AUGMENTATION OF LEARNING IN INTRODUCTION TO COMPUTER SCIENCE

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ABSTRACT

Introduction to Computer Science (ICS) is a compulsory course for freshmen of the electrical engineering (EE) department at our institute, which lays the foundation for more advanced courses. To arouse the interest and learning initiative of students, an optional "Special Practical Experiment in Computer Science (SPECS)" practice was introduced in 2010, emphasizing the integration of concepts with hands-on practice. Questionnaires on teacher evaluation were given to students nearing the end of the ICS course to evaluate their satisfaction with the teaching and their perception of the benefits derived from ICS. Participants and non-participants of SPECS were compared according to their post-SPECS class attendance and performance in ICS. The academic scores of SPECS participants were significantly higher than non-participants (80.16±5.33 vs. 72.79±10.39 in 2010, $p<0.05$; 81.35±4.30 vs. 75.52±6.35 in 2011, $p<0.001$). The SPECS not only improved students' satisfaction with teaching, but also their enthusiasm and performance in the ICS course.

Index Terms—Introduction to Computer Science (ICS), Special Practical Experiment in Computer Science (SPECS), education, hands-on, electrical engineering (EE)

1. INTRODUCTION

With the tremendous speed of development in information technology, the turnover rate of electronic products is remarkable [1]. As a result, sustained effort is constantly being made worldwide to meet the needs for advanced research and development in this highly competitive field, including staggering financial investments and an ardent recruitment of manpower [2]. In terms of manpower, strong preference is given to those who have relevant experience and can make immediate contributions [3], [4]. However, a wide gap exists between academic knowledge and the assembly line [3], [5]. To cope with the real-world scenario, many tertiary educational institutes worldwide have included hand-on courses for specific subjects in the curriculum of electrical engineering (EE) such as the advanced courses on microprocessor units (MCU) [6] and digital signal processing (DSP) [7], [8]. On the other hand, another study has shown that fundamental knowledge and study initiatives acquired through the course of Introduction to Computer Science (ICS) in the freshman year are crucial in determining the performance of the students in the subsequent advanced courses [9]. It is therefore conceivable that an augmentation of the academic foundation of students through an improved compulsory course of ICS in their first year in college can theoretically facilitate their later successful participation in the advanced courses which, in turn, make them more available to the industrial market.

Nevertheless, significant difficulty has been reported in the teaching of ICS as most college students have not encountered similar courses in their high school years [9]. In addition, since ICS covers a wide variety of concepts that are difficult to completely comprehend, incomplete understanding and a loss of learning initiative are the possible results [8], [9]. To tackle these pitfalls, previous studies have adopted different strategies, including the use of internet resources, multi-media, and puzzles as supplementary teaching tools to arouse the interest of students [9]-[11]. Other studies have reported the utilization of popular programs such as JAVA for the purpose of reinforcing the students' programming capacity and bridging their knowledge to that of advanced programming design [12]. Taken together, there has been an overall positive impact of supplementary courses on students' academic performance. On the other hand, most hands-on courses in EE focus on programming with no particular emphasis being placed on circuit design. For instance, while programming languages such as assembly language and C++ are being used as supplementary teaching tools, little attention is paid to the possibility of organizing hands-on courses on circuit design such as the embedded and digital circuit systems.

Therefore, this study tested the hypothesis that through organizing an optional evening hands-on practice on "Special Practical Experiments in Computer Science" (SPECS) that focused on circuit design, the first-year college students who participated in SPECS should exhibit a better academic performance in ICS compared to those who did not. Two-year data on the academic performance and satisfaction of teaching was collected from students of EE at National Dong Hwa University with and without participation on the SPECS for comparison.

