What are the Differences among Pre-service Teachers of Diverse Achievement Levels in Their Online Instructional Design Collaboration? —— Analyzing from the Perspective of Behavior Pattern

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***Abstract*—Instructional design plays a vital role in the development of pre-service teachers. Sharing and communication based on instructional design is the norm of professional development of pre-service teachers. Based on the instructional design activities of pre-service teachers guided by the collaborative knowledge building, this research adopts the methods of lag sequence analysis and content analysis method to analyze and compare the participation and behavior pattern of 20 pre-service teachers in both high- and low-achievement groups. This is in order to analyze the differences of online behavior pattern among pre-service teachers of diverse achievement levels. Moreover, a few suggestions are put forward: We should encourage pre-service teachers in the low-achievement group to be more active in participating in various stages of collaborative knowledge building activities, and improve the ability of pre-service teachers in the low-achievement group to deeply reflect on themselves after consulting with members of their cohort.**

Keywords—Collaborative Knowledge Building, Pre-Service Teachers, Online Behavior Patterns, Lag Sequence Analysis

I. INTRODUCTION

Instructional design is generally viewed as an important part in teachers' professional development [1-2]; teachers consider and plan what to teach, how to teach and how to evaluate so as to maximize the greatest wealth of experience [3]. In the process of instructional design, teachers can effectively organize the course by identifying the teaching objectives that meet the needs of the students, the teaching methods and learning activities in the class, as well as the teaching resources necessary for the learning process [4]. Existing studies have shown that there is a close link between instructional design and teaching quality, which can exert a significant impact on students' learning achievement and teachers' teaching performance [5]; ultimately, the success [6] and failure [7] of teaching are mostly attributed to instructional design. Teachers argue that instructional design activities can improve their teaching outcomes better than other professional development activities [8]. It can be seen that the professional sharing and communication based on instructional design is a common norm in teachers' professional development, which is key to the development of both in-service and pre-service teachers.

Great differences remain between the process and outcomes of teachers' participating in online collaboration, which is a result of their varied knowledge background and teaching ability. As big data has developed rapidly in recent years, educational data mining and learning analysis techniques have gradually emerged as a new research method and means for education, in which the learning analysis technique visually presents learners' learning behaviors and emotions, knowledge structures and learning paths in the online learning process. As an important part of the learning analysis technique, the learning behavior analysis can reveal learners' behavior patterns, behavior habits and behavior rules through analyzing behavioral data so as to promote people's understanding and optimization of the online learning process, results and environment [9]. This provides us with support in analytical methods and techniques to capture the behavior pattern characteristics of different participants in activities as well as analyze the depth of their participation.

Therefore, based on the theory of collaborative knowledge building, this study designs a five-stage collaborative learning task oriented to the instructional design of pre-service teachers. Twenty Chinese pre-service teachers are selected as the research objects (10 teachers each from high- and low-achievement groups). By using the learning behavior analysis and content analysis, this paper explores the characteristics and differences in the behavior patterns and cognitive levels of pre-service teachers with different achievement levels in online collaborative knowledge building activities and the reasons for these differences.

The main research questions are as follows:

(1) Considering the degree of overall participation, what is the difference between the high- and low-achievement groups in the online collaborative knowledge building activity?

(2) Considering the behavior process model, what are the respective characteristics of and differences between high- and low-achievement groups?

II. METHODOLOGY

A. Participants and research design

The study was conducted based on a project-based task in a course for pre-service teachers, which required the pre-service teachers to choose a text in the Chinese textbook for

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grade 2, begin their instructional design and create teaching courseware. A total of 56 pre-service teachers completed the task and none of them had learned or participated in a similar task before. Based on the scores of their final work, the top 10 and the bottom 10 pre-service teachers were selected to form the high-achievement group and the low-achievement group as the participants in this research. Figure 1 shows the specific process to carry out the activities.

