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How Different Cognitive Style Groups Affect Learners' Knowledge Construction in Collaborative Argumentation

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ABSTRACT

The ability of innovation, critical thinking, communication and cooperation are highly emphasized. Knowledge construction has been recognized as a crucial collaborative process contributing to individuals' learning and to high-productivity collaboration. Cognitive style is an important factor that affects the knowledge construction of students. This research aims to explore how the combination of people with different cognitive styles affects students' collaborative knowledge construction. The intuition-analysis cognitive style classification is used as the basis for grouping. There are eight groups in four different combination which include all-analysts, two intuitivists & one analysts, two analysts & one intuitivist, and all-intuitivists. They were asked to take part in a collaborative argumentation which were recorded for further analysis. The results show that, the group with different cognitive style students performs better than those with same cognitive style members in knowledge construction in the collaborative argumentation. In the group of mixed cognitive styles, the more analytic students, the higher and more logical the entire group' knowledge construction is. Therefore, it is recommended that teachers adopt the heterogeneous cognitive styles grouping strategy.

CCS CONCEPTS

• **Applied computing**; • **Collaborative learning**;

KEYWORDS

Knowledge Construction, Collaborative Argumentation, Cognitive Styles, Higher Order Thinking Skills

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1 INTRODUCTION

1.1 Knowledge construction in collaborative argumentation

The ability of innovation, critical thinking, communication and cooperation are highly emphasized in the knowledge society. Knowledge construction has been recognized as a crucial collaborative process contributing to individuals' learning and to high-productivity collaboration [1]. Knowledge construction refers to collaborative process in which learners deals with the production and improvement of ideas in a context specific situation [2]. There are several models explaining the process of knowledge construction [3; 4]. Gunawardena [3] constructed an interactive knowledge construction model, which consists of five stages of knowledge construction: information sharing and comparison, discovery and analysis of disagreement, negotiation of meaning or construction of new knowledge, inspection and modification agreement and applications of newly constructed meaning. This model is widely used to conduct research on the process of student knowledge construction.

Researches have shown that knowledge construction can be effectively achieved through well-organized classroom discourse [5]. Argumentation has a feature of dialogue [6] which make a logical connection between facts and ideas [7]. Therefore, argumentation can be an effective way to help students achieve high level knowledge construction. It can not only enable learners to gain a deeper understanding towards concepts [8], but also can reconstruct knowledge in the interactive process, providing a prerequisite for further construction of knowledge [9]. In short, argumentation is an effective way to construct knowledge, and knowledge construction is an important criterion for testing the quality and effectiveness of argumentation.

Argument-based learning activities are usually carried out in groups. There are usually two strategies to grouping: heterogeneous and homogeneous. Previous studies tend to use heterogeneous groupings [10, 11]. Heterogeneous grouping based on academic performance is the most common, which has been proved some negative effects exists [12, 13]. Because the group is composed of

students who usually have very different personalities, making it difficult for all students to adopt the same learning methods. Therefore, it is necessary to determine whether different personalities affect the performance of students' collaborative knowledge construction and to determine the effectiveness of personalities as a basis for grouping.

1.2 Cognitive style and collaborative grouping

Learning styles is a relatively stable way that reflects how learners perceive information, interact with and respond to the learning environment. Slightly different from learning style, cognitive style is a preference for individuals to organize and represent information [14]. A large number of recent studies have shown that different cognitive styles are closely related to students' problem-solving ability [15], reasoning ability [16], metacognitive skills [17], critical thinking [18] etc. Therefore, it is necessary to explore the influence of cognitive style as a strategy for grouping on students' collaborative knowledge construction.

