Lecture management of parallel classes in a blended learning style: The case of Digital Signal Processing I as a compulsory course

Kohichi Ogata* and Tsuyoshi Usagawa†

Faculty of Advanced Science and Technology, Kumamoto University, 2–39–1 Kurokami, Chuo-ku, Kumamoto, 860–8555 Japan

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Abstract: This paper introduces an implementation of a compulsory course, “Digital Signal Processing I,” in a blended learning style. This subject is delivered by two lecturers as weekly parallel classes using the same e-learning contents including online quizzes for weekly homework. This sophomore-level basic course is compulsory for all the students of the Department of Computer Science and Electrical Engineering, Kumamoto University. The course has been assessed over several years from the students’ activities on an e-learning system and the final record of this course as well as a questionnaire-based survey. The averages of the total grades for both classes are almost the same and the distributions of the evaluation scores have a similar pattern. These tendencies suggest the usefulness of the teaching style for maintaining the equivalence of the subject provided in parallel classes by different lecturers.

Keywords: Education in acoustics, Signal processing, e-learning, Blended learning, Learning management system

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1. INTRODUCTION

Over the last few decades in Japan, much effort has been made toward the quality assurance of education under harsh conditions including a declining birth rate, the “Yutori generation” (a generation of students educated under a “pressure-free” system), and budget reductions for higher education.

In the field of education in acoustics, long-term projects include a survey of syllabi of education in acoustics [1] and the introduction of attractive education in acoustics ranging from primary education to higher education, speech-language-hearing therapist level, and company level [2]. Projects also include an ongoing survey of syllabi and new trends of education in acoustics [3–5] and the accumulation of various results in education in acoustics and the enhancement of education-related activities [6].

The recently published Special Issue on Education in Acoustics of Acoust. Sci. & Tech. introduces the history and activities of the Research Committee on Education in Acoustics [7] and the continuous development of educational tools aiming to help students to intuitively understand speech production [8]. In the issue, a new trend of transferring the technical listening training curriculum at university to corporations is also introduced and its effectiveness is described in terms of providing educational opportunities to acoustic engineers in a rapidly changing business environment [9]. The issue makes us realize again the importance of education that adapts to changing social needs.

Thus, trying to introduce new learning styles to education to move with the times as well as ongoing projects including surveys are important. In addition, evaluating their effects on student outcomes from a long-term perspective is necessary. Blended learning is one of the styles based on information and communication technology (ICT) and is now widely used in education. Its effect on student outcomes of a subject provided in parallel classes by different lecturers is an interesting topic because an imbalance of student outcomes between classes often becomes a problem from the point of view of maintaining the equivalence of the subject.

This paper introduces education in signal processing using a learning management system in the Department of Computer Science and Electrical Engineering, Faculty of Engineering, Kumamoto University [10]. The authors take charge of two classes for the compulsory subject Digital
Signal Processing I and provide each lecture as a blended learning style using a learning management system to provide common online contents and assessments for both classes. In this paper, computer environments for education at our university, lecture management of Digital Signal Processing I with examples of contents, and so forth, are introduced and the effectiveness of the lecture management is shown for balancing students’ outcomes with parallel classes.

2. E-LEARNING ENVIRONMENT AT KUMAMOTO UNIVERSITY

In 1999, Kumamoto University started the School Information System, named SOSEKI after the famous Japanese writer Mr. Soseki Natsume, who was a teacher of The Fifth High School in the Meiji Era. The system has provided academic services: syllabus registration by lecturers; syllabus browsing and course registration by students; credit registration by lecturers; and browsing the status of credits. In 2002, Kumamoto University started campus-wide education to improve IT literacy, and a commercial learning management system (LMS), WebCT [11], was first used to manage learning contents in 2003. Information on course registration by students on SOSEKI was transferred to WebCT through a daily batch process. Therefore, lecturers were able to use WebCT without account management [12]. Since 2012, an open-source learning management system, Moodle [13], has been used as an e-learning system at Kumamoto University. The system is available on and off campus 24 hours a day [14,15].

3. DIGITAL SIGNAL PROCESSING I

3.1. Course Overview

Digital Signal Processing I is compulsory for sophomores in their Fall semester. It started in 2007, in which our current department, Department of Computer Science and Electrical Engineering (CSEE), Faculty of Engineering, had its first sophomores. The current department was established in 2006 by integrating the former Department of Electrical and Computer Engineering and the Department of Computer Science. An elective subject “Signal Processing I” and a compulsory subject “Digital Signal Processing” were provided by the former Department of Electrical and Computer Engineering and the Department of Computer Science. An elective subject “Signal Processing I” and a compulsory subject “Digital Signal Processing” were provided by the former Department of Electrical and Computer Engineering and the Department of Computer Science, respectively. With the reorganization of the departments, the authors have started to produce online contents and deliver them with WebCT. We changed the e-learning platform from WebCT to Moodle in academic year 2012.

