An Active Learning Project with Deliberate Practice in Vocational Training for Environmental Energy Engineers

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Abstract Vocational trainees should graduate with the capability to perform their jobs. Along with advances in science and technology, the abilities provided in vocational training have changed from sensory work to related knowledge work. However, vocational training has not adequately responded to the advancement and broadening of such technical abilities. In this paper, we describe an active learning project to train environmental energy engineers through deliberate practice. As a final goal, the project aims for trainees to complete jobs by thinking like environmental energy engineers. It integrates conventional lectures and practical training. First, in a pre-training orientation, the overall contents of the training and its evaluation criteria are explained. Then, trainees learn job operations through practical training with equivalent and actual equipment used by energy engineers. Finally, job operation knowledge and related knowledge are connected. In evaluating and verifying this project, we identified significant improvement in training effects compared to conventional training.

Keywords: deliberate practice, active learning, vocational training, effect size, rubric

1. Introduction

Serious global environmental problems are causing many people to pay attention to environmental energy technologies. Japan’s national government has established Departments of Electrical Energy at 16 polytechnic colleges; these departments require teaching of environmental energy technologies. However, environmental energy technologies encompass a wide field of knowledge and both understanding relationships among those various fields and obtaining sufficient training effects are difficult to achieve.

In post-secondary education, many conditions have been clarified for optimum learning (1,2). The most cited condition concerns students’ motivation to attend to the task and to exert efforts to improve their performances. Embodiments of such education are widely known as active learning. In active learning, the task design should take into account learners’ preexisting knowledge so that the task can be correctly understood after a brief instructional period (3). Additionally, learners should receive immediate informative feedback about their performance results, and they should repeatedly perform the same or similar tasks. When these conditions are met, learning improves accuracy and performance speed on cognitive, perceptual, and motor tasks (4–6). So far, many active learning lessons that satisfy these conditions have been implemented (7–9). Under such circumstances, active learning by deliberate practice that dramatically increases educational effects is drawing much attention (10). Deliberate practice is a model not only of experts’ behaviors, but also of their mind images including concepts; it obtains maximum performance on the basis of immediate feedback. Until now, active learning by deliberate practice has largely been used in medical education (11–13) and university education (14,15) that targets persons with high prior knowledge levels and high general abilities. Practical research on deliberate practice has not been conducted in vocational training programs for diverse groups of trainees.

In this paper, we describe the effectiveness of an environmental energy engineer training project conducted as active learning with deliberate practice (hereafter referred to as the project), which integrates environmental energy engineering lectures (36 h) and environmental energy experiments as practical training (36 h). Training of the environmental energy engineers includes self-feedback based on evaluation criteria and model answers presented in advance and on feedback from instructors and group members while trainees work on tasks. In this way, trainees receive a variety of feedbacks and learn how to perform tasks by thinking like environmental energy engineers (hereafter referred to as job performance) while correcting erroneous understandings. First, trainees learn job operations during practical training with actual, equivalent equipment.
used by energy engineers. Next, we link job operation knowledge and related knowledge, with practice coming first.

2. Vocational Training for Environmental Energy Engineers

2.1 Outline of Environmental Energy Technologies

In Japan, until 2030, all new construction will be promoting the “net-zero energy house” (hereafter referred to as ZEH). This is a plan to make house energy generation and consumption equal. The Department of Electrical Energy has been newly established in 16 polytechnic colleges in anticipation of the demand for environmental energy engineers. From this background, instruction in environmental energy technologies in the Department of Electrical Energy is positioned as particularly important.

In vocational training for environmental energy engineers, trainees learn the five basic technologies shown in Figure 1. Basic technologies consist of solar power generation, wind power generation, power conditioners, heat pumps, and regenerative energy. In the Department of Electrical Energy, these basic technologies are learned from environmental energy engineering lectures (36h) and environmental energy experiments as practical training (36h).