There are many types of cognitive styles, such as field-independent and field-dependent [14], holist-analytic and verbalizer-imager [19], intuition-analysis [20]. In the past, the researches of cognitive style mainly focused on the field dependence/field independence proposed by Witkin et al. [14]. Some recent studies have tried to transfer to other dimensions of cognitive style [21], such as Intuition-Analysis. Students with Intuitive and analytical cognitive styles have different learning preferences [20]. Intuitivists are relatively unconventional, prefer open-ended problem-solving methods, rely on random exploration methods, and can better deal with ideas that require overall evaluation. Analysts tend to be more conservative, prefer structured problem-solving methods, rely on systematic methods. They are especially suitable for ideas that require step-by-step analysis. Argumentation is a process that requires students to analyze, reason, and use evidence or data to support their own claims, conclusions or rebuttals [22]. Theoretically, this style classification is more closely related to the process of argumentation. However, there is still few researchers to explore the process of knowledge construction from the perspective of intuition-analysis cognitive styles. Therefore, this study uses intuition-analysis cognitive styles as the grouping strategy.

Regarding the combination of cognitive styles in collaborative learning, only a few studies have shown that mixed cognitive style groups perform better than homogeneous groups [23]. However, Further research is still needed on how to combine students with different cognitive styles in one group. This is important because it helps us adjust teaching strategies to take learners' personalities into consideration and make collaborative learning more effective. Therefore, this study uses the cognitive style of Allinson & Hayes [20] as the grouping basis for collaborative argumentation, dividing students into 4 kinds of groups including all intuitive members, all analytical members, 2 intuitive and1 analytical members, 2 analytical and 1 intuitive members The purpose of this study is to analyze the differences between the knowledge construction behavioral patterns among all the mentioned groups in order to provide a grouping strategy for future knowledge construction in collaborative argumentation. Thus, the research questions of this study are as follows:

- What are the characteristics of students' knowledge construction under different cognitive style grouping strategies?
- What are the differences in the sequential patterns of groups' knowledge construction behaviors in different cognitive style combination?

2 METHODS

2.1 Participants

The participants consisted of 24 graduate students (Female = 18, Male = 6; approximately 19-25 years old) from a university in China. They were selected by their different cognitive styles which were tested by Cognitive Style Questionnaire. Half of them are intuition style, and the rest of them are analysis. Students were divided into four groups, each with 3 students according to their cognitive style.

2.2 Experiment Procedure

The experimental process is shown in Figure 1. Before the experiment, participants were shortly informed about the procedure of the whore experiment and some other tips. Then all participants need to take a cognitive style test to figure out which kind of cognitive style they are (about 5mins). According to the cognitive style test, the students were divided into 4 types of groups with different cognitive style combinations. They are: type 1(three analytical students), type 2(three intuitive students), group 3(two intuitive students and one analytical students), group 4(two analytical students and one intuition student). There are 2 groups in each type, a total of 8 groups.

During the experiment, students were asked to carry out a collaborative argumentation based on a given socio-scientific issue regarding food safety, which lasted 30-60 minutes. Participants were allowed to express their opinions until they reach an agreement. During the experiment, the process of collaborative argumentation will be videoed and recorded for later analysis.

2.3 Instruments

2.3.1 Cognitive style questionnaire. To identify students' cognitive styles, the study used the cognitive style questionnaire developed by Allinson, C. W., & Hayes, J. [20], which divides the cognitive style into intuition and analysis. The scale has 38 questions, with a total score of 76. An intuition style with a score equal to or lower than the average and an analysis style with a score above the average.

2.3.2 Knowledge construction coding scheme. We adopted the Gunawardena et al. [3] knowledge construction coding scheme, which is a widely accepted coding scheme for studying knowledge construction. In order to cover all discourse texts and ensure the comprehensiveness of the coding results, this study added two new items, namely Z (organization and coordination of the development of the argument) and O (off topic), as shown in Table 1

2.4 Data collection and analysis

Data for this study were collected from participants' argumentation which were converted into text. According to Gunawardena's

