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Exploring the Correlation between Students' Attention and Learning Performance

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Abstract: In the field of education, the use of big data to improve students' learning performance has been a very popular topic recently. The attention of students in the curriculum is obviously a key factor affecting learning performance. In past studies, the attention of students is often measured through questionnaires. The results obtained through the questionnaire are not objective enough, and there are problems of those who feeling good or lack of confidence. Therefore, the measurement of attention was gradually changed to a hardware method, such as brain waves or heart rhythm, etc. Although, the hardware measurement method is more accurate, the cost of the equipment greatly increased, and allowing students to wear these hardware devices may cause the students to perform measurements in an unnatural learning environment. As a result, this study attempts to use a software method to measure and analyzes students' attention in class through e-book reading log, and to explore whether attention can be used as an important indicator of predicting learning performance, and design a set of training to improve student's attention. The research results show that both the e-book reading log and the student's question-posing score can be used to measure attention, and student's attention in class is a key factor affecting their learning performance, that is students with high attention tend to achieve better learning performance.

Keywords: Attention, learning performance, question-posing, linear regression

1. Introduction

In the recent educational environment, analyzing the learning status of students through big data has become a very popular topic in the field of learning analysis, and the engagement of students in class has been proven to effectively improve their learning performance (Park, Denaro, Rodriguez, Smyth, & Warschauer, 2017). Attention, which means the degree of students are focused in class, is also an important indicator of course participation. Therefore, measuring students' attention in class has become an important task. In the past research, the measurement of attention was mostly carried out by questionnaires or hardware methods. The questionnaire measurement method cannot objectively measure the abilities of each student, and the reasons may include feeling good about themselves or insufficient confidence. The hardware method has disadvantages such as high cost or putting students in an unnatural learning environment. As the result, the development of a new attention measurement method is the goal of this research.

This paper focuses on measuring students' attention in class through students reading logs on e-books, and then analyzes whether the attention of students is an important factor affecting learning performance. Therefore, the research questions discussed in this study include the following three:

RQ 1: Does students' attention in class affect their learning performance?
RQ 2: Can students' attention be measured from the e-book reading log?
RQ 3: Can students' attention be used for predicting their learning performance?

2. Literature Review

2.1 BookRoll

BookRoll is an online e-book learning platform developed by Ogata et al. (2015, January) in Kyoto University. BookRoll's functions provided for reading behavior include next page (Next), previous page (Previous), Jump page (Jump), add/delete Bookmark, add/delete Marker , Add/delete Memo, search keywords (Search) and other operations, and record the open and close file operations of the e-book.

2.2 Learning Attention

Learning attention represents the learner's ability to concentrate on the class or something. This indicator plays a very important role in class learning. When students are not focused for a long time, it will lead to a significant decline in learning efficiency. This also shows that attention will affect the overall learning performance of students (Chiang, Hsiao, & Liu, 2018).

In the past, many studies have explored how to measure learning attention. The early stages of attention was mainly through questionnaires, (Lee & Kim, 2011), however, there are many problems with questionnaires, such as the measurement results are too subjective. Recently, the attention measurement method has gradually changed from questionnaires to hardware device measurements (Cheng et al., 2015; Siennicka et al., 2019). Physiological signals such as heart rate or brain waves have been proven to be key feature for measuring attention, and the result obtained by hardware measurement are more accurate. However, using hardware to measure attention still has disadvantages, such as the cost of physiological signals equipment is too high, and whether students wear these equipment will make students study in an unnatural environment is still a big doubt.

2.3 Factors Affecting Learning Performance

In recent years of education-related research, most researchers are dedicated to finding the key factors that affect learning effectiveness (Lu, Huang, Huang, & Yang, 2017). Most early studies predicting learning performance are based on students' quiz scores and homework scores, but these characteristics must be accumulated for several weeks to get the data, so early prediction cannot be achieved. However, if the students' participation, attention, or reading log and other learning behavior-related characteristics can be used, we can get data in the first few weeks before class to start forecasting. Therefore, we believe that reading behaviors such as attention are more suitable for predicting learning outcomes. In third research question, this research will also explore whether attention can be used as a key factor in predicting learning outcomes.

3. Methodologies

3.1 Participants

The target course of this research experiment is the Python programming course in the second semester of the 2020 academic year of university in northern Taiwan. This course has 3 hours of class per week, the experiment lasts for 8 weeks, and there are 62 participants. This course provides students with BookRoll system, which students can read the contents of the teaching materials on the e-books. Students' reading records on the system and the time of each action will be recorded in the database.

