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The impact of supplementary hands-on practice on learning in introductory computer science course for freshmen

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ABSTRACT

Introduction to Computer Science (ICS), which is a compulsory theoretical course for freshmen of the electrical engineering (EE) department, lays the foundation for more advanced courses. Nevertheless, since ICS covers a wide variety of concepts that are difficult to completely comprehend, incomplete understanding and a loss of learning incentive are possible problems. The aim of implementing hands-on practice (HOP) activities was to prepare the students for the actual hardware manipulation in the field of EE and also to enhance their performance in the future advanced practice courses. Through organizing optional evening hands-on practice (HOP) activities, this study investigated whether the first-year college students who participated in HOP would exhibit a better understanding in ICS compared to those who did not. The enrollment in HOP was optional in which the performance did not affect the score in the ICS course. The results showed that HOP participants not only had significantly higher academic scores ($p < 0.05$), but were also less stressed toward the ICS course ($p < 0.05$) than the non-participants. The former also showed increased interest in accepting challenges (e.g. Two HOP participants later entered the National Microcomputer Design Competition and were awarded the third prize). In conclusion, the introduction of optional HOP for freshmen of electrical engineering not only alleviated the stress that they face in response to the ICS course, but also improved the students' academic performance and class attendance rate as well as raising their interest and boosting their confidence in further challenges in the field of electrical engineering.

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1. Introduction

Introduction to Computer Science (ICS), which is a compulsory theoretical course for freshmen of the electrical engineering (EE) department, lays the foundation for their future courses because it consists of a broad spectrum of knowledge including information, hardware, programming, operating systems, application, and communications. Besides, a previous study has shown that fundamental knowledge and study initiative acquired through the course of ICS in the freshman year are crucial for determining the performance of students in the subsequent advanced courses (Verginis, Gogoulou, Gouli, Boubouka, & Grigoriadou, 2011). 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.

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 (Verginis et al., 2011). 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 obstacles (Merrick, 2010; Verginis et al., 2011). To tackle these pitfalls, previous studies have adopted different strategies, including the use of internet resources, such as puzzles, as supplementary teaching tools to increase the interest of students (Koile & Singer, 2006; Merrick, 2010; Parhami, 2009; Verginis et al., 2011). In addition, previous research (Martin et al., 2005) on ICS also focused on the use of different software designs to enhance learning motivation

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without emphasizing on hands-on practice in basic hardware design. Although awareness of the importance of hands-on practice is evident in advanced courses for EE students that combined the supplementary teaching tools of software such as MATLAB and UNIX (i.e. MATLAB is a simulation software for programming design, while UNIX provides the necessary platform) (Lang, Nugent, Samal, & Soh, 2006; Merrick, 2010) with accompanying hand-on practice in the field of EE such as digital logic design, microprocessor unit (MCU) (Martin et al., 2005; Sahin, Olmez, & Isler, 2010), and digital signal processing (DSP) (Gan & Kuo, 2006; Wu & Kuo, 2008) to facilitate the students' understanding of the theories that they learned from lectures, no corresponding activities on hands-on practice have been introduced for junior students. Therefore, it is conceivable that the incorporation of basic hands-on practice into the first compulsory purely theoretical course of ICS for EE students would augment their understanding of and interest in the course materials.

To augment the outcome of students' learning in the field of engineering, the use of online laboratory has been proposed. Two approaches have been generally adopted, including the virtual laboratories and remote laboratories (Chen, Song, & Zhang, 2010). The former are based on software to simulate the situation of actual experiment (Alhalabi, Hamza, Hsu, & Romance, 1998), whereas the latter are conducted through Internet, using real components or devices (Bochicchio & Longo, 2009). Although virtual laboratories allow students to learn from failures without causing damages to real components, the approach has been reported to limit students' learning activities (Alhalabi et al., 1998). To overcome this limitation, the use of wireless networking as a practical online laboratory platform to provide students with hands-on experience on real devices has been proposed (Lin, Fung Po, Di, & Weijia, 2012). On the other hand, despite the advantage of the use of real components for practice as well as freedom in time and space of learning, the lack of real-time feedback from instructor may restrict the learning outcome.

In view of this issue, optional hands-on practice (HOP) activities emphasizing on simple circuit architecture and Graph-language with on-site tutoring was implemented to facilitate the students' understanding of some of the theories introduced in the ICS course. The aims of HOP were to prepare the students working in groups for the actual hardware manipulation in the field of EE and to enhance their performance in the future advanced practice courses. Accordingly, this study tested the hypothesis that, through organizing optional evening HOP that focused on circuit design, the first-year college students who participated in HOP would exhibit a better understanding in ICS compared to those who did not. The data of this study were acquired from the Department of Electrical Engineering, National Dong Hwa University. Data from a teaching satisfaction questionnaire obtained from 323 first-year EE students, who completed the online questionnaire on an anonymous basis between 2007 and 2011, were compared before (2007–2009) and after (2010–2011) the introduction of HOP. On the other hand, to compare the overall academic performance of the 124 students with and without participating in HOP between 2010 and 2011, their class attendance and scores in ICS course were analyzed.

2. Arrangement of HOP for ICS 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 (W.S., 2007). Through continuous assessment and improvement, the institute aims at bringing up 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 duration of 3 h for 18 weeks. In addition to the required ICS course in this study since the year 2007, HOP, a series of optional supplementary 2-h hands-on practice activities, has been introduced to the curriculum since 2010 in the evening.

2.1. Study population

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 HOP (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.

2.2. ICS course

The core conceptual framework of the ICS course consists of 6 layers (Fig. 1) which extend from the innermost layer of information, hardware, programming, operating systems, and application to the outermost layer of communications (Dale & Lewis, 2007). Basic concepts in computer science (Dale & Lewis, 2007) were presented through a combination of slide and oral presentation with an occasional insertion of examples of application to facilitate the students' understanding of the underlying concept. For instance, the early atherosclerosis assessment system (Wu et al., 2011) would be introduced when the discussion focused on problem solving, data analysis, program languages, and algorithms. Likewise, the use of analog-to-digital converter (ADC) in the six-channel electrocardiogram-based pulse wave velocity system (Wu et al., 2012) would be mentioned during the teaching of data acquisition.

On the other hand, this study introduced an optional supplementary HOP to facilitate the first-year EE students' understanding of the abstract theories and potentially reinforce their performance in the future advanced EE practice courses. The curricular program of the EE course included four mandatory courses of hands-on practice in the third and fourth years, each of which required the submission of a final assessment project that covered the scopes of hardware design and software simulation. The assessment of students' performance in ICS course included two written tests on concepts (70%) and home assignment (30%) that also focused on theories. No evaluation was given to practical work.

2.3. HOP design

During the first lesson of the ICS course, the HOP was introduced for all the students by the teacher. The interested students could sign up for the HOP in groups. The enrollment in the HOP was optional and the practical performance did not affect the score in the ICS course. To combine academic theories with daily application, the students were taught by the tutors, who were PhD candidates with at least three

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