The enrollment in our department is approximately 160 and the main compulsory subjects are delivered to two classes, class A and class B, formed on the basis of the student ID number. Digital Signal Processing I is delivered to both classes A and B, and each of the authors is in charge of one of the classes. Because there are students who repeat the course and some transfer students in their junior year, each class has approximately 100 students.

The objective of the course is for students to acquire the capability of the following items based on mathematical expressions:

1. Sampling theorem
2. z transform and other transforms
3. Transfer function and spectrum

The course consists of the following 15 lectures:

1. What is “digital signal processing” and what is multimedia signal processing?
2. Signal processing systems 1
3. Signal processing systems 2: LTI systems, convolution
4. Signal processing systems 3: stability, causality
5. z transform and transfer function of systems 1
6. z transform and transfer function of systems 2: poles and zeros of transfer function, inverse z transform
7. z transform and transfer function of systems 3: frequency characteristics
8. Frequency analysis of signals 1: analysis of periodic signals, Fourier series
9. Frequency analysis of signals 2: analysis of non-periodic signals, Fourier transform
10. Frequency analysis of signals and the sampling theorem
11. Fast Fourier transform and windowing function 1: FFT
12. Fast Fourier transform and windowing function 2: Windowing
13. Interim review of previous classes including interim evaluation
14. Spectrum analysis: correlation function, power spectrum, and cross spectrum
15. Review of digital signal processing in the field of multimedia information processing

3.2. Course Management

3.2.1. Lecture overview

The lecture is conducted as a blended learning style.

The same textbook [16] is used and common e-learning contents are provided on Moodle so that the students of both classes can use them for preparation and review. Each lecturer gives a face-to-face lecture with a blackboard and a projector.

Figure 1 shows the top page of the Moodle contents. On the page, a course menu, general instructions, and news regarding upcoming events such as online quizzes are provided. Students have their own appropriate registration
code for this course depending on the class and the curriculum, i.e., there are different codes for this course. The binding function “Course metalink” of Moodle is used to provide the same contents for all the students taking this course.

At the end of each lecture, students take an offline quiz, which is a short written test, to check their understanding of the topic of the day. Other online quizzes related to each lecture are available as weekly homework on Moodle. The details of the online quizzes are shown later.

Although the online contents, test materials, and so forth, are the same for both classes, each lecturer gives a face-to-face lecture in his/her own style. The lecturers exchange information about students’ understanding, the results of the short written tests, and other information, through daily communication and/or by email. The results of the short written tests are useful for the lecturers to check students’ understanding as feedback and for making comments on students’ questions in the next class.

3.2.2. Online quizzes

Most of the online quizzes on Moodle for each lecture consist of four or five questions. Students are allowed to try them up to five times before a deadline. The highest score among the trials is registered as the result for each lecture. Examples of quizzes are shown in Figs. 2–4. Figure 2 is an example of a multiple-choice quiz. This quiz asks students about the poles of the transfer function and its stability for an assigned difference equation. Figure 3 is an example of a quiz requiring a numerical answer. In this quiz, the value at a specified time for the response of a linear time-
invariant system to an input sequence is asked. Figure 4 is an example of a quiz involving a matching-type question that asks students to obtain an analog signal from its spectrum.

3.2.3. Midterm and final examinations

A midterm examination is conducted as an online test just after the winter vacation. To provide the students of both classes with problems simultaneously, campus-wide computer systems are used. Two computer rooms are allocated to the students. Three or four problems consisting of part of the online quizzes are used and each problem can be attempted up to three times. The students are asked to make a draft before entering the solutions to the problems on Moodle within the test time of 90 minutes. The sheet for the draft also includes questions testing the students about their understanding of signal-processing-related items.

The final examination is conducted as a paper test during the sixth period (18:00 to 19:30) for both classes. The paper test consists of two sheets, each of which is prepared and graded by each lecturer to provide the same problems to both classes and to unify the scoring criteria.

3.2.4. Grading students’ performance

Student grades are based on the scores of course activities including the online quizzes and the midterm examination, and the score of the final examination. The scores of the course activities and the final examination are converted into a final grade accounting for 50% of the total evaluation score. The grading categories are Excellent (90–100%), Very good (80–89%), Good (70–79%), Pass (60–69%), and Fail (0–59%).

Fig. 5 shows a history log of Quiz No. 3 for a student in academic year 2013. The student took the quiz

4. COURSE EVALUATION OF DIGITAL SIGNAL PROCESSING I

In this section, the effectiveness of the blended learning in Digital Signal Processing I is evaluated from the point of view of students’ grades and results of questionnaires.

