Concept Mapping to Learn and Innovate
Proc. of Sixth Int. Conference on Concept Mapping
Santos, Brazil, 2014

A STUDY OF EFFECTIVENESS OF SCHEMATIC INTERACTIONS VISUALIZATION IN ADVANCED ENGLISH READING TEACHING - A CASE STUDY ON SOLO TAXONOMY

Xiang Zhang, Southern Medical University, China
Email:arithens@163.com

Abstract. The paper aims to investigate the effectiveness of schematic interactions visualization (SIV) in enhancing individual's critical thinking in Advanced English reading teaching. SIV is a new form of interactive strategy with support of learning technology of concept maps, which consist of five interactions in three phrases-before class, in class and after class. The experiment utilizes SOLO taxonomy scores to evaluate the individuals' learning outcome in four classic English articles under two different scenarios: the one with traditional learning strategy and the one with SIV learning strategy. The preliminary results reveal that the application of the multi-layered ordering SIV strategy is advantageous for individual's critical thinking and thus sets a good example for advanced English reading teaching.
Key words: schematic interactions visualization, SOLO taxonomy, critical thinking.

1 Introduction

Concept maps, a knowledge visualization tool, can be combined with recent technology to provide integration between knowledge and information visualizations (Cañas et al., 2005). With the support of concept maps, individual's implicit schematic knowledge is explicitly represented. The author has proposed concept maps-based interactive teaching model for thematic English reading based on case study. This teaching model shows that visualized implicit schematic interactions functioned as a kind of new interactive teaching strategy to enhance students' critical thinking. The theoretical framework of schematic interactions visualization in English reading teaching refers to the visual, multi-layered, orderly interactive teaching strategy between teachers and students or between students, using schema theory on the expressive form of concept maps under informational technology environment, aiming at improving the interactive effectiveness of English reading teaching and enhancing students' critical thinking (Xiang Zhang, 2014).

2 Schematic Interactions Visualization

According to schema theory, to accurately understand the main idea of the text, there are two fundamental elements: one is that possessing corresponding schemata with the text; the other is successfully activated the corresponding schemata of the text during the process of reading. When the input information can't coincide with the schema stored in individual's memory, there will be two kinds of possibilities: one is negatively refusing to accept the new information; the other is positively modifying the original schema structure to absorb "fresh" information. Schema theory advocates the necessity of interaction in reading teaching. How to, through effective interaction with learning technology, activate students' schema so as to enhance their critical thinking. This is a new problem of the application of schema theory in reading teaching.

Schema was originally created by German philosopher Kant in the 19th century, who described schema as "productive imagination" that "hides deep inside the human psyche" (Kant, 2008). Schema theory derived from Bartlett's radical experiments on retelling stories (Bartlett, 1995). According to Bartlett, by "schema" he meant "an active organization of past reactions or past experiences". Although scholars have different elaborations on the nature of schema and on how schema affects the cognition process, they do share some consensus, which paves the ground of the modern schema theory. Their common viewpoints include:

1) People have schemata in their mind;
2) People's schemata affect their cognition process;
3) People's schemata develop as a means of accommodating new facts;
4) Schema is stored in people's mind in the form of networks with concepts as nods and the relationship between concepts as links.

Schematic interactions are kind of cognitive activities that are influenced by the individuals' implicit existed schemata. There exists various forms of schematic interactions in English reading teaching: linguistic schemata and cultural schemata interaction, language and cultural knowledge of source language and target

language schemata interaction, universal knowledge schemata and professional knowledge schemata interaction, encyclopedic schemata and language and cultural knowledge schemata interaction, contextual knowledge schemata and language and cultural knowledge schemata interaction as well as new information and existed information schemata interaction (Rong Xia, 2008). Due to the difficulties in confirming the defaults caused by implicit schematic interactions, such interactions are prone to generate schematic overlap, new schema recognition boundary ambiguity, new schema tolerance and uncertainty strategy, etc. These problems directly influenced the effective application of implicit schematic interactions in language reading teaching.