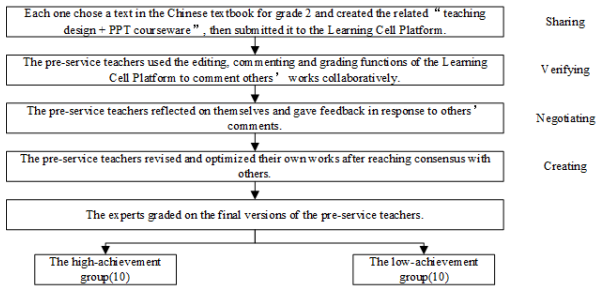

Fig. 1. The flow chart of conducting the activity

At first, in the sharing stage, each one chose a text in the Chinese textbook for grade 2 and created the related "instructional design + PPT courseware" oriented to the class, then submitted it to the Learning Cell Platform [10] for sharing;

Secondly, in the verifying stage, the pre-service teachers were required to use the editing, commenting and grading functions of the Learning Cell Platform to comment on others' work and collaboratively put forward suggestions;

Thirdly, in the negotiating stage, the pre-service teachers reflected on comments left for them and gave feedback in response to others' comments.

Finally, in the creating stage, the pre-service teachers revised and refined their own work after online communication and reaching consensus with others.

Fig. 2. The work knowledge group

The pre-service teachers spent two weeks carrying out the corresponding operations through the Learning Cell Platform. After the above four stages of the activity, experts with rich practical and teaching experience graded the final work of the pre-service teachers, and ranked them according to the results. In this study, the top 10 and bottom 10 in the ranking were selected as the high-achievement group and the low-achievement group respectively. Parts of the interface for the Learning Cell Platform are shown in Figure 2.

B. Instruments

The Learning Cell Platform (http://lcell.bnu.edu.cn/) is an open learning management and content creation system [11]. Its basic resource organization unit is the learning cell, with the functions of resource and learning management [12]. Based on the functions provided by the Learning Cell Platform and the requirements of this study, the corresponding behavior coding scheme is shown in Table 1, including seven different behaviors: editing, browsing, resource uploading, commenting, scoring, feeding back and checking. In this study, a learning cell is the work from one pre-service teacher.

Table 1. The online behavior coding scheme

Code	Behavior	Description
ED	Editing	Editing the learning cell created by oneself.
BR	Browsing	Browsing others' learning cells.
UL	Resource uploading	Uploading relevant resources, such as courseware, documents, pictures and so on in one's own learning cells.
CM	Commenting	Commenting on others' learning cells.
SC	Scoring	Scoring others' learning cells.
FD	Feeding back	Replying to others' comments.
CN	Checking	Checking the learning cell created by oneself.

All the data of the pre-service teachers on the Learning Cell Platform was exported to an Excel form broken down by various dimensions including operation time, operation behavior and specific operation content. The top 10 and the bottom 10 in the ranking list were selected in line with the behaviors in the table. A total of 977 records were obtained, as shown in Figure 3.

Fig. 3. Data table

III. DATA ANALYSIS AND RESULTS

A. Comparative analysis of the participation levels of the high- and low-achievement groups

1) Overall participation analysis

The 977 records of the 20 pre-service teachers operating in the Learning Cell Platform are classified according to the code table shown in Table 1. The results are shown in Figure 4. Seven kinds of behaviors are all involved, indicating that the 20 pre-service teachers have actively used the Learning Cell Platform. Among these behaviors, checking their own learning cells occupies the highest frequency (24%); next are browsing others' learning cells (23%), editing their own learning cells (17%), uploading resources in their own learning cells (13%), commenting on others' learning cells (12%), and feeding back on others' comments (6%), with the lowest frequency in scoring others' learning cells (5%). Conclusions can be drawn that pre-service teachers are more often engaged in browsing, including browsing their own and others' learning cells, followed by interaction with their personal work, including editing their own learning cells and uploading resources; at the same time, pre-service teachers are not good at interacting with others, shown by their low frequency of commenting on others' work, replying to others' comments, scoring others' work, etc.