For vocational training quality assurance, the national government has convened a committee that gathers experienced instructors and experts to create curriculums and standard textbooks. For environmental energy engineering lectures, instructors are free to select textbooks and are trained according to the curriculum created by the committee. Meanwhile, for the environmental energy experiments, the instructors’ freedom is limited because the same equipment is introduced uniformly nationwide, and training is conducted according to the national committee’s curriculum and standard textbooks. Standardization of the curriculum is important for quality assurance of training that utilizes a combination of advanced expert knowledge such as knowledge of environmental energy technologies. However, with this external standardization of the curriculum, it is difficult to guarantee the quality of training for the diversity of trainees enrolled at a particular polytechnic college.

In the 2016 academic year, from a class of 19 trainees at Shikoku Polytechnic College, 3 trainees in the lecture classes of environmental energy engineering and 1 in the classes of environmental energy experiments had failing grades and did not pass to the next year of study; they were required to repeat the classes. However, this decision of failure also took into consideration attendance points. If only raw class scores were considered, 8 trainees in the lecture classes of environmental energy engineering and 6 in the classes of environmental energy experiments failed. In the lecture classes of environmental energy engineering, along with the textbook reading, the instructor wrote important contents on the blackboard and explained those contents. In conventional lecture classes at Shikoku Polytechnic College, a method of mastery learning(16) has been adopted and divided the final examination into seven mini-tests to prevent leakage of the test contents (The seven mini-tests in Fig. 2). In mastery learning, mini-tests and supplements were repeated until passed. However, failed trainees began to memorize calculation methods and technical terms only to the point of avoiding retesting, and they did not try to reduce failures by actually learning the lecture contents. Also, since there was only one set of laboratory equipment for practical training, there was a problem that learning contents of lectures and the practical training could not be experienced at the same time. From the trainees, there have been many saying “Although practical training can be understood roughly, lectures are difficult to understand.” Therefore, in this project, we set the hypothesis that the main cause of failures came from lack of understanding

![Figure 1. Basic Technologies for Environmental Energy Engineers.](image-url)
of the correspondence between job operations (practical training) and operation knowledge (lectures). Therefore, we redesigned the active learning project by adding deliberate practice, and we successfully reduced the number of trainee failures and raised the overall level of trainee achievement.

2.2 Redesign of Vocational Training for Environmental Energy Engineers

Our active learning project featured active learning with deliberate practice. It was redesigned with reference to practical research on active learning incorporating deliberate practice published in the literature\(^{(15)}\). The project was the redesign of a conventional training and had the following five conditions.

1. Teaching material design was based on images as seen in the minds of experts.
2. Teaching material design imposed a learning load slightly exceeding the ability of the trainees.
3. Teaching material design was such that tasks could be correctly executed after short-term guidance by instructors.
4. Teaching material design was intended to give instant feedback and allow self-evaluation.
5. Teaching material design featured practice alone, without lectures.

Conditions (2) to (4) are the basic design conditions of active learning. We redesigned the active learning environment so that trainees could learn actively by preparing tasks, model solutions, and rubrics. The role of the instructor in this project was to offer guidance and support for problem solving for each trainee. For example, as guidance on how to learn, before group learning, the instructor might offer the advice: “First of all think for yourself, discuss it further.” The goal of conventional training was to train students in the ability to utilize energy-saving technology and natural energy technology. The content that was learned by lectures and practical training was utilized in occupational scenes. On the other hand, in this project, we redesigned the final goal as to propose and design a ZEH. The training content was focused on proposing and designing the ZEH by thinking like environmental energy engineers. Also, the deliberate practice became an educational method that emphasized practice alone. By redesigning practical training first, each trainee could learn related knowledge through try and error.

Figure 2 compares details of conventional training and the active learning project. The two training ranges and the training time were the same. In conventional training, lecture and practical training were conducted separately. In lectures, along with the textbook reading, the instructor wrote important contents on the blackboard and explained the contents. As aforementioned, it was not possible to set learning contents of lectures and practical training at the same time. On the other hand, in the project, we integrated the lectures and the practical training, and divided the project contents according to the five basic technologies of environmental energy; each technology was treated in its own stage. Each stage consisted of practical training first. The practical training was basically the same as in the conventional training, with discussion in groups and repeating by trial and error. But the practical training also included mini-lectures. After that, the trainees engaged in active learning with learning tasks including and mini-tests.