Novak (Novak, 1977) proposed that the primary elements of knowledge are concepts and relationships between concepts are propositions. Novak (Novak, 1998) defined concepts as "perceived regularities in events or objects, or records of events or objects, designated by a label." Propositions consist of two or more concept labels connected by a linking relationship that forms a semantic unit. In summary, the teaching functions of concept maps are as follows

1) Concept maps are an effective way of representing a domain of knowledge.

2) Concept maps are visual indication of the semantic network that reveals patterns, interrelationships, and interdependencies, which result in stimulating creative thinking.

3) *Excellent concept map constructors can either identify new model or regularities, or explore the relationship between concepts; or capable of forming new hierarchical framework. These types of activities are high-level meaningful learning activities that can cultivate creative thinking.*

4) *The multi-functions of what concept maps hold make it an effective instructional tool for educators.*

Based on the-above-mentioned literature review, this study seeks solution from concept maps to effectively visualize individual schematic interactions in order to further facilitate the efficiency of critical thinking training in advanced reading teaching. This study quotes the term of visualization from the field of computer science, and puts forward a new term, namely "Schematic Interactions Visualization". Based on the instructional design of schematic interactions visualization under concept maps-based interactive teaching model for thematic English reading, the features of the framework are as follows:

A. Visualization

1) Schema representation normalization.

Thematic concept maps construction is strictly in accordance with concept maps construction procedure. Inclusive concepts are found at the highest levels, with progressively more specific, less inclusive concepts arranged below them with different shapes required by teachers. During this construction, students' implicit schema cognitive process has been conversed from static state to dynamic and interactive state, which provide direct cognitive data for teachers to quickly ascertain students' recessive schemata defaults.

2)Preservability and reviewability of cognitive process and result.

With the support of recorder on the CampTools, students' construction process and result have been preserved as text files. These files plus students' concept maps provide teachers and students with strong cognitive evidence to review individual schemata, making it convenient for distinguishing the dividing line between the new and the old schemata knowledge, thus avoiding the repetition of schemata and leading to deepened exchange and innovation regarding comprehension.

3）Flexibility and sharing of critical thinking.

From an education perspective, there is a growing body of research that indicates that the use of concept maps can facilitate meaningful learning (Cañas & Novak, 2003). The freedom of carefully chosen all the triples (concept, linking phrase, concept) show how nuances of meanings have been developed, thus making students a creator to personal knowledge. Expandability of thematic concept maps develops an environment where students can collaborate and share in their knowledge construction.

B. *Multi-layered ordering*

The framework of visualization of schematic interactions in English reading teaching consists of 5 thematic concept maps interactions in 3 teaching segments.

3 SOLO taxonomy

SOLO Taxonomy is a model established by John Biggs and Kevin Collis, which aims to assess individual's learning outcome (John 2014). According to Biggs and Collis (John & Kevin 1982), individual's general cognitive structure is a purely theoretical concept, which can't be examined definitely, and it's called hypothetical cognitive structure, HCS; while individual minding structure during responding to certain questions

can be examined and it is called structure of the observed learning outcome, SOLO. SOLO Taxonomy targets to describe different levels in the quality of individual learning, which can be divided into 5 levels as follows:

- Pre-structure: individual misses any relevant points completely, such as misunderstanding the questions, lacking tested knowledge.
- Uni-structure: individual responds with only one relevant point.
- Multi-structure: individual makes use of more than one point to respond but in an inconsistent and unrelated way.
- Relational: individual can integrate all the points into a coherent framework within the scope of content in questions.
- Extended Abstract: individual generalizes the previous integrated framework into an abstract level, beyond the already-existed area of topics.

In addition to the above 5 levels, there are transitional levels between every two sequent levels.

Since its birth in 1982, SOLO has been applied extensively in different disciplines, teaching evaluation and curriculum design. Over the past 20 years, there had been more than 1000 empirical study cases based on SOLO and what's more, a quantity of doctoral thesis had applied the model (Cai 2006).

In this experiment, SOLO test were scored according to the above-mentioned five levels, showed in the following table, with the maximum score of 40 points.