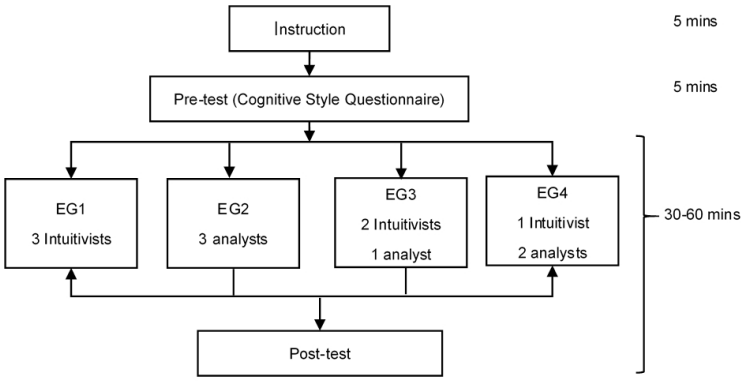

Figure 1: Experiment Procedure

Table 1: The coding scheme for knowledge construction

PHASE	Description	Code
PHASE I: Sharing/Comparing of Information.	A statement of observation or opinion	1A
	A statement of agreement from one or more other participant	1B
	Corroborating examples provided by one or more participants	1C
	Asking and answering questions to clarify details of statements	1D
	Definition, description, or identification of a problem	1E
PHASE II: The Discovery and Exploration of Dissonance or Inconsistency Among Ideas, Concepts or Statements.	Identifying and stating areas of disagreement	2A
	Asking and answering questions to clarify the source and extent of disagreement	2B
	Restating the participant's position, and possibly advancing arguments or considerations in its support by references to the participant's experience, literature, formal data collected.	2C
	proposal of relevant metaphor or analogy to illustrate point of view	2D
PHASE III: Negotiation of Meaning/Co-Construction of Knowledge	Negotiation or clarification of the meaning of terms	3A
	Negotiation of the relative weight to be assigned to types of argument	3B
	Identification of areas of agreement or overlap among conflicting concepts	3C
	Proposal and negotiation of new statements embodying compromise, co-construction	3D
	Proposal of integrating or accommodating metaphors or analogies	3E
PHASE IV: Testing and Modification of Proposed Synthesis or Co-Construction	Testing the proposed ideas and views and modify it.	4A
PHASE V: Agreement Statement(s)/Applications of Newly Constructed Meaning	Summarization of agreement(s) and applications of new knowledge	5A
Organization	Organize and coordinate the development of argumentation	Z
Off Topic	Content that has nothing to do with argumentation	O

knowledge construction model, all students' discourses were coded respectively by two independent coders who received training of applying the coding schemes. In the coding process, a researcher first coded all the 784 pieces of formal data. Then another researcher will randomly check 350 coding results for consistency test. The results showed that the Kappa coefficient was 0.778 (p<0.01). After the coding is completed, to further explore the different sequential patterns of knowledge construction between groups of different cognitive styles, lag sequential analysis (LSA) was used by GSEQ5.1.

3 RESULTS

3.1 The Different Characteristics of Students' Knowledge Construction in Different Groups

Table 2 shows the frequency and distribution of the participants' different knowledge construction behaviors of different groups. First of all, phase 1 (sharing and comparing information) accounted for the largest proportion. As the level of knowledge construction

Table 2: The frequency and distribution of each level of knowledge construction

Style Tag	All ANALYSTS	All INTUITIVISTS	2 INTUITIVISTS 1 ANALYST	1 INTUITIVIST 2 ANALYSTS
1A	46(12.78%)	80(28.17%)	17(13.93%)	23(12.11%)
1B	12(3.3%)	41(14.44%)	12(9.84%)	13(6.84%)
1C	6(1.67%)	7(2.46%)	5(4.1%)	3(1.58%)
1D	39(10.83%)	33(11.62%)	12(9.84%)	21(11.05%)
1E	12(3.33%)	10(3.52%)	11(9.02%)	7(3.68%)
2A	25(6.94%)	20(7.04%)	3(2.46%)	7(3.68%)
2B	37(10.28%)	7(2.46%)	10(8.2%)	29(15.26%)
2C	24(6.67%)	15(5.28%)	14(11.48%)	15(7.89%)
2D	2(0.56%)	3(1.06%)	5(4.1%)	3(1.58%)
3A	21(5.83%)	19(6.69%)	4(3.28%)	0(0%)
3B	3(0.83%)	1(0.35%)	3(2.46%)	17(8.95%)
3C	2(0.56%)	3(1.06%)	1(0.82%)	4(2.11%)
3D	18(5%)	3(1.06%)	7(5.74%)	2(1.05%)
3E	1(0.28%)	3(1.06%)	3(2.46%)	1(0.53%)
4A	5(1.39%)	0(0%)	0(0%)	0(0%)
5A	1(0.28%)	0(0%)	0(0%)	0(0%)
Z	44(12.22%)	19(6.69%)	4(3.28%)	29(15.26%)
O	62(17.22%)	20(7.04%)	11(9.02%)	16(8.42%)

becomes higher, the frequency of behavior of each phase in all groups gradually decreased. And only the group with three analysts reached the fourth and fifth phase.