2. ARRANGEMENT OF SPECS AND QUESTIONNAIRE DESIGN

National Dong Hwa University (NDHU) is situated in eastern Taiwan. The Department of Electrical Engineering, which was established in 1997, received Institute of Engineering Education Taiwan (IEET) accreditation in 2007 in accordance with the Washington Accord [13]. Through continuous assessment and improvement, the institute aims at bringing on elites in programming and circuit design in EE. The subjects participating in this study were freshmen of the Department of EE at NDHU for whom ICS is a weekly compulsory course with a duration of 3 hours. In addition to the required ICS course that has started since the year 1997, SEPCT, an optional supplementary 2-hour hands-on practice, has been introduced to the curriculum since 2010 in the evening. Regarding the number of subjects for comparison, the number of students taking the mandatory ICS course was 65 and 59 in 2010 and 2011, respectively. The students were divided into four groups: Those who did not participate in the SPECS (Group A) and the participants (Group B) in 2010 as well as the non-participants (Group C) and participants (Group D) in 2011. The number of students in Group A, Group B, Group C, and Group D was 48, 17, 32, and 27, respectively.

Table I

QUESTIONS INCLUDED IN POST-QUESTIONNAIRE

Q1	What do you think are the topics included in the course of "Introduction to Computer Science (ICS)"?
Q2	What do you expect to learn from ICS?
Q3	What do you usually use your personal computer for? (Please give examples)
Q4	How do you consider the importance of ICS in your future career? (Range: 1-10; 1 – Not important at all; 10 – Most important)
Q5	Are you interested in the ICS course? (Range: 1-10; 1 – Not interested at all; 10 – Most interested)

2.1. ICS course and evaluation

2.1.1. First lesson in ICS course

ICS at NDHU is a weekly 3-hour course for 18 weeks. The teacher was responsible for introducing the content and stating the study objectives of the course during the first lesson. The content and application of SPECS as an optional practice were also explained to the students. To evaluate the efficacy of an introductory lesson in enhancing the students' basic concepts in computer science and in arousing their interest in the subject, the Post-questionnaire was given to all students of the ICS course after the first lesson (Table I). Post-questionnaire consisted of two sections: The first section comprised three questions (Q1-Q3) that required short answers, focusing on the evaluation of the students' understanding of the subject. The second section of the questionnaire consisted of two questions regarding the students' subjective evaluation of the importance of the course and their interest in the subject (Q4-Q5).

2.1.2. Combination of knowledge and application in ICS course

Basic concepts in computer science [14] were presented through a combination of slides and oral presentations with an occasional insertion of examples of application to facilitate the students' understanding of the underlying concepts.

2.1.3. Evaluation at the end of the course

Three weeks before the end of the ICS course, all students were required to fill out the online teaching evaluation form to assess their satisfaction regarding the teacher's performance (i.e. attitude and method).

2.2. SPECS design

Since the operation of the commercially popular real-time system involves the concepts of data acquisition, hardware interface, programming, and operating systems in the ICS course, the SPECS was designed with the intention of providing an opportunity for the students to build a simple real-time system so as to put their academic concepts into practice and familiarize themselves with relevant applications in the future.

Enrollment in the SPECS was optional and the performance in the course did not affect the score in the ICS course. The SPECS covered textbook materials in computer science [14] and also some basic concepts in electric circuits. The major topics included in the SPECS were as follows: Analog filter design, Analog amplifier design, Sampling and quantization, Programming design, Algorithm implementation, Problem solving skills, Abstract data types, and Simulation and applications.

To simplify the learning process, the SPECS included the design of an electrocardiographic (ECG) electric circuit system (Fig. 1) using an analog-to-digital converter (NI USB-6009 DAQ, National Instruments, Austin, TX) and NI LabVIEW 8.6 software for data analysis and storage.

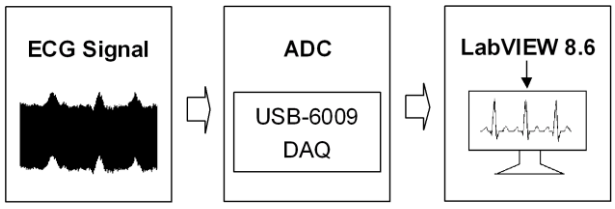

Fig. 1. Basic architecture of a real-time electrocardiogram (ECG) system.

