PCN: QUANTIFYING LEARNING ACTIVITY FOR ASSESSMENT BASED ON TIME-SERIES COMMENTS

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Abstract: Learning activity plays important role in enhancing one's knowledge and skill. There are many ways to acquire and extract learning activities of students from their learning information; we focus on comments handwritten in their attendance sheets. It is easy for teachers to collect the sheets every class and for students to write their activities as comments. The sheets consequently provide time-series text data related to students; such the data are treasures because the comments and the questionnaire reflect their learning activities directly and indirectly. We propose a method called a PCN method for quantifying the comments into triple showing inferred learning activities student by student. Case studies illustrate the validity of the PCN method.

1 INTRODUCTION

Recently, e-learning systems in the classroom have been popular. They give students useful opportunities to learn class contents anytime and anywhere through the Internet, and automatically gather the students' access logs which include the history of pages visited, with their visited order, by the students. The e-learning systems have many tools and components for analyzing digitized and well-formed data such as server logs of the systems; using the tools, teachers can analyze the data from their points of views, extract the relationships from the data, and use them, with their experience and intuition, to derive and grasp the learning status of their students so that they can improve their class. In addition to the server logs of e-learning systems, teachers gather students' learning information in many forms such as questionnaires, quizzes, and examinations. They gather their answers and comments in digitized or non-digitized forms.

On the other hand, there exists other information related to the learning activities which are not always gathered automatically, such as Questionnaires, Quizzes, Examinations, Feedback Comments and so on. Especially Students' handwritten freestyle feedback comments are easy to collect and useful for grasping each of their learning status and holistic class tendency. Since these comments usually express rich information on learning status of the students, some teachers gather the comments of their students in the class at the end of every period of the class. However there are unfortunately not so many tools for analyzing free style data such as students' comments in the class. So, they can just read them and confirm the overall tendency or the some typical problems of the class. If such the students' unformatted comments can be analyzed and transformed into quantified ones which can easily be reused or recorded, it is useful for teachers to record, compare, and visualize as graphs, figures or tables.

This paper proposes a method of quantifying the freestyle comments and analysis procedure for the quantifycation. We call the method a **PCN method**. The PCN method enables teachers to acquire a temporal learning status of each student as a form of triple (**P, C, N**); **P** (Previous) indicates the learning activity before the classtime such as review of previous class and preparation for coming class, **C** (Current) shows the understanding and achievement during the classtime, and **N** (Next) tells the learning

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activity plan until next class. The PCN method provides some data expressing the learning status of each student quantified from his/her comments and special items implying something about learning attitudes student by student. It is useful for class assessment if components supporting the PCN method are built as assessment tools and are deployed to e-learning systems which gather comments of the class.

The rest of the paper is organized as follows; Section 2 describes the quantifying strategy of the PCN method, which analyses comments and quantifies into triple (P, C, N); Section 3 discusses the case study; Section 4 shows related wok and makes the difference from this work clear; finally Section 5 concludes the paper and describes our future work.

2 QUANTIFYING STRATEGY

2.1 Overview of the PCN Method

First, teachers read class comments written in natural language with free-style, and analyze them according to 3 time-series viewpoints: Previous, Current, and Next. The teachers evaluate the analyzed comments, convert them numerically, and record them. In numerical conversion, one value of (-1, 0, 1, 2) is provided. **Absence** is treated exceptionally and given as -5 to all of P, C, and N. Figure 1 shows a working sheet for quantifying the comments to triple (P, C, N), and special items. The sheet also contains phrases that directly express learning status of students or show notes concerning to the students. As need arises, the teachers, further to PCN, can also record special items described in Section 2.1.4. After all the comments are quantified, teachers can adjust the values from other information as the questionnaire of the day, the memories concerning the students, and/or the experience of the class. The concrete criteria of rating values of PCN are described in the following subsections.

Figure 1: Analyzing the comments (in Japanese).