3. Environmental Energy Engineer Training by Deliberate Practice

3.1 Instructional Methodology

This section describes the project methodologies:
practical training and lectures. In the overall training, each trainee actively learns with other group members each part of the training tasks to reach the final goal.

Figure 3 shows trainees carrying out the heat pump experiment as an example of a task learning of practical training. In practical training, the division of roles and jobs is collaboratively decided in groups of three to four trainees. After the practical training, trainees learn related knowledge in group-learning and mini-lectures.

Figure 4 shows a conceptual knowledge task and a design knowledge task. These are examples of two tasks in lectures. The learning tasks of the lecture and practical training are related to the design and proposal of the ZEH. In the lecture tasks, each trainee reads the same range of textbooks as in a conventional lecture, using the same textbook as before the training. In this way, trainees learn techniques of proposing and designing the ZEH through active learning. Conceptual knowledge tasks link understanding and relationships of knowledge distributed across a wide field. The example shows an overview of environmental problems occurring on a global scale. From the aspect of economic growth, energy supply, and global environmental conservation, the task is to write the technical terms in parentheses. In this task, only the technical terms related to the proposal and design of the ZEH in the conventional training are written in parentheses. On the other hand, by the installation-knowledge task trainees acquire knowledge in order to propose and design environmental energy equipment. Another example is the problem of the heat pump performance coefficient. Design knowledge tasks are the same as in the conventional training. With reference to the practical training textual example, trainees repeatedly practice exercises and increase their ability. As in conventional training, we conduct a mini-test (previously one-seventh of the final examination). Also, as in the conventional training, the mini-tests are conducted seven times as divisions of final examination, and the mini-test and commentary were repeated until the former was passed.

3.2 Training Flow Details

The training flow first explains the whole picture through an orientation and, second, presents the five fundamental technologies. The training content of each stage for learning the five basic technologies is shown below. Table 1 also summarizes experimental and measuring devices for practical training.
Table 1. Experimental and Measuring Devices for Practical Training.

| Stage       | Experimental device                      | Measuring device                          |
|-------------|------------------------------------------|-------------------------------------------|
| S1: Solar power | ∙ Solar cell module                     | ∙ Pyrheliometers                          |
|             | ∙ Charge controller                      | ∙ Data logger                             |
|             | ∙ Transducer                             | ∙ Personal computer                       |
|             | ∙ Current detection resistor             | ∙ Spreadsheet program                     |
|             | ∙ Inverter                               |                                           |
|             | ∙ 12V battery                            |                                           |
|             | ∙ Inverter                               |                                           |
| S2: Power conditioner | ∙ Power Conditioner                  | ∙ Digital wattmeter                        |
|             | ∙ DC power supply unit                   | ∙ Oscilloscope                            |
|             | ∙ Load device                            | ∙ Solar cell simulator                     |
|             | ∙ GPIB-USB conversion adapter            |                                           |
|             | ∙ Digital wattmeter                      |                                           |
|             | ∙ Oscilloscope                           |                                           |
| S3: Wind-power generation | ∙ Indoor wind power generation  | ∙ Voltmeter                               |
|             | ∙ 12V battery                            | ∙ Ammeter                                 |
|             |                                           | ∙ Tachometer                              |
|             |                                           | ∙ Anemometer tester                       |
|             |                                           | ∙ Personal computer                       |
| S4: Heat pump | ∙ Heat pump                              | ∙ Mollier chart                           |
|             |                                           | ∙ Voltmeter                               |
|             |                                           | ∙ Thermography                            |
| S5: Regenerative energy | ∙ AC servomotor                          | ∙ Regeneration energy                     |
|             | ∙ Flywheel                               | ∙ measuring software                      |
|             | ∙ Electric double phase capacitor        | ∙ Spreadsheet program                     |
|             | ∙ Power supply with power generation function | ∙ Personal computer                      |
|             | ∙ Inverter                               |                                           |

A. S1 Solar power
In the solar panel practice, trainees calculate PV efficiency for various cases, such as when shade covers part of a solar panel. Specific tasks include shade occurring on part of the solar panel or consideration of the area characteristics. After that, mini-lectures are done by using video on solar photovoltaic system structures and use-situations in electrical equipment related jobs. Each trainee tackles a design knowledge task. In S1, 3 mini-tests are conducted.