Table 1: SOLO taxonomy for English reading

Levels of SOLO taxonomy	**Meaning of the level**	**Students' possible answers**	**Order of evaluation**	**score**
Pre-structure	Individual misses any relevant point completely, such as misunderstanding the questions, lacking tested knowledge.	Focus on meaningless information	A	0
Uni-structure	Individual responds with only one relevant point	Know the cultural background; or find out obvious information	B	30%
Multi-structure	Individual makes use of more than one point to respond but in an inconsistent and unrelated way	Analyze the structure; know the stylistic features and expression skills	C	50%
Relational	Individual can integrate all the points into a coherent framework within the scope of content in questions	Discriminate the content venation and logic according to the style; understand the aims and purposes of writing	D	70%
Extended Abstract	Individual generalizes the previous integrated framework into an abstract level, beyond the already-existed area of topics.	Use example in the context to support the idea; discriminate the reality through the author's thoughts, opinions and attitudes; analyze and appreciate the linguistic features	E	100%

4 Case study

4.1 Research Question

The main purpose of this study is to investigate the efficiency of schematic interactions visualization in enhancing individual's critical thinking during English reading, with the measurement of SOLO taxonomy in SOLO test as a reference in minding progress.

4.2 Research Design

4.2.1 Study Setting and Participants

The research project, named as CMAP Project, was conducted from April 2 to June 6 2014, with two-round ABAB experiments. The goal of the whole project is to evaluate the effectiveness of schematic interactions visualization as teaching strategy in English reading with experimenting on traditional assignment, such as cloze, summary, and SOLO test, while this study specifies its domain on SOLO test.

10 students from China, India, and Mauritius in Southern Medical University volunteered to participate in the project as the sample subjects for the experiment. And none of them has ever been practiced cmaps before. They are required to obtain certain level of English proficiency so as to meet the reading comprehension ability regarding of target reading materials. All of them finished the complete process of the two-round ABAB experiment. Table 2 is enclosed, as the following shows, to provide basic information about the 10 participants in the experiment.

Table 2: Information about the 10 volunteers

The volunteers	Nationality	Grade	Mother tongue
郭培莉	Chinese	3rd	Chinese
肖达辉	Chinese	3rd	Chinese
邬卓彬	Chinese	3rd	Chinese
Raj	Indian	5rd	Hindi, English
Hasibur	Indian	5rd	Hindi, English
Doonish	Mauritian	3rd	French, English
Doushant	Mauritian	3rd	French, English
Anusha	Mauritian	3rd	French, English
Zaina	Mauritian	3rd	French, English
Ziyaad	Mauritian	4rd	French, English

4.2.2 Reading Materials

The selected reading materials are the classics that have been studied by scholars many times, all from Advanced English textbooks so that depth and breadth can be guaranteed. Passage I is Face to Face with Hurricane Camille from Advanced English 1. Passage II is Marrakech from Advanced English 2. Passage III is Inaugural address from Advanced English 2. Passage IV is In favor of capital punishment from Advanced English 2.

4.2.3 Research Method and Procedures

This research adopts ABAB method with two-round experiments and utilizes SOLO taxonomy scores to evaluate the individuals' learning outcome in four classic English articles under two different scenarios: passage I and passage III use traditional learning strategy that could be regarded as method A while passage II and passage IV with schematic interactions visualization learning strategy that could be regarded as method B.

Before the experiment, a pre-meeting and gathering were arranged so that their complete unfamiliarity with concept maps construction and SOLO test were confirmed. Oval-shaped concept refers to the theme of the passage, oblong-shaped concepts refer to subordinate concepts and round-shaped concepts refer to supporting examples. And times of treatment and materials for these two different scenarios are specified the same.

As for the traditional learning strategy, participants would receive traditional learning materials through email, such as PPT involving vocabulary, extensive reading materials related with the text, teaching plan with grammar explanation, author's background cultural knowledge and text structural analysis. After traditional learning process of the passage, participants were required to finish the SOLO test of the passage with support of all those traditional learning materials.

