result, young people not in education, employment, or training (NEET) and unemployment rates increase [5]. Therefore, it is important to address the negative reasons that students drop out.

To address this issue, it is necessary to increase the motivation of high school students to enroll in university science and engineering. Thus, we focus on the high school science courses taken by the applicants to the department of Science and Engineering at the university level. In such courses, some students are highly motivated to enroll in courses at a university's department of science and engineering, and others are not. The highly motivated students will choose and follow an appropriate path because they have a clear career plan. Those with low motivation will not do so because their career plan is vague. However, if they have many chances to come in contact with positive stimuli that increases their interest and gives them satisfaction, their motivation may increase. An education environment that is constructed using an educational design that has such an effect is one solution to improving students' motivation. Therefore, the instructor should be aware of each student's situation because each student is unique; for example, one student may lack interest, while another student lacks confidence. For this reason, it is important to develop an educational design that includes "adaptive" methods. To improve student's motivation effectively, the teacher must appropriately assess the shortage factors that affect a student's motivation. Thus, it is useful for instructors to assess their students' psychological state (e.g., interest, confidence, and satisfaction).

However, if only one of the teachers assesses the motivation of students, it is jot sufficient to increase their motivation. To effectively increase student's motivation to go to university science and engineering courses, many science teachers have to cooperate and aim to increase the importance factor (such as micro-insertion, mentioned later).

Thus, to increase students' motivation, we propose an educational design by which high school teachers of science-related subjects understand the important factors pertaining to Information Technology (IT) and cooperate with one another. The targeted students are high school students who have low motivation to enroll in university classes in science and engineering.

Section II explains the details of the proposed educational design. Section III presents conclusions and discusses future work.

II. EDUCATIONAL DESIGN

A. Factors Affecting Motivation

A student's motivation for the future is affected by interest, confidence and so on. For example, the student who thinks "I can learn something interesting by enrolling in the course" is likely to be motivated. However, the student who thinks "I cannot succeed in this course" is not likely to be motivated. If some external influence changes students' perception, their motivation also changes. Figure 1 illustrates an example. A new perception of science results from interaction between the current perception and an external influence. In addition, the student's motivation increases due to this new perception.

For example, when students experience uninteresting stimuli, their perception and motivation become negative. When they experience interesting stimuli, their perception and motivation improve (Figure 1). The aim of the present study is to increase students' motivation to enroll in university's department of science and engineering by improving their perception of science. Table I lists factors of perception that affect the motivation to enroll in university science and engineering courses. One theory regarding motivation for the future is the expectancy value model [6]. According to this model, choices for the future are affected by *expectation of success*, *intrinsic value*, and *attainment utility value*. Since *satisfaction* is also motivation for behavior selection [7], we assume that *satisfaction* affects an individual's choices for the future. Therefore, we tentatively adopted *intrinsic value*, *attainment utility value*, *expectation of success*, and *satisfaction* as factors affecting the motivation to enroll in university classes in science and engineering. We refer to these four factors as "*science perception*." We assume that students' motivation to enroll in science and engineering classes depends on their *science perception*, and that science teachers can change this *perception*. For example, if the teacher for the science subject performs the class to increase *intrinsic value* (e.g., talking to increase curiosity), their *intrinsic value* is increase. This increased *intrinsic value* raises students' motivation to enroll in university science and engineering classes. Thus, it is important for science teachers to improve their students' *perception* of science. We propose the use of *micro-insertion* to accomplish this goal.

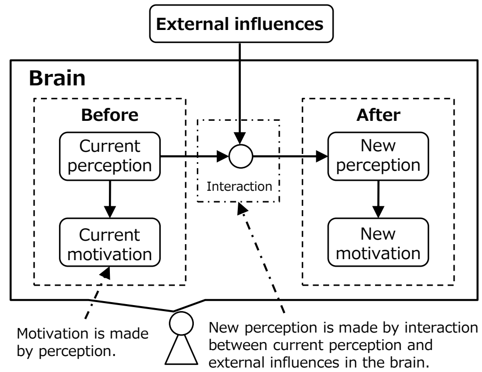

Figure 1. Change of perception and motivation.