B. S2 Power conditioner
In the power conditioner practice, trainees confirm power generation performance of the solar power with an open circuit voltage and short circuit current, they confirm I-V and P-V characteristics when shade covers part of a solar panel, they calculate the conversion efficiency of the power conditioner, and finally, they confirm the operation of the independent operation prevention function. After that, the mini-lectures are done by using video on the solar photovoltaic system structures and use-situations in electrical equipment related jobs.

Each trainee tackles a design knowledge task. In S2, 1 mini-test is conducted.

C. S3 Wind-power generation
In the wind power generation practice, trainees calculate the power coefficient of the wind turbine generator, the generated power and wind speed, and the theoretical output of the windmill. Here, consideration of the characteristics of the area is included in the task. After that, the mini-lectures are done using video on wind power photovoltaic generation system structures and use-situations in electrical equipment related jobs. Each trainee tackles a design knowledge task. In S3, 1 mini-test is conducted.

D. S4 Heat pump
In the heat pump practice, trainees draw a refrigeration cycle using a Mollier chart, and then they calculate the coefficient of performance for the cooling/heating cycle and they calculate the cooling/heating capacity. After that, the mini-lectures are done using video on the heat pump system structures and the main functions. Each trainee tackles a design knowledge task. In S4, 1 mini-test is conducted.

E. S5 Regenerative energy
In the regenerative energy practice, trainees measure the capacitor rising voltage, calculate the energy conversion efficiency, and improve the conversion efficiency. After that, the mini-lectures are done using video on regenerative energy mechanisms and problems. Each trainee works on design knowledge tasks. In S5, 1 mini-test is conducted.

4. Results
4.1 Results Assessment
In this section, we describe the project evaluation method for lectures and practical training. Evaluation of lectures is done from mini-tests which confirm mastery of the presented knowledge. Also, evaluation of practical training is done from reports prepared for the tasks.

Table 2 displays final problems and the evaluation items for the reports. The final problem of the report is
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Table 2. Final Tasks and Evaluation Items in Practical Training at Each Stage.

| Final tasks of each stage |
|---------------------------|
| **S1** | Explain how to calculate PV efficiency.  
| | Explain the relationship between intensity of solar radiation and PV efficiency. |
| **S2** | Explain the effect of open circuit voltage, short circuit current and fill factor on the power generation performance of the solar panel.  
| | Explain the important points when connecting multiple solar panels.  
| | Explain the change in output characteristics when light shielding occurs in a part of the solar panel.  
| | Explain the problem of hill-climbing method to realize MPPT.  
| | Explain the independent operation function. |
| **S3** | Explain how to calculate the power coefficient (wind power generator).  
| | Explain the relationship between electric power generation and wind.  
| | Explain the relationship between load resistance and rotation speed.  
| | Explain how to calculate the theoretical output of the windmill.  
| | Explain the relationship between load resistance and current load. |
| **S4** | Explain how to write a refrigerating cycle to Mollier chart.  
| | Explain how to calculate the coefficient of the refrigerating cycle.  
| | Explain how to calculate the coefficient of the heating cycle.  
| | Explain how to calculate the cooling capacity.  
| | Explain how to calculate the heating capacity. |
| **S5** | Explain the relationship between regenerative energy and voltage.  
| | Explain how to calculate energy conversion efficiency.  
| | Explain how to increase conversion efficiency. |

Trainees create reports on the final tasks from the following three viewpoints.

(Evaluation item 1) Organization and completeness:  
The report is well-structured and planned and reflects coordination between the trainees, showing integration of both team members and sharing of tasks according to a schedule.

(Evaluation item 2) Clarity and effectiveness:  
The trainees use correct language to explain the contents of the report, and answer all the questions using graphical elements or tables to help the resolution of set problems.