As for schematic interactions visualization learning strategy, participants also received traditional learning materials through email, which is similar with the traditional one. And then they were required to go through 5 thematic concept maps interactions in 3 teaching segments. Let's take passage II for example.

The first segment is pre-class cooperative interaction among students. The first interaction is students' thematic concept map construction. This strategy was intended to construct visualized diagnose platform for learning.

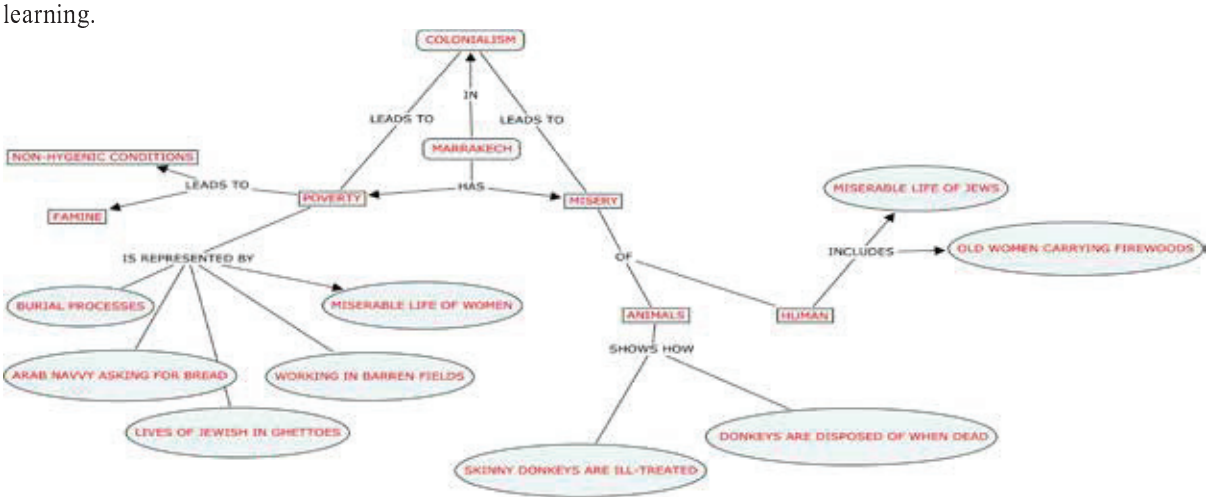

Figure 1: SIV before-class interactive activity: Student's thematic concept maps construction

The second segment is in-class collaborative interactions between teacher and students, which includes 3 interactions.

1) The second interaction is students' thematic concept maps presentation. The presentation adopts "one group reports, others evaluating" model, which fully mobilize students involvement in mutual learning process and conduct "peer review" process.

2) The third interaction is debate on key concepts in thematic concept maps. The instructional design is based on cognitive data obtained from 1st interaction. Teachers purposely pick up concepts selected from students' thematic concept maps and leave out propositions and cross-links targeted to the teaching objectives, which aims at assessment on students' application of relevant knowledge, including linguistic knowledge, cultural knowledge and structural knowledge.

Figure 2: SIV in-class interactive activity 2: debate on key concepts in thematic concept maps

3) The fourth interaction is reconstruction of thematic concept maps and comparison between expert-student thematic concept maps. Students fill up the thematic concept maps discussed before to extract the potential cognitive data and then compare with expert-student thematic concept maps.

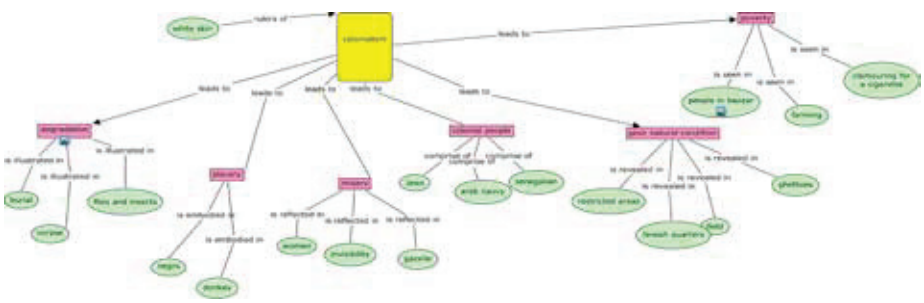

Figure 3: SIV in-class interactive activity 3: student thematic concept maps reconstruction after debate