3.2 Learning Attention Measurement

3.2.1 Page Synchronization Ratio

This study tracks the learning process of the students in e-book, and uses the learning log data to calculate students' attention in class. Therefore, we only use the data in the three hours of class time per week to calculate student's attention. The measurement method of attention is the percentage of the time that students successfully follow the teacher's e-book pages in class. The number of pages that fail to keep up with the teacher at all is counted as 0 points, and the number of pages that follow the teacher all the time is counted as 100 points. We call this method "page synchronization ratio". This method was

proposed by past researchers (Abe, Tanaka, & Matsumoto, 2020). It was mainly used to measure the learning attitude of students in class. If the page turning of a students' is not synchronized with the teacher, it will be considered that the student is not attending class or doing non-class-related activities. We think this method is novel and suitable to measure learning attention in this research. In order to test the accuracy of this method, this study used the attention questionnaire proposed by previous researchers to measure the attention of students (Yang, Li, & Lu, 2015), and analyze the correlation coefficient between the results of the questionnaire and the attention of students calculated on the system. Check whether the results calculated by log data are highly correlated with the results of the attention questionnaire to confirm that the log data attention calculation method is reliable.

3.2.2 Question-posing Quality

In the experimental course of this study, the teaching form was mainly focus on e-book teaching in the early stage, but it transformed from e-book teaching to programming practice in the middle of the course. Teachers only spend little amount of time on e-book while teaching, therefore, page synchronization ratio method is no longer suitable to calculate student's attention under programming practice teaching form. As the result, we must use other methods to measure student's attention. Past research mentioned that students' question-posing in class are closely related to their attention. For example, students' proactively raise questions may make them more integrated into the curriculum, and ultimately enhance students' engagement and attention in the classroom (Almeida, 2012). Therefore, we began to introduce question-posing activities from Chapter 3(C3). The teacher asked students to raise questions about this chapter at the end of each chapter. We would score students' questions according to the question classification framework proposed by past researchers (Dori & Herscovitz, 1999). This question-posing framework contain three rating categories, namely Orientation, Relation, Complexity. Each question will get a score of 1 to 3 points in three different categories, of which the score 3 is the highest level. The average of the scores obtained by the three categories is score of the question. Finally, we will verify whether the attention can be measured by Question-posing Quality through the attention questionnaire.

3.3 Learning Attention Prediction

The method of prediction in this study is Linear regression, this method is mainly used to explore the linear relationship between the independent variable (x) and the dependent variable (y), and through the establishment of a linear model, it is possible to predict or infer the effect of dependent variable. This study wants to explore whether attention can be used as an important factor for predicting learning effectiveness. Therefore, we regard attention as an independent variable (x) and learning effectiveness as a dependent variable (y). If the F-value of the model is significantly predictive, it means that the degree of attention can predict the effectiveness of learning, and there is a linear relationship between the two, which also shows that the degree of attention of students is an important key factor affecting the effectiveness of learning.

4. Results and Discussion

4.1 RQ1: Does students' attention in class affect their learning performance?

Table 1. *Linear Regression of Questionnaire and Quiz score*

	β value
Independent variables	Quiz 1 score
Constant	56.570***
Questionnaire score	6.697*
F	5.419*
R^2	.101
Adjusted R^2	.083
Durbin–Watson	.200

In order to find out if the learning attention of student in class affect their learning performance, we use linear regression model to analyze. The independent variable is score of attention questionnaire take in the first week of class, and the dependent variable is the score of Quiz 1, which the scope includes Chapter 1 and Chapter 2. According to Table 1, it can be known that the F statistical value is significant, which means the regression model has predictive ability, and the constant and questionnaire score are both significant. This also shows that attention is indeed an important factor affecting the effectiveness of learning and can be used to understand the learning status of students.

4.2 RQ2: Can students' attention be measured from the e-book reading log?

The following steps are the process how we implement "Page Synchronization Ratio". First, we fetch the log data during the class period from database. Next, we divide each user's data according to four actions, namely Open, Next Page, Previous Page, Close. Then, we can construct each student's e-book reading history which contain the page number they stay during class every minute. From the example shown in Figure 1, we can know that teacher stay in page 1 from 09:25 to 09:28, so we label every minute between 09:25 to 09:28 as 1, and so on. Finally, we use teacher and student e-book reading history to calculate page synchronization ratio.

User	Operation	Operation_Time	Page_No	
Teacher	Open	Am 09:25:25	1	Action 1
Teacher	Next	Am 09:28:32	2	Action 2
Teacher	Next	Am 09:28:33	3	Action 3
Teacher	Next	Am 09:28:34	4	Action 4
Teacher	Previous	Am 09:31:25	3	Action 5
Teacher	Close	Am 09:33:57		

Figure 1. Example of fetching log data from database.

In response to the second research question, this research uses the attention measurement method mentioned in section 3.2.1 to measure the attention of students in the first chapter of the e-book, and conducts the Person correlation analysis with the results of the attention questionnaire. The results are shown in Table 2. As shown, by measuring the percentage of time that students have successfully followed the teacher's current page number in the first class of the semester, it is significantly correlated with the results of the student's attention questionnaire, indicating that this method can measure the attention of students.