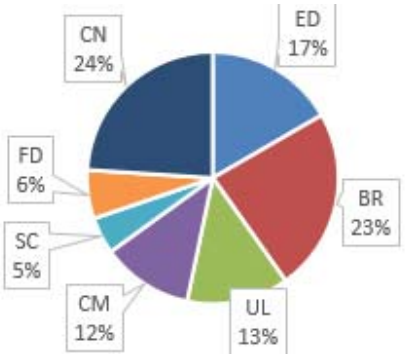

Fig. 4. The frequency of all behaviors of the high- and low-achievement groups

2) Comparison of the overall participation of the high- and low-achievement groups

Table 2 shows the frequency of the high- and low-achievement groups in terms of each behavior dimension. It can be seen that the frequency of the seven behaviors of the high-achievement group is higher than that of the low achievement group, indicating that the participation rate of the high-achievement group is higher than that of the other group. Moreover, the biggest gap between the two groups appears in both scoring and feeding back, which reflects that the low achievement group is not good at or has not developed the awareness and habit of scoring others' works or feeding back on others' comments.

Table 2. The behavior frequency comparison in the high- and low-achievement groups

	ED	BR	UL	CM	SC	FD	CN	Total
The high-achievement group	113	145	94	78	41	59	153	683
The low-achievement group	50	84	34	37	5	3	81	294

In order to further compare the participation levels of the high and low achievement groups, this study analyzes the social network relationship diagrams of the members in the high and low achievement groups separately, as shown in Figure 5 and Figure 6. As can be seen, the social network relationship in the high-achievement group is relatively intact, and 10 members have commented on other members of the group, indicating that the high-achievement group has been actively involved in the activities; the social network relationship of the low-achievement group is sparse, and two members did not comment on others or get comments from others. Compared with the high-achievement group, the low-achievement group shows lower levels of overall participation.

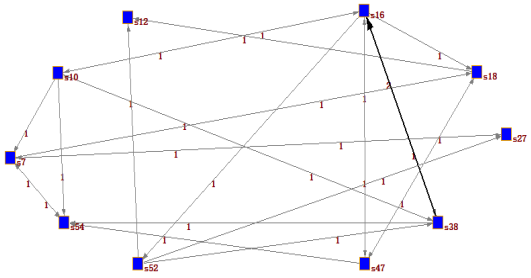

Fig. 5. The social network relationship diagram on the comments of the high-achievement group

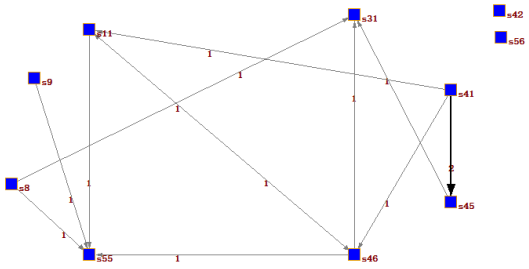

Fig. 6. The social network relationship diagram on the comments of the low-achievement group

3) Comparison of the participation levels of various stages of collaborative knowledge building in the high- and low-achievement groups

Fig. 7 shows the statistical graph for participation levels at the four stages—sharing, argumentation, negotiation, and creation in accordance with collaborative knowledge building. Each pre-service teacher in the high- and low-achievement groups submitted his or her own work to the platform, so the sharing stage is not considered in the statistics.

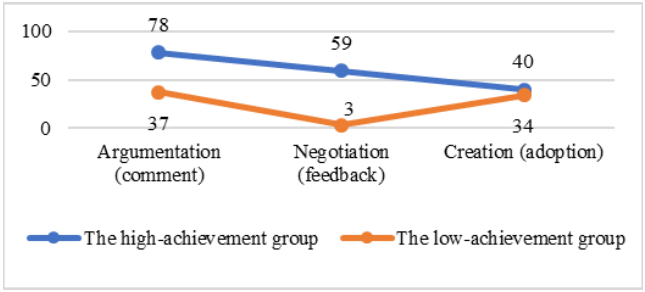

Fig.7. The participation level statistics of the high- and low-achievement groups in various stages of collaborative knowledge building

It can be seen from Figure 7 that the participation level of the high-achievement group in each stage of collaborative knowledge building is all higher than that of the low-achievement group. The gap between the two groups is the biggest in the negotiation stage, and to a certain extent, this can be seen as resulting from the lack of any significant negotiation stage; in the creation stage, the participation gap between the two groups is small, indicating that compared to feeding back on others' comments, the low-achievement group is more likely to directly adopt the comments.