TABLE I. FACTORS OF SCIENCE PERCEPTION AND ITS DEFINITIONS

Factor	Definition
Intrinsic value	The enjoyment one gets from engaging in the task or activity
Attainment utility value	The instrumental value of the task or activity for helping to fulfill another short or long-range goal and the link between the task and one's sense of self and identity
Expectation of success	Confidence about one's personal efficacy to master the task
Satisfaction	The degree of feelings such as "I want to do this task" after the task or activity about science in high school.

B. Micro-insertion

Micro-insertion is a teaching method proposed by Michael Davis for engineering ethics [8]. This method involves not only teaching engineering ethics as a major subject but also inserting ethical topics in other classes. The object of our research is not engineering ethics. However, this teaching method such as aiming at achievement purpose of the education with a part of lesson time in many subjects would be applicable to not only engineering ethics but also other purpose on education. Therefore, we include *micro-insertion* in our educational design. Figure 2 (a) depicts typical education, and Figure 2 (b) depicts education using *micro-insertion*. Sample students in Figure 2 (a) and (b) have high enough factors except *attainment utility value*. In other words, the teacher should increase *attainment utility value* for these students. For example, in typical education, the mathematics teacher sets a high value on *attainment utility value*; the physics teacher sets a high value on

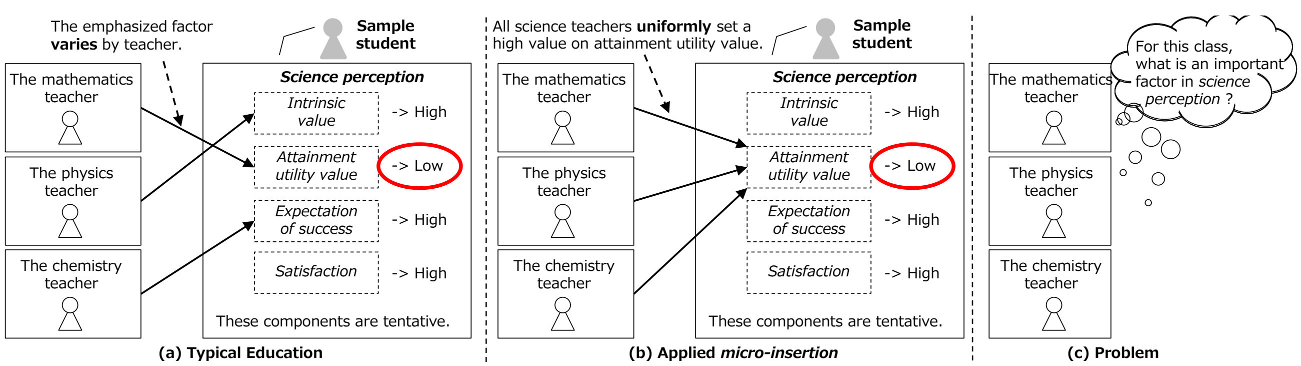

Figure 2. Typical education, *micro-insertion*, and problem.