Secondly, only the three analysts group showed a higher frequency in 4A (testing the proposed ideas and views and modify it, 1.39%) and 5A (summarization of agreements and applications of new knowledge, 0.28%) than the other groups. In the three-analysts group, the three intuitivists group and the group with two intuitivists and one analyst, 1A (a statement of observation or opinion,12.78%, 28.17%, 13.93%) is the most frequent knowledge construction behavior, but with regard to the group with two analysts and one intuitivist, 2B (asking and answering questions to clarify the source and extent of disagreement, 15.26%) is the most frequent behavior. This result shows that the argumentative process of the two analysts one intuitivists groups is mainly focused on asking and answering questions to clarify the inconsistencies, while the other three groups tend to describe or state facts or views.

The frequencies of 1A (a statement of observation or opinion, 28.17%) and 1B (descriptions that agree with the opinions of other participants, 14.44%) of the all-intuitivists group were significantly higher than those of the other groups, indicating that the all-intuition group was more inclined to describe a fact or to show their position. As to the behaviors of the all-intuitivists group in the third phase, 3A (negotiation or clarification of the meaning of terms, 6.69%) accounted for a high proportion, while the percentage of the other behaviors (3B 0.35%, 3C 1.06%, 3D 1.06%) in the same phase is much lower, indicates that the intuitive styles members is more inclined to reach a consensus on the understanding of a certain concept or term in the third stage of the knowledge construction process.

3.2 The Different Sequential patterns of Knowledge Construction among Different Groups

In order to further explore the differences in knowledge construction behaviors between different groups, LSA was used. The figures present all the behavior transitions that are statistically significant according to the Z score of the behaviors. The connection between the nodes indicates that the two behaviors have a significant transition sequence. The arrow represents the direction of behavior transition, and the thickness of the line indicates the significant level

Figure 2 shows the significant behavioral transition sequence of the Homogeneous groups. Overall, the all-analytic groups' knowledge construction transition behaviors cover all the five phases and the transition process is complicated. In the process of the knowledge construction, 2C (Restating the learners' position, and advancing arguments to support their views) is a bridge between the low level and the high level of the knowledge construction (1B→2C→3C), indicating that when students encounter inconsistent views, group members will repeatedly elaborate the learner's position, identify conflicting concepts, and other group members will also express their agreements. In addition, although the knowledge construction in this kind of groups contains five phases, it has a leap (such as 1C→5A), which means, the level of knowledge construction has directly crossed from the first phase which is a lower level to the high level of knowledge construction, the fifth phase.

As to the knowledge construction behavioral sequence of the groups with all intuitivists, it can be seen that, first, the behaviors of groups with all intuitivists only include the first three lower phases and there is fewer behavioral transition between the first two phases. Second, the knowledge construction behavior of the all-intuitivists groups jumps repeatedly between the second and