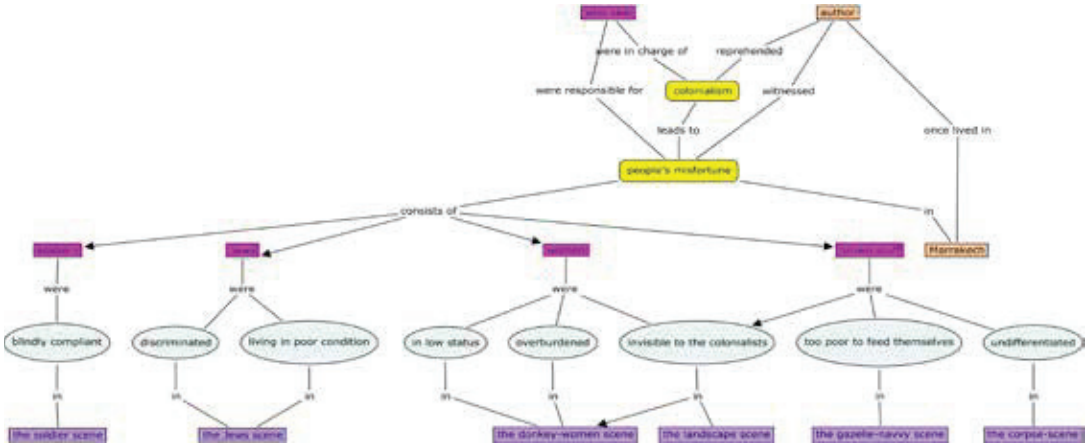

Figure 4: SIV in-class interactive activity 4: expert-student thematic concept maps comparison

The third segment is post-class students' autonomous interaction. The fifth interaction is students' extended thematic concept maps design. Students enrich their thematic concept maps with new concepts summarized and extracted from after-class extensive reading. Meanwhile, teachers preside at such kind of communication through class-blog or QQ social website for evaluating students' extended knowledge structure.