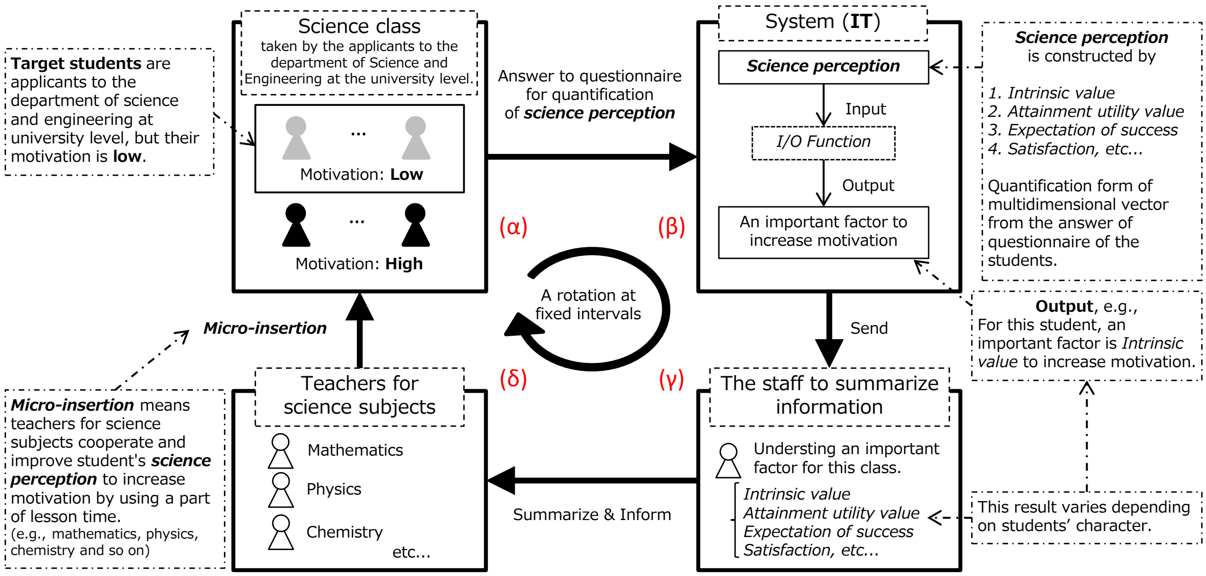

Figure 3. Educational design.

intrinsic value; and the chemistry teacher sets a high value on *expectation of success*. The emphasized factor varies by teacher, as depicted in Fig. 2 (a). Figure 2 (b) presents an example of a teaching method using *micro-insertion*. Unlike typical education, all science teachers uniformly set a high value on *attainment utility value* in their lessons. Because students are provided stimuli uniformly by all science teachers, we assume that the motivation to enroll in a university's department of science and engineering will increase as a result of the use of *micro-insertion* (Figure 2 (b)), unlike the situation with the typical educational approach (Figure 2 (a)).

C. *Application of IT*

One problem with the application of *micro-insertion* in education is illustrated in Figure 2 (c). Figures 2 (a) and (b) present an example of students whose *attainment utility value* increases. However, in reality, some students' *intrinsic value* or *expectation of success* should increase. To understand an important factor from among *science perception* needed to increase student's motivation, teachers must have expert education experience and a lot of time. This is very difficult. To solve this problem, it is necessary to construct a function that outputs the most effective factor in *intrinsic value*, *attainment utility value*, *expectation of success* and *satisfaction* to increase motivation to go to university science and engineering classes when we input student's *science perception*. In addition, we need to construct a method that summarizes each student results in comparison to the whole class results. Therefore, we must develop a system using machine learning and statistics (IT).

D. *Proposed Educational Design*

Based on the information above, we propose an educational design using IT and *micro-insertion* (Figure 3).

Figure 3 (α) depicts a high school science class of students who have applied to enroll in university science and engineering classes. This class includes both students with low motivation and those with high motivation. The target of our proposed educational design is those with low motivation. We utilize a questionnaire to quantify the *science perceptions* of those students. The results are presented in Figure 3 (β).

(β) in Figure 3 is a system to output an important factor in *science perception* to increase student's motivation. First, to quantify students' *science perceptions*, the system transforms responses to the questionnaire into a multidimensional vector consisting of *intrinsic value*, *attainment utility value*, *expectation of success*, and *satisfaction*. Next, this vector is input into an input-output (I/O) function. Finally, the I/O function outputs an important factor of *science perception*. This result depends on the students' *science perceptions*. For example, some students' motivation is strongly increased due to increasing *intrinsic value*. However, others' motivation depends on increasing *expectation of success*. This result is sent to (γ) in Figure 3.