B. Comparison of the behavior patterns of the high- and low-achievement groups

The frequency of each behavior that occurred in the high- and low-achievement groups is recorded according to the lag sequence analysis method. Sequence analysis is conducted by using the LSA analysis software GSEQ based on the statistical results, which can judge whether the relationship between the sequences has reached a significant statistical level. The resulting residual table is shown in Table 4, where the rows represent the different initial behaviors, and the columns show the resultant behavior. For example, 4.13 in the fourth column of the second row shows that the Z value of the CM occurrence after BR happens is 4.13. According to the lag sequence analysis method, Z values higher than 1.96 indicate that the continuity between sequences reaches a significant level ($p < .05$) [13]. As can be seen from Table 3,

the sequences reaching a significant level in the high-achievement group include ED->ED, ED->CN, BR->BR, BR->CM, BR->SC, UL->UL, CM->BR, CM->SC, SC->CM, FD->FD, CN->ED and CN->CN; the sequences reaching a significant level in the low-achievement group include ED->ED, ED->CN, BR->BR, BR->CM, UL->UL, CM->BR, CM->SC, SC->CM, CN->ED and CN->CN.

Figure 8 shows the behavior conversion graphs of the two groups resulting from the sequences that reached a significant level, and the values in the figure represent the Z values of respective sequences. The thickness of the lines stands for the degree of significance for the sequences, and the arrows point to each behavior's conversion direction.

Table 3. Contrast between all the operations of the pre-service teachers in the high- and low-achievement groups—adjusted residual table (Z-score)

	The high-achievement group						
	ED	**BR**	**UL**	**CM**	**SC**	**FD**	**CN**
ED	8.03*	-3.87	-1.98	-3.84	-2.52	-2.86	4.58*
BR	-3.34	6.05*	-5.11	4.13*	7.69*	-3.81	-3.63
UL	-3.38	-5.02	21.27*	-3.73	-2.65	-3.22	-3.24
CM	-3.50	7.11*	-3.78	-1.11	2.14*	-1.21	-0.21
SC	-2.92	-2.97	-2.66	17.88*	-1.68	-2.05	-3.58
FD	-3.19	-0.74	-3.24	-2.89	-0.34	16.79*	-2.74
CN	5.43*	-1.55	-4.23	-4.97	-3.52	-0.35	6.23*
	The low-achievement group						
	ED	**BR**	**UL**	**CM**	**SC**	**FD**	**CN**
ED	3.95*	-4.21	-0.49	-3.20	-1.58	-0.78	4.52*
BR	-1.83	3.09*	-3.82	5.99*	0.54	-1.05	-3.43
UL	-1.60	-3.29	11.75*	-2.42	-1.20	1.31	-1.57
CM	-3.02	5.26*	-2.50	-1.86	4.65*	-0.68	-1.38
SC	-1.50	-2.12	-1.24	8.97*	-0.69	-0.34	-2.27
FD	0.88	-1.05	-0.61	1.02	-0.34	-0.17	0.16
CN	2.33*	-0.19	-1.26	-4.13	-1.57	1.48	2.63*
*p<0.05							

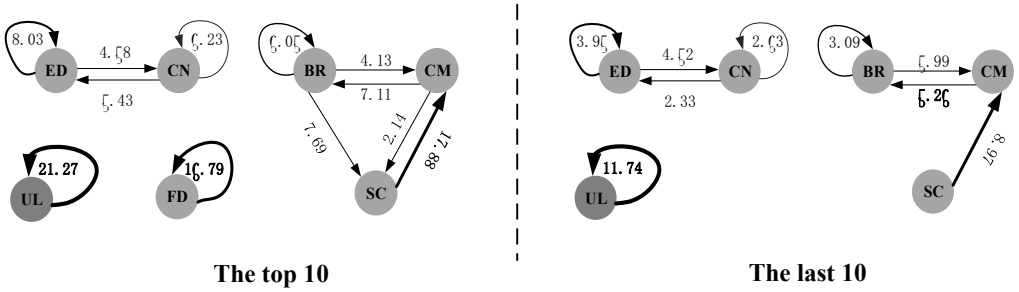

Fig. 8. The comparison-conversion graphs of all operational behaviors of the pre-service teachers in the high- and low-achievement groups

As can be seen from Figure 8:

(1) Both groups tend to repeatedly edit (ED-> ED), check (CN-> CN) their own work, and upload resources (UL-> UL) to their own work. In addition, both groups have re-checked their own work after completing editing (ED-> CN) and re-edited their work after checking (CN-> ED), indicating that both groups are concerned about repeatedly checking and revising their own work. But in these behavior sequences, the Z values of the high-achievement group are all higher than those of the low-achievement group, demonstrating that the former group pays more attention to reexamination and repeated revision.