2.3. Questionnaire

To assess the efficacy of the SPECS in augmenting the learning of basic computer science, questionnaires were given to all students of the ICS courses on the following occasion: Three weeks before the end of the ICS course (i.e. online questionnaire on teaching satisfaction).

2.3.1. Questionnaire on teacher evaluation

The questionnaire, which was issued by NDHU with a view to evaluating teaching performance in terms of the teacher's attitude and method of teaching, was completed online anonymously by every student who had participated in the ICS course three weeks before the end of the course. The lowest and highest score for teaching satisfaction was 1 and 5, respectively.

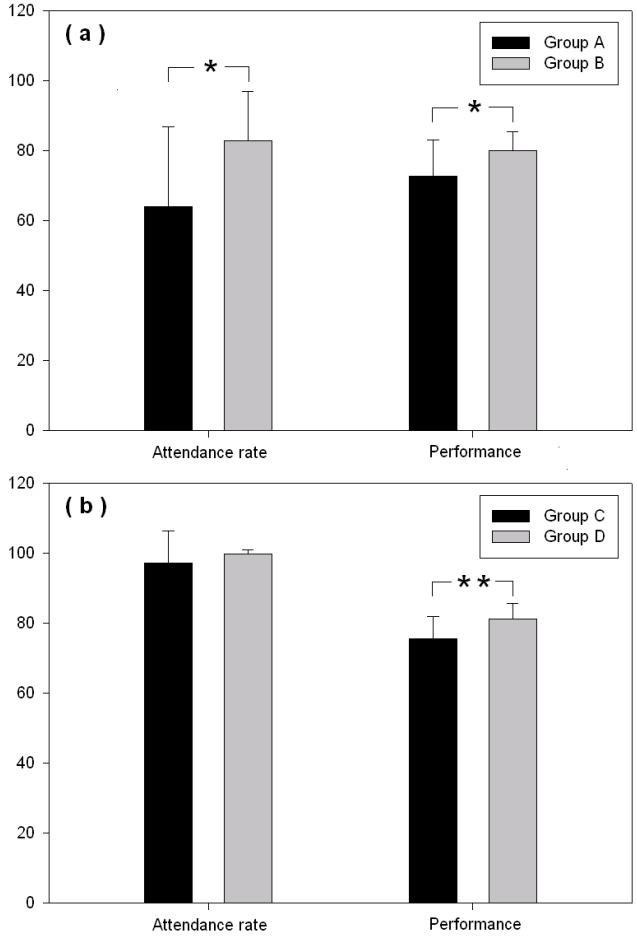

Fig. 2. (a) Attendance rate and performance of non-participants (Group A) and participants (Group B) in the Special Practical Experiment in Computer Science (SPECS) in 2010; (b) Attendance rate and performance of non-participants (Group C) and participants (Group D) in the SPECS in 2011; *p < 0.05 and **p <0.001.

2.4. Statistical Analysis

The Statistical Package for the Social Science (SPSS, version 14.0, SPSS, Inc., Chicago, IL) was the statistical software used in this study. Two-sample t-test was used for the whole study. A p value of less than 0.05 is considered statistically significant.

3. EVALUATION AND ASSESSMENT

The results of this study are discussed in two sections. Part A focused on the effect of the implementation of the SPECS on students' satisfaction with teaching performance. The period of data collection was from 2007 (i.e. the year of IEET accreditation) to 2011. Part B discussed the impact of SPECS on student attendance and performance in the ICS course as well as their responses to the items in the questionnaire.