Table 2. *Correlation between Attention (Page Synchronization Ratio) and Questionnaire*

Chapter	Students	Attention score	SD	Pearson's r
C1_1_Python intro	56	45.54	24.48	0.349**
C1_2_Variable	56	49.32	23.62	0.434***
C1_3_In/Output	56	37.93	22.41	0.410***
C1 total	56	44.26	20.44	0.460***
C2 total	44	23.66	13.01	0.352*
C3 total	47	12.92	11.95	0.252
C4 total	47	11.22	12.48	0.288*
C5 total	47	14.14	14.54	0.301*

Through the correlation analysis results shown in Table 2, it can be observed that the student's page synchronization ratio score in the previous few weeks is significantly correlated with the Pearson correlation coefficient of the attention questionnaire score. This means that the page synchronization ratio attention measurement method we proposed can indeed measure the student's learning attention in class, and it means that the higher the ratio of synchronization with the teacher's page, the higher the attention of students.

Although the proportion of students' page synchronization at the beginning of the course is significantly related to the attention questionnaire, it can be found that the attention of students gradually decreases from C2. This situation is caused by the change of the teacher's teaching method. At the beginning of the course, C1 was taught through e-books, but after entering the C2, some activities such as program implementation are gradually added, resulting in the proportion of students using e-books reduce. Therefore, in the course after C3, we use the Question-posing Quality method mentioned in Section 3.3.2 to try to measure the attention of students, and do a correlation analysis with the questionnaire. The results are shown in Table 3. The quality of questioning is indeed significantly correlated with the degree of attention, which shows that students' participation in questioning in class can also be used as an indicator to measure the degree of student's learning attention.

Table 3. *Correlation between Attention (Question-posing Quality) and Questionnaire*

Chapter	Students	Attention score	SD	Pearson's r
C3 total	39	2.13	0.732	0.346*
C4 total	41	2.32	0.722	0.489**

4.3 RQ3: Can students' attention be used for predicting their learning performance?

In order to explore the third research question, this study uses linear regression. A total of two quizzes were conducted in the course. We extract the scores of each chapter from the two quizzes, so there is a corresponding score in each chapter. The independent variable is the attention of each chapter of the student, and the dependent variable is the quiz score of the corresponding chapter. The attention in the first two chapters is measured by using the page synchronization ratio of students in class, and the results after linear regression are shown in Table 4.

Table 4. *Linear regression of learning Attention (Page Synchronization Ratio) and Quiz score*

	β value	
Independent variables	C1 Quiz score	C2 Quiz score
Constant	62.924***	72.347***
Attention (page synchronization ratio)	.320***	.398*
F	12.620***	5.613*
R^2	.219	.118
Adjusted R^2	.202	.097
Durbin–Watson	2.003	2.435

According to Table 4, it can be known that the F statistical value is significant, which means that the regression model has predictive ability, and the constant and attention are both significant. Although the C1 model has good predictive ability, its R2 does not reach the generally expected 0.5, which means that the model's ability to explain the amount of variation is not excellent.

Table 5. *Linear regression of learning Attention (Question-posing Quality) and Quiz score*

	β value		
Independent variables	C3 Quiz score	C4 Quiz score	C5 Quiz score
Constant	65.255***	61.771***	49.227***
Attention (Question-posing Quality)	9.381*	13.509***	15.455***
F	5.983*	55.613***	43.800***
R^2	.146	.588	.535
Adjusted R^2	.122	.577	.523
Durbin–Watson	2.148	2.031	1.798

Then we use another focus measurement method of C3, C4, C5 chapters and the quiz scores of the corresponding chapters to perform a linear regression modeling. The results are shown in Table 5. The F statistic value of this modeling is as high as 55.61, and the p value is less than 0.001, which means that

the regression model has better predictive ability. Among them, the R2 determination coefficients of the two chapters C4 and C5 are also higher than 0.5, indicating that the model has good explanatory power. It can be seen that the student's question score can be more accurate to predict the student's learning performance, and students who ask higher-level questions often have better results.

5. Conclusions

After eight weeks of data collection and analysis, we found that the reading log of students in e-books can measure students' attention in class, but this method is limited to teachers who use e-books for teaching almost the entire class. In addition, we also found that students' question-posing score and quality of questions in class are significantly related to their attention. In order to further explore how students' attention in learning affects learning effectiveness, we conduct a linear regression analysis of learning attention and learning performance. The research results show that whether it is the attention measured by the proportion of page synchronization used in the first two chapters or the attention measured by the question quality in the last three chapters, they are both significantly correlated with students' learning performance and have significant predictive properties. Through regression modeling results, it can be known that attention can be used as an important factor in predicting learning performance. This also shows that the higher the attention, the better the learning performance, and the attention can indeed predict the learning performance.

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