2.1.1 Rating P

P indicates the learning action between the previous class and the current class, such as reviews of the previous class or preparations for the current class. In the real comments, students describe this kind of action such as “I trained typing” or “I read chapter 3 of the textbook”. For quantifying the value of **P**, one is selected from 4 levels: **Attention (-1), Bad (0), Fair (1), and Good (2)**. **Attention (-1)** is rated if there are no expressions related to previous learning actions, in any form, directly or indirectly. **Bad (0)** is rated if there is abstract expression concerning previous actions, but not in detail. Teachers can confirm the fact of the action but not detailed contents. For example, from real comments, “I trained typing” insists reality of actions, but does not explain in detail such as training time, or achievement level. **Fair (1)** is rated if there are any concrete expressions concerning previous actions, but the action level implied from the expression does not reach the level expected in the class. For example, the comment, “I trained typing, and achieved the speed of 100 strokes per minute” describes the fact and detail on the previous action, but the described fact (100 strokes per minute) does not reach the expected level (150 strokes per minutes) of the class. **Good (2)** is rated if there are any concrete expressions concerning previous actions and the action level implied from the expressions reach the level expected in the class. For example, the comment, “I trained typing, and achieved the speed of 200 strokes per minute” shows the fact and detail on the previous actions, and the described fact (200 strokes per minute) goes beyond the expected level (150 strokes per minute) of the class. It is so difficult to acquire comments relating to **P** at the first period of the class that we exceptionally rate **Bad (0)** as a default value.

2.1.2 Rating C

C indicates understanding and achievement of the current class. Teachers determine the value from their experience. For example, for the comments, “I finished the first exercise” or “I didn’t finish all exercise because time is up,” one value is empirically rated by the teachers.

For quantifying the value of **C**, one is selected from 4 levels: **Bad (-1), Normal (0), Good (1), and Very Good (2)**. **Attention (-1)** is rated if there are no expressions indicating the facts of students’ understanding or achievements in the current class,

in any form, directly or indirectly. **Bad (0)** is rated if there are any expressions indicating the facts of students' understanding or achievements, but those expressions are too abstract for teachers to extract the students' understanding level. For example, the comment "I didn't understand it" or "It was difficult," shows facts about students' understanding, but their achievement level is not clear. **Fair (1)** is rated if there are any concrete expressions that help teachers infer the students' understanding and achievement level, but the level is not so high. For example, the comment "I have done the first exercise," concretely shows the fact of student's achievements, but only "the first exercise" does not reach the expected level of the class. **Good (2)** is rated if there are any concrete expressions that help teachers infer the students' understanding and achievement level, which goes beyond the expected level of the class, such as "Today I have done all exercises."

Since it is sometimes difficult to acquire comments related to **C** at the first two or three periods of the class, teachers request students to write comments related to **C** because comments are freestyle and students have not accustomed yet. In such cases, we rate **Bad (0)** as a default value and adjust them per each student with questionnaire of the day, and teachers' experience and memories for students.

2.1.3 Rating N

N indicates action plan after the class, and is guessed from comments of students. Teachers guess students' action plan from comments, and rate them numerically. For example, for comments "I will make preparation by next class," "I found necessity to train typing," teachers rate **Good (2) or Attention (-1)**. **Attention (-1)** is rated if there are no expressions concerning action plan in the comments, in any form, directly or indirectly. **Good (2)** is rated if there are any expressions concerning action plan in the comments, in any form: determination, declaration, or implication, such as "I found necessity to train typing," "I think my preparation is not enough," "I recognized that I should do exercise not only in mind but also by hand," and so on.

It is known facts from teachers' experience that motivation of students becomes weaker at the final period of the class after submission of their final reports. They feel so free that they write their plans, determinations, and declarations related to **N** more boldly and intrepidly than ever. We do not adjust the values of the final period at present.

2.1.4 Extracting Special Items

We currently record 5 special items: **Quantity, Readability, Blank, Caution, and Citation**. They are defined as follows: **Quantity** is quantified into an integer if extremely short or long. **Readability** is quantified if the letter and figure in the comment are extremely rough or polite. **Blank** is quantified if any item required in the comment is blank or not found. **Caution** is quantified if a phrase should be shared in the class such as common mistakes, good hints, inappropriate attitude, or laziness. **Citation** is sample sentences clipped from the comments.

The reasons of recording such items are to help teachers adjusting the results into more precise one. These items reflect the characters of students and reinforce the reliability of the same results as teachers' experience and memories to the students. In addition, they enhance and improve teachers' own experience if new facts are found.

3 CASE STUDY

3.1 Environment of Case Study

We teach information processing courses including computer literacy and C programming for entry level. The course is taken by almost all first year students in Kyushu University. We have two classes for the course: 54 student class, say Class-A, and 55 student class, say Class-B, in the 2nd semester, 2009. Each class consists of 13 periods of the class. We gather students' attendance sheets in size of A6 at the end of every period of the class. Each of the sheets has the head side used for OCR data (ID information), and the tail used for giving questionnaire of the day and comments, although some students use as memoranda of the class.