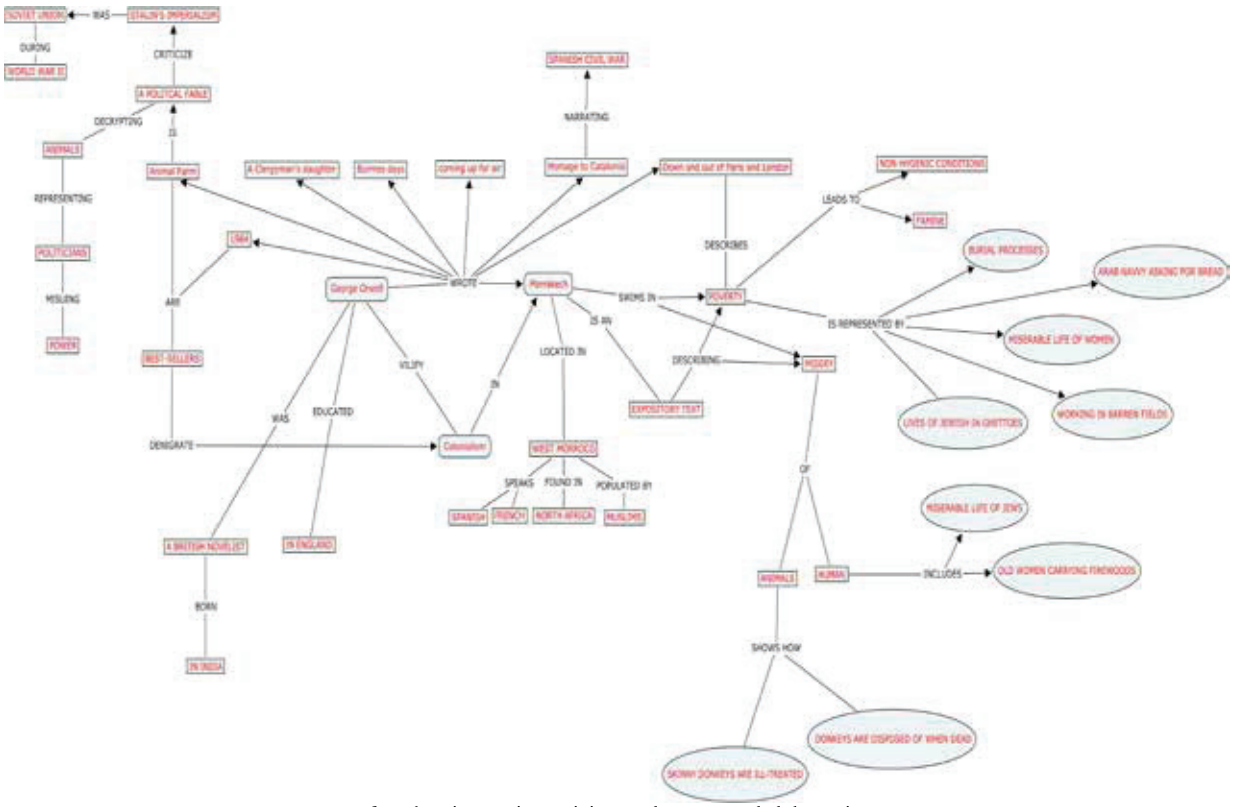

Figure 5: SIV after-class interactive activity: students' extended thematic concept maps

4.3 Results and Discussion

After two-round ABAB experiment, SOLO test scores are collected. To examine whether there is a significant difference among the individual performance under two different scenarios, repeated-measures ANOVA in SPSS is used to make data analysis as presented in Table3.

Table 3: Individual SOLO test scores of PI, PII, PIII and PIV

Name	P_I	P_II	P_III	P_IV
郭培莉	22	20	24	25
肖达辉	24	26	26	30
邬卓彬	22	26	24	25
Raj	26	22	18	35
Hasibur	18	26	18	25
Doonish	12	32	24	33
Doushant	18	38	24	26
Anusha	16	26	24	33
Zaina	12	30	28	35
Ziyaad	14	16	28	36
Mean±SD	18.40±4.971	26.20±6.215*	23.80±3.458*	30.30±4.644*#
Group Comparison	F=8.58, P=0.000			

Note: * indicates there was a significant difference compared with passage I; # indicates there was a significant difference compared with passage III

A standard deviation is utilized in order to better analyze the range of value in the changed scores. In the ranges of the improved scores, the mean score PI (M1) is 18.40, standard deviation (S1) is 4.971. Meanwhile, in the ranges of increased scores, the mean score PII (M2) is 26.20; standard deviation (S2) is 6.215. The mean score PIII (M3) is 23.80; standard deviation (S3) is 3.458. Meanwhile, in the ranges of increased scores, the mean score PIV (M4) is 30.30; standard deviation (S4) is 4.644. It's obvious to conclude from the fact ---- M2>M1, S2>S1, M4>M3, S4>S3, there's significant improvement in PII and PIV SOLO test with schematic interactions visualization learning strategy.