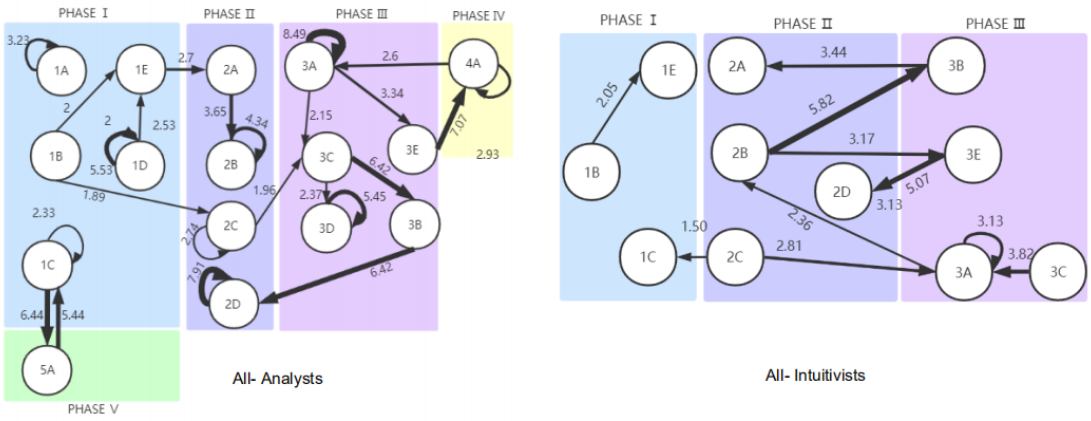

Figure 2: The Behavioral Transition Diagram of Groups with All Analysts and All Intuitivists

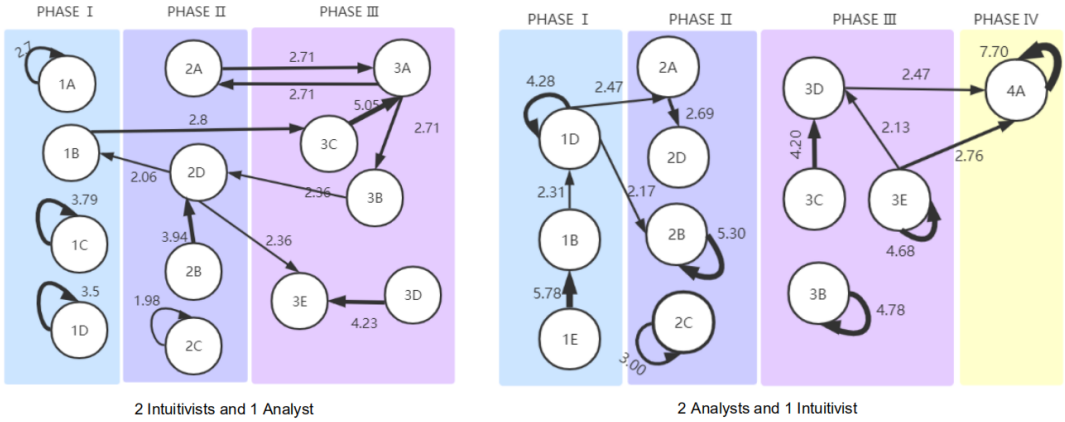

Figure 3: The Behavioral Transition Diagram of Group with 2 Intuitivists & 1 Analyst and 2 Analysts &1 Intuitivist

the third phases, such as 2B→3B→2A, indicating that intuitivists will first ask and answer questions to clarify the inconsistency and the disagreement, and then negotiate various views and distinguish their importance. In the process of that, they find that there may be some problems with the original views, so they return to identify the inconsistencies.

Figure 3 shows the significant knowledge construction behaviors of heterogeneity group. Compared with the groups with full intuitivists, it can be seen that the behaviors of groups with 2 intuitivists and 1 analyst are similar with all-intuitivists groups. It also only includes three phases of knowledge construction, and there are frequent and repeated behavior transitions between the three phases. For example, 1B→3C (agree with the other participants→identify the commonalities between conflicting views), 3B→2D (negotiate various views and distinguish their importance→propose alternative hypotheses). While groups with 2 analysts and 1 intuitivist have a high-level knowledge construction behavior (4A), and consists of 4 phases. Their knowledge construction behaviors do not exist a big jump between the four phases, and increase from low to high level gradually.

4 CONCLUSIONS AND DISCUSSION

The purpose of this research is to explore the different characteristics and behavioral transformations of groups with different cognitive style combinations in knowledge construction by content analysis and lag sequential analysis.

This research reveals some features of different groups. In all knowledge construction phases, phase 1 accounts for the largest proportion. As the level of knowledge construction increases, the dialogue interaction of all groups gradually decreases. This shows that a higher level of knowledge construction is more difficult for all groups. In many cases, knowledge construction stagnates on sharing and comparing information (the first stage), that is, elaborating existing knowledge rather than constructing new knowledge [24; 25].