3.2 Analyzing by the PCN Method

3.2.1 Correlation between PCN Value and Credit

As mentioned earlier, the PCN method quantifies learning activities described in freestyle comments. This enables teachers to visualize the tendency of each student's behavior in each period of the class; teachers acquire the clues of understanding of students' learning activities if those are accidental or natural. Actually, **P** indicates preparation activity for the class. **N** indicates some activities related to reflection and motivation for the next class.

Table 1: The correlation between PCN values and credits in a class. Pos. And Neg. Present positive and negative values, respectively.

	P	C	N
Pos. and Neg.	0.742	0.786	0.655
Pos.	0.378	0.515	0.329
Neg.	0.769	0.776	0.748

Moreover, if we combine **N** and **P**, e.g., the m-th period value of N ($\mathbf{N_m}$ for short) and the (m+1)-th period value of P ($\mathbf{P_{m+1}}$ for short), we will find the relationship between the m-th preparation activity plan and the corresponding (m+1)-th real preparation activities. To apply the PCN method, we first analyzed the comments, and found that the following facts:

1. Many students tend to skip preparation activities to the class.
2. Many students describe the action plan to their next class.
3. Most of them do not make practice in real.

The PCN shows these facts numerically.

Next, we sum up P, C, and N of all the periods for each student, and also calculate the correlation coefficient between the sum and the final score of each student's credit. The results illustrate strong correlation. Then, we sum up in two ways such as positive part and negative part of comments, and calculate the correlation coefficient between the sum of each part and the final score. The positive part of comments is the part that only non-negative values are summed up and negative values are treated as zero. The negative part of comments is the par that only non-positive values are summed up and positive values are treated as zero. The results shown in Table 1 say the strong correlation for the sum of negative part of P, C, and N. On the other hand, the sum of positive part of P, C, and N only show weak correlation. As references, the final score and points of students' report make strong correlation of 0.634.

3.2.2 Overall Tendency of Learning Activities during All the Class Periods

Firstly, we calculated the average sum of PCN values for Class-A and Class-B at each period. The results are shown in Table 2. From the results, we found two singular points. For N_7, P_8 and P_9, two areas are distinguished from other areas. When considering N_7, the contents of the class changed marvellously. There was the switching point of the subjects between the 6th period and 7th period of the class, i.e. the 6th period class gives a lecture of computer literacy, which gives how to use word processor, spread sheet, and presentation tool, and

Table 2: The transition of PCN values by periods.

		1	2	3	4	5	6	7	8	9	10	11	12	13
P	Ave	▲ 1.3	▲ 1.2	▲ 0.4	▲ 1.2	▲ 0.4	▲ 0.0	▲ 0.1	▲ 1.5	▲ 0.1	0.3	0.5	0.5	0.3
	diff	X	0.1	0.8	▲ 0.8	0.8	0.3	▲ 0.0	▲ 1.4	1.3	0.4	0.2	0.0	▲ 0.2
C	Ave	0.5	0.5	0.5	1.0	0.9	1.2	0.4	▲ 0.1	0.1	0.1	0.3	0.0	▲ 0.1
	diff	X	0.0	▲ 0.0	0.5	▲ 0.1	0.3	▲ 0.8	▲ 0.6	0.2	0.0	0.2	▲ 0.3	▲ 0.2
N	Ave	▲ 0.1	▲ 1.2	▲ 0.2	▲ 0.2	▲ 0.1	▲ 0.4	1.2	0.8	0.7	▲ 0.5	0.7	0.0	▲ 0.8
	diff	X	▲ 1.0	1.0	▲ 0.0	0.1	▲ 0.3	1.7	▲ 0.4	▲ 0.1	▲ 1.3	1.2	▲ 0.7	▲ 0.8

the lecture was changed to C programming from the 7th period class. The computer literacy subject is educated compulsory and widely all over senior high schools in Japan, and only a few contents differs their detail. However, C programming, or programming using other language, is not a required subject until entering the university, and most students are novices at programming. At the 7th period, the teacher explains the fundamental element and basic procedure of C programming slowly and precisely. The each student may feel that programming is very difficult, and feel the necessity and importance of preparing the class. We regard it as natural that such the situations mentioned above greatly increase the value of N_7 from that of N_6.