The staff of (γ) receives the results from (β). They summarize the results and send messages about them to science teachers (e.g., the target class has many students who need *expectation of success* to increase their motivation to enroll in science and engineering classes). The results vary, depending on students' *science perceptions* in class. This result is sent to (δ) in Figure 3.

In Figure 3, (δ) corresponds to teachers of science-related subjects (e.g., mathematics, physics, and chemistry). These teachers follow an education design that includes *micro-insertion* as depicted in Figure 2 (b), referring to the information from the staff of (γ). For example, if many students need increased *intrinsic value* to increase their

 ISBN: 978-1-61208-390-2

motivation to enroll in university science and engineering classes, the teachers of science-related subjects should give them information that will increase their *intrinsic value* as part of the lessons. Likewise, if many students need increased *expectation of success* to increase their motivation to enroll in university science and engineering classes, teachers of science-related subjects should give them information that will increase their *expectation of success* as part of the lessons. Applicants' motivation to enroll in university science and engineering may increase as a result of using this educational design in various science-related classes rather than in only one subject.

The proposed educational design, as illustrated in the process from (α) to (δ) in Figure 3, increases students' motivation.

III. CONCLUSION AND FUTURE WORK

In this paper, we proposed an educational design that increases students' motivation to enroll in university science and engineering. The target is high school students with low motivation in science classes. To realize it, we will implement the following procedure. First, we need to determine the constituent factors of *science perception* that affect students' motivation to enroll in university science and engineering (In this paper, we use *intrinsic value*, *attainment utility value*, *expectation of success* and *satisfaction* as *science perception*). Second, we need to develop a questionnaire to quantify these factors. Lastly, we need to construct a function to output an important factor to increase students' motivation when we input students' science perception.

After resolving the above issue, we will verify the effect of our proposed educational design. We have conducted a questionnaire survey of high school students (n = 120). We are in the process analyzing the acquired data and will report the results in future work.

ACKNOWLEDGMENT

This work was supported in part by JSPS KAKENHI Grant-in-Aid for Scientific Research (No. 24501146). This work was also supported in part by Nagaoka University of Technology Presidential Research Grant (D).

We would like to thank Takako Mitsui, Yoko Tsuchiya and Rai Shukuin at Yamanashi Eiwa Junior and Senior High School for cooperating on our research.

REFERENCES

[1] Surper Science High School. [Online]. Available from: https://ssh.jst.go.jp/ 2014.11.17

[2] Science Pertnership Program. [Online]. Available from: http://www.jst.go.jp/cpse/spp/ 2014.11.17

[3] Ministry of Education, Culture, Sports, Science and Technology, "Basic Research on School" [Online]. Available from: http://www.mext.go.jp/b_menu/toukei/chousa01/kihon/1267995.htm 2014.11.17

[4] C. Uchida, "Daigaku ni okeru kyu-taigaku ryunen gakusei ni kansuru tyousa (The 32th report of survey about the dropout students in the university)", the report of the 32th meeting of the japanese association for college mental health, 2011.

[5] Ministry of health, labourt and welfare, "NEET no zyoutai ni aru wakamoono no zittai oyobi siensaku ni kansuru tyousa kenkyu (Sruvey about actual state of young fellow for NEET)", [Online]. Available from: http://www.mhlw.go.jp/houdou/2007/06/h0628-1.html

[6] J. S. Eccles, "Where are all the women? Gender differences in participation in physical science and engineering", American Psychological Association, 2005, pp. 199-210.

[7] M. Kitajima and K. Naitou, "Syouhisya koudou no kagaku (Science for consumer behavior)", Tokyo Denki University Press, 2010.

[8] D. Michael, "Integrating ethics into technical courses: *Micro-insertion*." Science and Engineering Ethics 12.4, 2006, pp. 717-730.