(Evaluation item 3) Comprehension of the system:  
The trainees contribute with conclusions, go into detail about the implemented stages and make relationships between the subject and concepts studied in the project.

created by elemental decomposition of the ability to propose and design the ZEH by thinking like an environmental energy engineer. Reports are scored from the three viewpoints shown in the evaluation items. In previous training, we did not clearly tell trainees about the evaluation items. In contrast, in this project, for evaluation items 1–3, a self-evaluation rubric was created, and preliminary instructions were provided.

Table 3 shows details of evaluation items 1–3. For the trainees, we distribute a paper which ranked the evaluation items 1–3 at four level rubric (excellent, good, satisfactory, unsatisfactory). By showing trainees a rubric of evaluation criteria, they can better understand the ideal effort attitude. We receive a variety of feedbacks from group members, so that trainees can immediately correct something they misunderstood. Evaluation item 1 shows a rubric for how to learn on group; it shows organization and completeness using five items. Evaluation item 2 shows a rubric for how to write a report; it shows the report clarity and accuracy using three items. In this way, by presenting trainees with the report evaluation items in advance, reports become much more successful compared to the conventional training. That is, evaluation items 1 and 2 are the lowest criteria for receiving reports. If evaluation items 1 and 2 are satisfied, the score is 60. The difference in the score of a report occurs from evaluation item 3. Evaluation item 3 is worth 40 points. There are 20 points for “logical explanation” and 20 points for “job performance.” For example, S2 has 5 tasks, and if there is no logical explanation of one of them, there is a 4-point deduction.

4.2 Learning Effectiveness

By comparing with conventional training, we describe the training effect of the active learning project with deliberate practice. First, the training effect is evaluated by effect size and the t-test. In recent years, learning effectiveness tends to be evaluated not only by the
t-test but also by effect size\(^{(17)}\). Many academies are obliged to show effect size, and here, we examine effect size and \(t\)-test. For calculation of effect size, the effect quantity calculation sheet is available, and it is used in many fields (http://www.mizumot.com/stats/effectsize.xls). Effect size is a standardized version of the average value difference between groups, the strength of the relationship between variables, etc., so as not to be influenced by the data unit. The effect size of 1.0 means that it is 1 SD (standard deviation) apart. That is, effect size 1.0 means that the SD has increased by 10.

Improvement in knowledge of physics using deliberate practice was reported to have an effect size of 2.5\(^{(15)}\), and educational methods using deliberate practice are drawing attention. Other science and engineering classroom studies report\(^{(18)}\) effect sizes less than 1.0. An effect size of 2, obtained with trained personal tutors, is claimed to be the largest observed for any educational intervention\(^{(19)}\). Also, in practical training, an effect size of 1.34 was obtained. This effect size is the result of applying quality-guaranteed training. Therefore, this effect size is very high value. Next, in the \(t\)-test, the \(P\) value was 8.24E\(-04\)** in the lectures, and a significant difference was observed at the 1% significance level. In the conventional training, the average was 66.2 points and the SD was 19.38. In this project, the average was 86.7 points and of the SD was 11.96. In practical training, the \(P\) value was 5.28E\(-04\)**, and a meaningful difference was recognized at the 0.1% significance level. In conventional training, the average was 68.7 points and of the SD was 23.40. In this project, the average was 92.1 points and of the SD 4.15. Next, the maximum value, the minimum value, and the median are shown from the results distribution of the lectures and practical training.

Figure 5 shows score distribution of the lecture results. The score of each mini-test represent the results of the lectures. The results of the lectures are the average of seven mini-tests with a 100-point scale. If we do not add attendance points to the results, there were 8 failures. On the other hand, in this project for lectures, the maximum value of a trainee was down 0.9 points (97.9→97.0 points), the minimum value was down 24.0 points (20.7→44.7 points), and the median value was 22.6 points up (67.6→90.2 points). There was one failure. This result was considered as the effect of active learning (not of lectures), of receiving feedback from instructors and group members, and of doing tasks alone.