Secondly, we consider P_8 and P_9. P_8 goes the biggest down at this period in the semester. On the other hand, P_9 goes up with the second biggest gap. It makes V curve between P_8 and P_9. This is because in the 7th period, its subjects change drastically from that of 6th, and students feel so uneasy that they need to prepare their class more than before and that makes P go up powerfully. Then, P_8 falls down very much because, at the 7th period, the teacher spoke a lot so that students felt programming was easy and fun. On the other hand, it made them underestimate the difficulties of the programming, and not to prepare the class. However, at the next period, P_9 rose again because students recognized and reflected that they should have prepared the class sufficiently. We found the big difference between the 6th and 7th period of the class, and analyzed and compared the two segments, before sixth (first half) and after seventh (second half), and also classified the students into positive and negative thinking groups. As we inferred, second half periods and the negative thinking groups showed the strongest correlation with their final scores of the class. This shows the fact that negative actions or do nothing on learning affect the final score (credit score) greater than what and how they learned, or process of learning.

3.2.3 Class Tendency of Learning Activities during All the Class Periods

Firstly, we calculated the average of PCN values for each class, both Class-A and Class-B show in Table 3. The results are shown in Figure 2. From this figure, we found two tendencies. In the first half

Table 3: Analysis by period group.

	ALL			7th–13th			1st–6th		
	P	C	N	P	C	N	P	C	N
orig	0.742	0.786	0.655	0.726	0.717	0.609	0.577	0.633	0.443
Plus	0.378	0.515	0.329	0.401	0.365	0.339	0.154	0.455	0.149
Minus	0.769	0.776	0.748	0.744	0.721	0.694	0.622	0.634	0.576

periods of the class, values of which are plotted left side in Figure 2, Class-B tends to be higher than Class-A. In the second half, values of which are plotted right in Figure 2, Class-B seems to be more stable than Class-A. Secondly, we considered the difference between Class-A and Class-B from viewpoint of the comments. We read the comments again, and found that the comments of Class-B students tend to be more straight-forward and concrete than those of Class-A students. This implies that Class-B students tend to be more direct and talkative than Class-A, and Class-A students tend to be more shy. Thirdly, we compared the average of PCN values between Class-A and Class-B, and found Class-A tends to be higher than those of Class-B about P values shown in Table 4. This means that Class-A students tend to make more preparation than Class-B, and also implies Class-A students tend to more serious than Class-B which is similar to the intuition of the teacher's. About C values Class-A tends to be lower than Class-B. This means that Class-A students tend to understand or achieve less than Class-B, and implies the average sum of credits of all the Class-A students is lower than those of Class-B, and this inference is against the result, or credits of the class. From this gap and teacher's feelings in the classroom, we infer Class-A students are pessimistic (or they write worse than real) and Class-B ones are optimistic (or they write better than real). Although we trust all the comments of each student as premise, some exaggerations cannot be avoidable and should be accepted.

Next, we focus on N value comparison between classes, and found that Class-A tends to be lower than Class-B, opposite tendency again C value transition. This implies Class-B students tend to declare their preparation or reviews explicitly but fail to do as they have written. At the 7th period, both P and C values of Class-A are much higher than those of Class-B, but N values of both classes are similar. This may be because the teacher tells students slowly and precisely the importance of preparation at the beginning of the every time of the class and the effect of the advice has come at that period. On the other hand, at the 8th period, the two class students returned as before. Totally, over all the periods, Class-A students tend to seek preparation even if the correlation coefficient

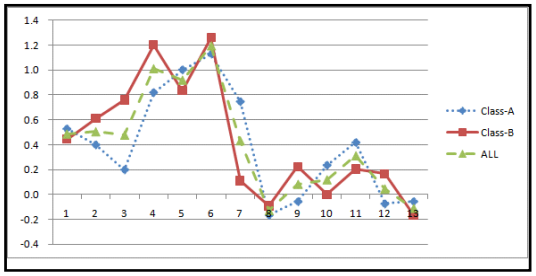

Figure 2: C value transition of Class-A, Class-B, and Both.

Table 4: The PCN value transitions by classes.