3.1. Improvement in student satisfaction with teaching performance after implementation

Online questionnaire on teacher evaluation: The NDHU-issued anonymous questionnaire on teacher's attitude and method of teaching aimed at reflecting students' satisfaction with teaching performance. Data collected from 2007 to 2011 showed that, although the textbook, teacher, and scheme of teaching remained unchanged, the mean score significantly increased from 4.09 ± 0.44 before starting the SPECS (i.e. 2007-2009) to 4.37 ± 0.02 after implementation of SPECS (i.e. 2010-2011) (p<0.05) as well as the lowest and highest score was 1.00 and 5.00. The results suggest that SPECS may enhance the students' understanding of the subject and also their satisfaction with the teacher's performance as they may more easily get the gist of what the teacher mentioned in the ICS course.

3.2. Comparison between participants and non-participants of SPECS in terms of ICS course attendance, academic performance, and perception of gain from the ICS course

To rule out the possibility that the students who subsequently decided to take the supplementary SPECS initially had a stronger learning initiative than those who did not participate in SPECS, the scores of both groups given to Question 4 and Question 5 in the Post-questionnaire were compared. The results in both academic years (i.e. 2010 and 2011) demonstrated no significant difference (p>0.05) between the participants and the non-participants in terms of their understanding of the scope of the course and their interest after the introductory ICS lesson.

To investigate the impact of SPECS on the ICS course attendance rate and performance, data in 2010 and 2011 was collected and compared (Fig. 2). The ICS course attendance

rate was significantly higher for SPECS participants (Group B) compared to that of the non-participants (Group A) in 2010 (80.16±5.33 vs. 72.79±10.39, $p<0.05$). The results may suggest a positive impact of SPECS on the students' interest in the ICS course and also their academic performance. On the other hand, a low course attendance rate itself is a factor that may contribute to poor academic performance [15]. In 2011, the difference in attendance rate of the ICS course between participants and non-participants of SPECS was eliminated (Fig. 2) through taking attendance in class. After ruling out the influence of attendance rate, substantially better academic performance was still noted in SPECS participants (Group D) than that in non-participants (Group C) in 2011 (81.35±4.30 vs. 75.52±6.35, $p<0.001$). Taken together, despite the initial absence of difference in learning initiative and understanding of the scope of the ICS course between the participants and non-participants of the SPECS, SPECS participants were significantly more enthusiastic and expressed a higher degree of interest in the ICS course with better academic performance compared to the non-participants. The results underscore the positive impact of the implementation of SPECS on the ICS course.

4. DISCUSSION AND CONCLUSION

The compulsory nature of the ICS course is based on its importance as a foundation on which the knowledge of more advanced courses such as DSP and MCU can be built. Such advanced and practical knowledge, in turn, is crucial for the students' survival in the industry of information technology. With a view to integrating various concepts in computer science with hands-on practice, the implementation of the SPECS was based on the realization of the gap between the two. The aim of the SPECS was to enhance the students' understanding of the ICS course and also arouse their interest at an early and critical stage of learning following an observation of the gap between concepts and real-world application by the same teacher after giving the ICS course for three years.

Despite the initial lack of difference in learning initiative and knowledge of the content of the ICS course between the SPECS participants and non-participants as reflected in the results of the Post-questionnaire, the former showed better academic performance compared to that of the latter. Also there was demonstrated a higher degree of satisfaction with the teacher's attitude and method of teaching (4.09±0.44 before SPECS between 2007-2009 vs. 4.37±0.02 after SPECS in 2010 and 2011 as well as the lowest and highest score was 1.00 and 5.00).

Limitations exist in the present study in spite of our efforts. First, based on the protection of students, the online questionnaire on teacher performance was anonymous and the results were not released by the University. Individual scores given by the SPECS participants and the non-participants, therefore, were not available for comparison. Second, since the freshmen who participated in SPECS did not take any previous courses on electric circuits, keeping up the progress was difficult despite the tutor's meticulous instructions on datasheet downloading and assistance in interpretation. Finally, student activities in the evening occasionally postponed the SPECS.

In conclusion, the introduction of SPECS, an optional supplementary hands-on practice, into the curriculum for freshmen of electrical engineering not only significantly improved the students' academic performance and class attendance rate but also aroused their interest and boosted their confidence in encountering further challenges in the field of electrical engineering.