Figure 6 shows this project practical-training score distribution. In the raw score, there were 6 failures. On the other hand, in the practical training of this project,
the maximum value of a trainee was 2.0 point (94.0→96.0 points), the minimum value was 62.0 points (16.0→78.0 points), and the median value was 20.0 points up (72.0→92.0 points). Significant improvements were seen for the minimum and median, and all the trainees passed with the raw score.

Table 4 shows the average scores of mini-tests in lectures and the average scores and submission rates of reports in practical training at each stage. In conventional training, S3 (63.2%) and S5 (52.6%) report tasks were difficult for trainees, so a lot of them failed to submit the reports. In this project, all stages had report submissions of 100%. In S3 and S5, trainees cannot write a theoretical report without understanding the calculation formulas. Therefore, the score of lectures was affected. On the other hand, S1 is a stage for considering how the properties of solar panels are utilized in occupational scenes. In S1, we examined the characteristics and prices of solar panels for each manufacturer and asked for a cost calculation report that considered regional sunshine hours. However, none of the trainees wrote such a report.

Deliberate practice improves performance with practice alone. In conventional training, the time allocation between lecture and practical training were the same, but in this project the time allocation of the lecture and practical training was approximately 4:6. With these changes, part of the report could be written during the training. Compared to conventional training, trainees clearly confirmed their knowledge from the active learning. In particular, we confirmed activation of discussion by group learning. Trainees thought about improving the results of both practical training and lectures through a cognitive load.

4.3 Discussion

We redesigned the active learning project by adding deliberate practice. As a final goal, the project aimed at trainees being able to complete jobs by thinking like environmental energy engineers. This dramatically increased the training effects, reduced the number of trainee failures, and raised the overall level of achievement by trainees. Discussions dramatically increased the training effects from the following five perspectives.

(1) Teaching material design was based on images as seen in the minds of experts.

In this project, we set the final goal to propose a ZEH based on mind images of environmental energy engineers. In vocational training, guidance associated with learned knowledge and actual work scenes is required. Concept understanding was promoted by mapping the knowledge to the work scene of the ZEH.

(2) Teaching material design imposed a learning load slightly exceeding the ability of the trainees.

The difficulty of tasks increased in small steps. For example, trainees tried to solve calculation tasks while referring to examples. Also, important technical elements were explained from various angles. With such a training environment, trainees could learn without difficulty.

(3) Teaching material design was such that tasks

| Stage | Lecture | Practical training | Lecture | Practical training |
|-------|---------|--------------------|---------|--------------------|
| S1    | 65.9    | 80 (100%)          | 87.3    | 80 (100%)          |
| S2    | 56.1    | 64.2 (84.2%)       | 92.5    | 89.4 (100%)        |
| S3    | 53.7    | 52.6 (63.2%)       | 86.3    | 100 (100%)         |
| S4    | 68.7    | 83.7 (94.7%)       | 73.6    | 93.1 (100%)        |
| S5    | 87.6    | 63.2 (52.6%)       | 92.5    | 100 (100%)         |

(Report submission rate)

Conventional: n=19 This project: n=16
could be correctly executed after short-term guidance by instructors.

In vocational training, trainees often learn knowledge in practical training. In this project, we removed the boundary between practice and lectures, and even in lectures, we made it possible to execute the task after mini-lectures. The instructor became a facilitator and was able to respond flexibly to each trainee.

(4) Teaching material design was intended to give instant feedback and allow self-evaluation.

By showing “Attitude towards project” and “How to write reports” as evaluation criteria, not only feedback from instructors but also feedback from group members were included in the training design. Feedback from group members was effective. Trainees could also give themselves feedback by model answers and rubrics.

(5) Teaching material design featured practice alone, without lectures.

In this project, trainees learned on their own initiative by doing tasks with group members.

From the above five perspectives, we discussed the high training effects of active learning by deliberate practice.

5. Conclusion and Future Work

In this paper, we explained a project in job-performance training that uses active learning to integrate practical training and lectures into vocational training. In addition, the training effects of active learning by deliberate practice were compared with conventional training, and the numbers of failed trainees were confirmed to decrease and there was overall improvement. For vocational training, the main practical training includes a training package for mastering job performance created by experts. However, we cannot fully cope with diversity among trainees. From an academic perspective, we believe that we should abandon passive training, and instead conduct training tasks that lead to the final goal, which is to create mind images of experts, and provide trainees with a variety of feedbacks from instructors and group members.