4.1. Examples of Results of Quizzes

In this section, some examples of the results of quizzes are shown.

Figure 5 shows a history log of Quiz No. 3 for a student in academic year 2013. The student took the quiz
four times and achieved full marks in the fourth trial. Figure 6 shows the logs for the third and fourth trials corresponding to Q2 in Fig. 5. In this quiz, the student was asked to find the impulse response of a system and enter the weighted sum of its components. At the third trial in Fig. 6(a), the student entered his/her answer as 25, while the correct answer was 30. Because the correct answer is shown with a comment immediately after the student’s answer, the student can review the related items such as exercises in the textbook. The student passed this quiz at the fourth trial, as shown in Fig. 6(b), although the assigned coefficients in the problem were different from those in the previous trial.

Figure 7 shows the final distributions of all students’ marks for Quiz No. 3, where the marks are the highest scores in up to five attempts. In academic year 2013, 148 students out of the total of 165 students who took the quiz achieved full marks, similar to the results in academic year 2014, in which 152 out of 167 students achieved full marks.

4.2. Distribution of Total Grades

Figures 8 and 9 show distributions of students’ total grades for six academic years. Actual numbers and percentages of the students belonging to each grading category are shown for classes A and B. The number of students for each class is shown to the lower right of each pie chart.

In addition to the categories of Excellent (90–100%), Very good (80–89%), Good (70–79%), Pass (60–69%), and Fail (0–59%) as described before, the category Fail_X has been added to show students who abandoned the course and did not take the examinations. In most years, approximately 85% of the students passed this course and the others failed. As can be seen, approximately 10% of students or more belong to category Fail_X. Because this course is compulsory, it is rare that students with almost full attendance fail to take the final examination. In most cases, the students belonging to Fail_X registered on the course but dropped out after a few weeks.

Although the grade distribution varies with the academic year, the distributions are similar between the classes. For 2013, there was less similarity between the classes. A detailed analysis showed that 22 out of 31 of the students who had failed the course in the previous academic year registered on the course in 2013 and were assigned to class A, and about half of them subsequently dropped out of the course. The difference between the number of students in the two classes was 23, which was the largest difference among all the academic years. This imbalance may have caused the difference in the distribution of students’ grades between the classes.

Table 1 shows the means of the total evaluation scores for both classes for the academic years shown in Figs. 8 and 9. The result for academic year 2013 shows a significant difference of approximately 4 points between the mean values for the classes. However, for the other academic years the means of both classes are almost the same and there are no significant differences between the
classes. These tendencies suggest consistent academic achievement between the classes.

4.3. Relationships Between Final Examination and Quiz Scores

Figure 10 shows the relationship between the final examination and quiz scores for academic year 2012. The maximum score is 50 for each item. In the graph, the points for all the students are plotted including students with 0 points for both items. The correlation coefficient between the items after excluding such students with 0 points is 0.3, showing a low correlation. A similar tendency was observed for other academic years. Similar to the tendency for academic year 2010 pointed out in [17], the distribution...
Fig. 7  Final distributions of all students’ marks for Quiz No. 3.

Fig. 8  Distributions of students’ grades for academic years 2009 to 2011.
does not show a clear relationship between the scores in the final examination and the quizzes. Such a low correlation may have arisen from the situation that many students achieved full marks for the quizzes and such students with high scores in the quizzes sometimes prepared for other subjects during the exam period.

4.4. Results of Questionnaire

At the end of the course, a course evaluation by students was conducted on the basis of a campus-wide faculty development (FD). Some examples of descriptive comments on the course are shown below:

| Academic year | Class A     | Class B     | t-test |
|---------------|-------------|-------------|--------|
| 2009          | 80.5 (14.7) | 83.0 (12.0) | n.s.   |
| 2010          | 81.7 (13.5) | 80.2 (11.2) | n.s.   |
| 2011          | 80.5 (14.5) | 81.8 (11.5) | n.s.   |
| 2012          | 78.9 (10.8) | 80.2 (9.9)  | n.s.   |
| 2013          | 76.4 (12.3) | 80.5 (9.0)  | p < 0.05 |
| 2014          | 82.2 (11.0) | 81.6 (9.0)  | n.s.   |

Table 1  Means and standard deviations (in brackets) of the total evaluation scores for both classes. Results of the t-test between the classes are also shown (n.s.: not significant).

Fig. 9  Distributions of students’ grades for academic years 2012 to 2014.
had a similar pattern. These tendencies suggest the usefulness of the teaching style for maintaining the equivalence of the subject provided in parallel classes by different lecturers.

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