5. RELATION TO PRIOR WORK

Previous researches [9]-[12] have adopted different strategies, including the use of internet resources and programming languages, such as puzzles, multimedia, and C++, as supplementary teaching tools to increase student's interest and understanding of ICS, but little attention has been paid to the possibility of organizing hands-on practice. The SPECS practice, an optional hands-on practice, including circuit design and programming, supplied real-world applications related to the concepts in ICS to the freshmen of the Electrical Engineering Department. The result of the work presented here also shows that SPECS participants have a better attendance rate and performance than non- participants.

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7. REFERENCES

[1] G. M. Qian, and L. Li, "Profitability of small- and medium-sized enterprises in high-tech industries: The case of the biotechnology industry," *Strategic Management Journal,* vol. 24, no. 9, pp. 881-887, Sep. 2003.

[2] D. E. Heckler, "High-technology employment: a NAICS-based update," Monthly Lab. Rev., vol. 128, no. 7, pp. 57-72, July 2005.

[3] N. Falkner, R. Sooriamurthi, and Z. Michalewicz, "Puzzle-based learning for engineering and computer science," *Computer,* vol. 43, no. 4, pp. 20-28, April 2010.

[4] S. Reisman, “Higher education's role in job training,” *IT Professional,* vol. 6, no. 1, pp. 6-7, Jan. 2004.
[5] V. J. Dongre, R. V. Yenkar, and V. H. Mankar, “Interactive learning through hands-on practice using electronic mini-Lab (EML): a case study,” *Journal of Engineering, Science & Management Education*, vol. 5, no. 1, pp. 357-362, May 2012.
[6] S. Sahin, M. Olmez, and Y. Isler, “Microcontroller-based experimental setup and experiments for SCADA education,” IEEE Transactions on Education, vol. 53, no. 3, pp. 437-444, Aug. 2010.
[7] H. T. Wu, and S. M. Kuo, “Teaching challenge in hands-on DSP experiments for night-school students,” *EURASIP Journal on Advances in Signal Processing,* vol. 2008, May 2008, doi:10.1155/2008/570896.
[8] W.S. Gan, and S.M. Kuo, “Teaching DSP software development: from design to fixed-point implementations,” *IEEE Transactions on Education,* vol. 49, no. 1, pp. 122-131, Feb. 2006.
[9] I. Verginis, A. Gogoulou, E. Gouli, M. Boubouka, and M. Grigoriadou, “Enhancing learning in introductory computer science courses through SCALE: an empirical study,” *IEEE Transactions on Education,* vol. 54, no. 1, pp. 1-13, Feb. 2011.
[10] K. E. Merrick, “An empirical evaluation of puzzle-based learning as an interest approach for teaching introductory computer science,” *IEEE Transactions on Education,* vol. 53, no. 4, pp. 677-680, Nov. 2010.
[11] S. Barua, “An interactive multimedia system on "Computer Architecture, Organization, and Design",” *IEEE Transactions on Education,* vol. 44, no. 1, pp. 41-46, Feb. 2001.
[12] J. Lang, G. C. Nugent, A. Samal and L. K. Soh, “Implementing CS1 with embedded instructional research design in laboratories,” *IEEE Transactions on Education,* vol. 49, no. 1, pp. 157-165, Feb. 2006.
[13] Y. Wang, G. Kong, and H. Lei, “" Washington Accord" and significance for reference towards higher engineering education in China,” *Research in Higher Education of Engineering*, no. 1, pp. 10-15, Jan. 2007.
[14] N. B. Dale, and J. Lewis, *Computer science illuminated*, 3rd ed., Boston: Jones & Bartlett Publishers, 2007.
[15] Z. Al Shammari, “Benefits of using tested attendance system to enhance student attendance and achievement in higher education,” *Journal of Advanced Social Research,* vol. 2, no. 3, pp. 120-125, May 2012.