(2) Both groups tend to browse others' work continually for a period of time (BR-> BR), and comment on others based on their browsing (BR-> CM), or continue to browse others' works after commenting on others (CM->BR). In addition, the Z value in the high-achievement group (6.05) is obviously higher than that of the low-achievement group (3.09), showing that the former group places more emphasis on finding reference points and inspiration by browsing others' works.

(3) Both groups include the behavior sequence of SC-> CM-> BR, indicating that both groups have the behavior patterns of scoring, commenting and re-browsing. However, compared with the low-achievement group, the behavioral pattern of the high-achievement group is more diversified, including the behavior sequences of CM-> SC and BR-> SC, which indicates that this group sometimes chooses to comment first and score later and browse first and score later. Conclusions can be drawn that the high-achievement group has formed a cycle of behavioral conversion among the three behaviors: browsing, commenting and scoring.

(4) Compared with the low-achievement group, the high-achievement group shows the behavior pattern of continually feeding back on others' comments over a period of time (FD-> FD), indicating that the high-achievement group prefers to feedback to others' comments, which embodies its self-reflection process.

IV. Discussion

Based on the comparative analysis of the participation, behavior patterns and cognitive levels of the pre-service teachers of the two groups in the collaborative knowledge building activities, this section will explain the above research findings from different perspectives, answer the research questions and make recommendations.

A. Encourage pre-service teachers in the low-achievement group to be more actively involved in all stages of the collaborative knowledge building activities

Through the above analysis, we can find that the participation levels of the low- achievement group are all lower than that of the high-achievement group at all stages of collaborative knowledge building, and the interaction among the members of the former group is relatively weak. We may draw the conclusion that the difference in the participation levels for the learning activities will affect the academic achievements of pre-service teachers to a certain degree.

By reviewing related literature, it is found that the reason for the low involvement of the low-achievement group in the learning activities might be their psychological states. In

general, pre-service teachers in the high-achievement group boast firm knowledge base and strong comprehension ability, so they often receive more attention and expectations from experts, while teachers in the low-achievement group often lack confidence because of their poor performance [14]. They assume there is a big gap between themselves and others, even if they comment on others' works, point out problems or make corresponding recommendations. They expect others will not accept their ideas, which results in a low participation rate. In response to this question, it is advisable to require pre-service teachers to comment on each other anonymously on the platform and set a rule that they must comment, encouraging the pre-service teachers in the low-achievement group to actively think and communicate with others so as to improve the participation rate.

B. Promote deep self-reflection based on peer consultation among the pre-service teachers in the low-achievement group

By analyzing the differences in the behavior patterns between the two groups, it can be found that the behavior pattern of the high-achievement group is more thorough and diversified than the other group, which is consistent with the results of relative existing literature analysis [15]. The most significant difference in behavior patterns is that the high-achievement group continually comments on others' comments over a period of time, indicating that at the negotiation stage of knowledge building, the group is more concerned about peer recommendations and communicating with peers. They then begin self-reflection based on this process. The frequency and quality of self-reflection will affect their academic achievements to a certain extent.

Related research show that pre-service teachers who begin self-reflection based on others' comments can reflect on their experience while drawing on those of others, recognize their strengths and weaknesses and accept suggestions that can improve their work [16]. This helps to improve learners' metacognitive ability and knowledge building level [17], and is conducive to their own learning effectiveness. As for the lack of self-reflection awareness and ability of the low-achievement group, on the one hand, relevant experts or mentors should consciously pay attention to cultivating this awareness and ability in pre-service teachers of the low-achievement group and motivate them to promptly reflect on their learning effectiveness during their daily teaching process [18]; on the other hand, technology can be used to develop the functionality of learning tutors on the learning platform. The pre-service teachers in the low-achievement group will be prompted when they receive comments from others, which will guide them to reflect on themselves and give feedback, training their ability and forming effective habits.

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