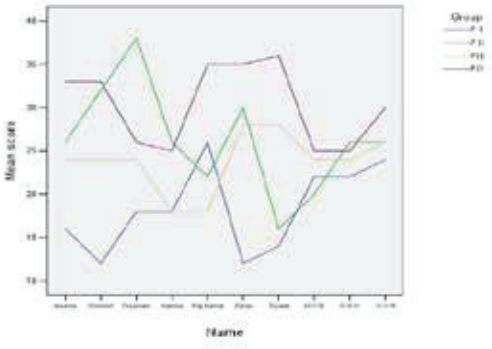

Table 4: Mean scores of Individual SOLO test scores

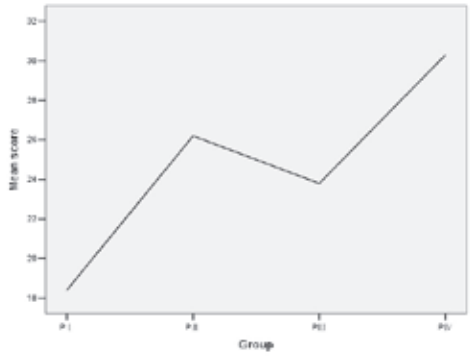

Table 5: Mean scores of PI, PII, PIII and PIV

Table 4 shows mean scores of individual solo test scores. Table 5 shows an effect of schematic interactions visualization learning strategy on the dependent variable. All four tests solo scores also show a significant difference, meaning that schematic interactions visualization learning strategy had a significant effect on students' critical thinking. Students' solo scores of passage I are the lowest one among the four test scores, and passage II solo test scores are significant improved compared with students' scores of passage I. The solo test scores of passage III are a little bit decline compared with students' scores of passage II, but not that significant. The solo test scores of passage IV are the highest one, higher than scores of passage I and passage III. However, there's no significant difference compared with passage II. That's to say, the intervention of SIV strategy would enhance students' critical thinking in Advanced English reading lesson.

5 Conclusion and Future work

In order to investigate the effectiveness of schematic interactions visualization in enhancing student's critical thinking in Advanced English reading, the case study carried out an ABAB experiment in which SOLO test scores under the traditional learning strategy and schematic interactions visualization strategy are compared. The results demonstrate that schematic interactions visualization learning strategy can improve students' critical thinking with the measurement of SOLO taxonomy in SOLO test as a reference in minding progress.

The present case study strides only a small step in investigating the effectiveness of schematic interactions visualization in improving students' critical thinking in English reading, but hopefully shall it provide a

springboard for those who are determined to continue the investigation. And more thoughts should be given to how to score students' thematic concept maps, a cognitive artifact that greatly transforms students' reading habit.

6 Acknowledgements

This research was supported both by Humanities and Social Sciences Project of Ministry of Education of the P.R.C (No: 14YJA740058) and China Scholarship Council Programme (CSC: 201308440308).

References

Cañas, A. J., Carff, R., Hill, G., Carvalho, M., Arguedas,M., Eskridge, T. C., ... & Carvajal, R. (2005). *Concept maps: Integrating knowledge and information visualization*. *In Knowledge and information visualization* (pp. 205-219). Springer Berlin Heidelberg.

Coffey, J. W., Carnot, M. J., Feltovich, P. J., Feltovich, J., Hoffman, R. R., Cañas, A. J., &Novak, J. D. (2003a). *A summary of literature pertaining to the use of concept mapping techniques and technologies for education and performance support* (No. Technical Report submitted to the US Navy Chief of Naval Education and Training). Pensacola, FL: Institute for Human and Machine Cognition.

Frederic Charles Bartlett. (1995). Remembering: *A study in experimental and social psychology*. Cambridge: Cambridge University Press.

John, B. (2014). *SOLO Taxonomy* [OL]. http://www.johnbiggs.com.au/academic/solo-taxonomy/.

John, B., & Kevin, C. (1982). *Evaluating the Quality of Learning: the SOLO Taxonomy* . New York: Academic Press. 1982.

Kant. (2008) *Kritik Der Reinen Vernunft*. People's publishing house.

Novak, J. D. (1977). *A Theory of Education*. Ithaca, NY:Cornell University Press.

Novak, J. D. *Learning, Creating, and Using Knowledge: Concept Maps as Facilitative Tools in Schools and Corporations*. [M]. Mahwah, NJ: Lawrence Erlbaum Associates. 1998.

Rong Xia. (2008). The study of the nature of interpreting process—initiative interaction of the schema. *Journal of GuangDong University of Foreign Studies*, 19(4):41-44.

Xiang Zhang. (2014). Theoretical Research on Visualization of Schematic Interactions for the Teaching of Reading in English. *China Educational Technology*, 326(3):123-128.

Yonghong Cai. (2006). SOLO Taxonomy Theory and Its Application in Teaching. *Teacher Education Research*, 18(1):34 – 40.