		1	2	3	4	5	6	7	8	9	10	11	12	13
P	Class–A	▲1.3	▲1.1	▲0.2	▲1.4	0.3	▲0.0	0.4	▲1.4	▲0.3	0.3	0.5	0.5	0.5
	Class–B	▲1.3	▲1.2	▲0.5	▲1.3	▲1.0	▲0.3	▲0.5	▲1.5	0.0	0.3	0.4	0.5	0.1
	diff	0.0	0.1	0.3	▲0.3	1.3	▲0.0	0.9	0.1	▲0.3	▲0.1	0.1	▲0.1	0.3
C	Class–A	0.5	0.4	0.2	0.8	1.0	1.1	0.8	▲0.2	▲0.1	0.2	0.4	▲0.1	0.0
	Class–B	0.5	0.6	0.8	1.2	0.8	1.2	0.1	▲0.1	0.2	0.0	0.2	0.2	▲0.3
	diff	0.1	▲0.2	▲0.1	▲0.1	0.2	▲0.1	0.7	▲0.1	▲0.3	0.2	0.2	▲0.2	0.3
N	Class–A	▲0.3	▲1.1	▲0.6	▲0.8	▲0.3	▲0.8	1.3	0.8	0.8	▲0.9	0.4	▲0.1	▲0.8
	Class–B	0.1	▲1.2	0.2	0.2	0.1	▲0.9	1.2	0.8	0.7	▲0.2	1.0	0.2	▲0.1
	diff	▲0.4	0.1	▲0.1	▲0.1	▲0.4	▲0.3	0.1	▲0.0	0.1	▲0.1	▲0.6	▲0.3	▲0.1

between P value and C value is not so strong. Class-B students seek to try preparations, but also easily give up them if they failed in understanding or achieving. Actually, this impression is very similar to the one the teacher (one of the authors) felt in the classroom. Or intuition to the two classes from the teacher's experience is explained by interpretation of the result of the PCN method.

4 RELATED WORK

There exists a lot of work related to the subject touched on in this paper, such as adaptive learning, text mining of time-series data and so forth.

First, we discuss some work on adaptive learning. From behaviorism, PSI (Personal System of Instruction) is one of teaching methods, person to person education well-known for Keller Plan (Keller 1968). Proctors play an important role in PSI and they should work very hard to grasp learning status of all the members in the class and manage the progress of the class, quality of which depends on their experiences. Since training proctors costs expensive and takes long time, PSI is only applied to limited students requiring special aid. CSCL (Computer Supported Collaborative Learning) is a pedagogical research area on learning environment derived from CSCW (Computer Supported Cooperative Work) (Koschmann 1996). It provides the learning environment for collaborative learning across classes, schools, sometimes countries by

computer connected to the internet. This breaks special barrier and students are located so wide in such environments that teachers encounter the difficulties in grasping learning status of all the students or even students in charge. The PCN method provides indexes expressing learning status of students and basic idea for a component of learning system supporting CSCL. Self-regulated learning is a learning style guided by metacognition (Zimmerman 1990). It is characterized three points, self-observation, self-judgment, and self-reactions. The PCN method provides indexes reducing the task for all of self-observation, self-judgment, and self-reaction. ID (Instructional Design) is the practice of maximizing the effectiveness of learning rooted in cognitive and behavioral psychology (Gagne 1965, Ito & Suzuki 2008), and there are many instructional design models but many of them are based on the ADDIE model with the five phases: analysis, design, development, implementation, and evaluation. The analysis process of ID needs the current learning status of the class. And the PCN can provide it. There exist so many user models concerning adaptive media systems (Brusilovsky 2001, Popescu et al. 2007) and they are roughly classified into three categories: the user model, the domain model, and the interaction model (Martins 2008). The PCN method helps the interaction model in inferring students' characters partly by PCN values.

Next, we will describe some work on text mining. There exist only a few researches of text mining using learning data (Romero 2007) because there is few data concerning learning status in time series. With respect to the content of the comments, most analyses of time-series comments are for marketing such as CRM (customer relationship management), and the contents of comments include reputations, opinions, and requests expressing directly and apparently their preferences and characters. Our purpose is for education and learning, and the comments from students reflect their learning activity directly or indirectly. In this research, we analyse time series comments. The comments are handwritten with free style, and include full name of students, which enable tracking the students easily.

5 CONCLUSIONS

In this paper, we proposed and discussed the PCN method which quantifies the freestyle classcomments. This method enables teachers to grasp the tendencies of students' learning activities in the class, which are not only for the whole class members, but also for each member in the class. Concerning individual learning behavior, we can grasp the current status and the change of his/her activities. As described in this paper, the PCN method provides the basis of improving both class and learning. In future, we will develop dynamic grouping module and build it into e-learning system, and attach the function which provide learning information or advice, and use result of analysis of both whole class and each individual in order to enhance adaptive contents to specific level group. The PCN method currently costs because the teacher of class read and evaluate into numbers. To continue this procedure, automation is required such as digitization of comments, keywords, text mining. This is very important task. Authors are planning to extend this research to design, develop, and implement the module for dividing and reconstruct the students cluster by specific criteria.

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