Moreover, it is shown that only the all-analysts group's knowledge construction reached the fourth and fifth stages whose proportion is relatively small, indicating that the students in the entire analysis group are able to perform higher-level knowledge construction behaviors. This may be attributed to the feature of students of analytic cognitive styles. If there are more students with analytic

cognitive style, it is easier for the group to analyze and solve problems step by step [20]and to promote the whole group to a higher level of knowledge construction.

Among all the groups, only in the two analysts one intuitivists group, 2B (Asking and answering questions to clarify the source and extent of disagreement) is the most frequent behaviors, while the other three groups' most common behaviors is 1A (a statement of observation or opinion). This shows that the combination of two analysts and one intuitivist push the group to higher level so that they can clarify disagreements rather than simply statement of facts. In summary, it is easier to achieve a higher level of knowledge construction which is important for new knowledge creation [24] and collaboration by assigning more analytic people in a group.

The all-intuitivists group has significantly more behaviors of 1A (a statement of observation or opinion) and 1B (a statement of agreement from one or more other participant) than the other groups, which is consistent with the characteristics of intuitive cognitive style [20], they are more inclined to describe an observed phenomenon or result or to relay the intuition while expressing agreement with others' views. In addition, in the third stage of knowledge construction, the frequency of 3A (negotiation or clarification of the meaning of terms) behaviors were much higher than the behaviors of 3B, 3C, and 3D, indicating that the all-intuitivists group is good at figuring out a term's meaning. To be precise, they pay more attention to the understanding of a certain concept and terminology and tend to reach a consensus rather than to construct and create together, which is not good for reaching a higher level of knowledge construction. This is in line with the feature of people with intuitive cognitive style who prefer open-ended problem-solving and random exploration while lack the overall awareness of problem-solving.

The sequential analysis shows that there are different knowledge construction behavior patterns between groups of different cognitive styles. Regarding the homogeneous groups, the knowledge construction pattern in the all-analysts' groups is more complicated. When students encounter disagreements, they will repeatedly elaborate their position (2C), identify conflicting concepts (3C), and other group members will also express their approval and opinions (1B). While in the groups of all-intuitivists, students will not construct the new knowledge in the general order, and they will jump repeatedly between the different levels of knowledge construction. The reason is probably due to the characteristics of the intuitive learners. Intuitive learners tend to think holistically in the process of knowledge construction [20], which will make them find the problems in the details at the beginning, so they would turn back and ask and clarify questions, distinguish the inconsistency, and then negotiate and integrate the views.

As to the heterogeneity groups, the knowledge construction behaviors of the groups with 2 intuitivists and 1 analyst are similar to the all-intuitivists groups. Their knowledge construction level changes between the first three phases. This may be due to two intuitive group members played important roles. While groups with 2 analysts and 1 intuitivist have a higher-level knowledge construction behavior, and their knowledge construction level gradually rises from low to high among the four phases. This may be due to the influence of two analytical members, who makes the knowledge construction of the whole group logical. Analytical members tend to structure problem-solving methods, and often conduct systematic analysis [20], so that the knowledge construction of the entire group is organized in an orderly manner, and the level of knowledge construction increased step by step.

In general, in the process of collaborative argumentation, the knowledge construction process of heterogeneous cognitive style grouping is more organized than homogeneous cognitive style groups. This result is consistent with the study of Cunningham-Atkins [23], which is, teams with more diverse cognitive styles perform better than non-diversified teams. Another finding of this study is that in the heterogeneous groups, of the more analysts in the group, the knowledge construction of the entire group is easier to reach a higher level, and the knowledge construction behavior is more sequential or logical. Specifically, in this study, the performances in the groups with 2 analysts and 1 intuitivist are better than the groups with 2 intuitivists and 1analysts. Therefore, we suggested that teachers can adopt the strategy of heterogeneous grouping, in the process of collaborative argumentation.

This research confirms the relationship between the cognitive style grouping and the collaborative knowledge construction patterns, and provides preliminary insights on how to group cognitive styles to facilitate collaborative argumentation which expands the previous research. The results of LAS revealed the characteristics and differences of the knowledge construction behavior of different groups, and explains the effect of collaborative argumentation of different groups.

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