The application to the skill area of sensory works, is a subject we leave for future study.

References
(1) Bower, G. H. and Hilgard, E. R.: Theories of Learning (5th ed.). Englewood Cliffs, NJ: Prentice Hall (1981).
(2) Gagne, R. M.: The Conditions of Learning (2nd ed.). New York: Holt, Rinehart & Winston (1970).
(3) Bonwell, C. C. and Eison, J. A.: “Active Learning: Creating Excitement in the Classroom”, 1991 ASHE-ERIC Higher Education Reports, ERIC Clearinghouse on Higher Education (1991).
(4) Fitts, P. and Posner, M. I.: Human Performance. Monterey, CA: Brooks/Cole (1967).
(5) Gibson, E. J.: Principles of Perceptual Learning and Development. Englewood Cliffs, NJ: Prentice Hall (1969).
(6) Welford, A. T.: Fundamentals of Skill. London: Methuen (1968).
(7) Hernandez-Jayo, U., Lopez-Garde, J. M. and Rodriguez-Seco, J. E.: “Addressing Electronic Communications System Learning through a Radar-Based Active Learning Project”, IEEE Transactions on Education, Vol. 58, pp. 269–275 (2015).
(8) Haak, D. C., HilleRisLambers, J., Pitre, E. et al.: “Increased Structure and Active Learning Reduce the Achievement Gap in Introductory Biology”, Science, Vol. 332, pp. 1213–1216 (2011).
(9) Freeman, S., Eddy, S.L., McDonough, M. et al.: “Active Learning Increases Student Performance in Science, Engineering and Mathematics”, Proc. of the National Academy of Sciences, Vol. 111, No. 23, pp. 8410–8415 (2014).
(10) Ericsson, K. A.: “The Role of Deliberate Practice in the Acquisition of Expert Performance”, Psychological Review, Vol. 100, No. 3, pp. 363–406 (1993).
(11) Nesbitt, J. C., St Julien, J., Absi, T. S. et al.: “Tissue-Based Coronary Surgery Simulation: Medical Student Deliberate Practice can Achieve Equivalency to Senior Surgery Residents”, J. of Thoracic and Cardiovascular Surgery, Vol. 145, No. 6 pp. 1453–1459 (2013).
(12) Price, J., Boodhwani, M., Hendry, P. et al.: “A Randomized Evaluation of Simulation Training on Performance of Vascular Anastomosis on a High-Fidelity in Vivo Model: The Role of Deliberate Practice”, J. of Thoracic and Cardiovascular Surgery, Vol. 142, No. 3, pp. 496–501 (2011).
(13) Crochet, P., Aggarwal, R., Dubb, S. S. et al.: “Deliberate Practice on a Virtual Reality Laparoscopic Simulator Enhances the Quality of Surgical Technical Skills”, Annals of Surgery, Vol. 253, No. 6, pp. 1216–1222 (2011).
(14) Mervis, J.: “Transformation Is Possible If a University Really Cares”, Science, Vol. 340, pp. 292–296 (2013).
(15) Deslauriers, L., Schelew, E. and Wieman, C.: “Improved Learning in a Large-Enrollment Physics Class”, Science, Vol. 332, pp. 862–864 (2011).
(16) Bloom, B. S.: “Learning for Mastery”, Evaluation
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Comment, Vol. 1, No. 2, pp. 1–5 (1968).
(17) Woolston, C.: “Psychology Journal Bans P Values”, Nature, Vol. 519, p. 9 (2015).
(18) Froyd, J. E.: Evidence for the efficacy of student-active learning pedagogies (Project Kaleidoscope). www.pkal.org/
documents/BibliographyofSALPedagogies.cfm (2007).
(19) Bloom, B.: “The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring”, Educational Researcher, Vol. 13, No. 6, pp. 4–16 (1984).

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