A Study on the Impact of Science Venues upon Chinese Students' Creative Imagination

Huiliang Zhang, Ling Chen
China Research Institute for Science Popularization (CRISP), Beijing, China

***Abstract*--This study examines the development of students' creative imagination and its relation to students visiting science venues. A nation-wide survey had been conducted to assess school students' creative imagination and factors influencing it. Data consisted of 4162 students from grade 4 through grade 12. Findings showed that frequently visiting science venues such as science and technology museums, science centers, natural science museums, botanical gardens, zoos, and aquariums is related to the development of students' creative imagination. Some implications and recommendations for science venues regarding nurturing students' creative imagination are also proposed.**

I. INTRODUCTION

Imagination as a concept generally refers to mental images of something that is neither perceived as real nor present to the senses. According to Holman and Kumar (1983) (as cited in Smith & Mathur) [1], imagination can be: (a) cognitive in nature, (b) related to fantasizing or dreaming, (c) an expression of individuality, or (d) an ability.

Rugg (as cited in Kind & Kind) [2] states that imagination can be either reproductive or creative, with the former being simple perceptual memories, while the latter is formed using memories derived from external objects. Creative imagination involves the process of creative problem solving and is related to creativity, a process through which new, original and valuable (from the social point of view) entities are produced [3].

Crucial elements of creative imagination are openness to experience and the ability to view concepts from another's perspective, emotions, i.e. an individual's profound involvement in solving a problem. The environment of science venues helps to guide or mediate the visitors' attitudes or perspectives, the meaning of their activity there, and how the institution views them.

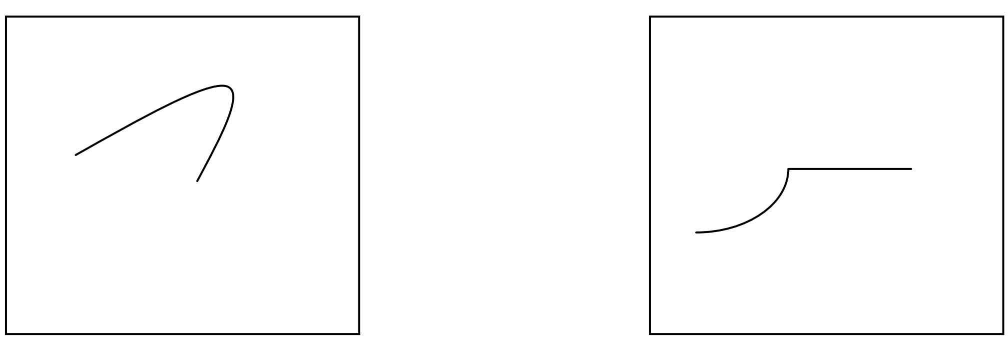
Experiences in science venues are often designed to elicit participants' emotion or sensory response to scientific and natural phenomena. For example, zoos and aquariums may develop thinking themes linking plant, animal, and human well-being. Science centers use multimedia to engage multiple senses, or build larger-than-life models that make phenomena visible and inspire participants' awe (National research council, 2009) [4].Perspective-taking is a part of the ability to use one's imagination. Imagination is thus predictive of future creativity [5].

II. METHOD

A. Test of Creative Imagination (TCI)

The authors drew upon the content and approach of creative thinking tests from Torrance and Orlow [6], and Williams [7] in making the TCI.

The TCI has a drawing section and word section. In the drawing section (time limit of 15 minutes), students are asked to draw a line in each of 10 frames, and give their drawings titles. Figure 1 shows examples of this section. The drawing score comprises sub-scores for the four dimensions (i.e. richness, flexibility, profundity and originality) and titles of drawings. In the word section, students are asked to write down as many different things as they can imagine happening in a certain scene. The instructions for this part are as follows: 'This is a story. Once upon a time, there were three penguins sitting at a table with a bowl of soup in front of them. Write down as many different things as you can imagine happening in this story'. Responses are scored on four dimensions: richness, flexibility, profundity and originality. Thus, these two sections yield two scores, with each comprising four or five sub-scores. (The total score for creative imagination is the sum of these two section scores.



1.______________________________ 2.______________________________

Figure1. Examples of the TCI figure part.

The following scoring rubrics are used for above mentioned various dimensions:

1. Richness -the 'scope' of creative imagination. The score for this dimension is the number of suitable answers, with the highest score being 10.
2. Flexibility -the 'categories' of creative imagination. This is a measure of the scope of creative imagination from another perspective. Scores reflect how many times categories depicted by the lines change, and the highest score is 9.
3. Profundity -the 'depth' of creative imagination. Scores are based on detecting details (a maximum of 13–19) with the highest score being 3.
4. Originality -the 'uniqueness' of creative imagination. Uniqueness below 1% is scored 1, and uniqueness above 1% is scored 0.
5. Creativity of titles. Imaginative titles for drawings score a maximum of 3 points.

TCI was initially reviewed by other creativity research experts from both inside and outside China. The TCI was then piloted with Chinese students in rural and urban schools five times in 5 different locations across the country. It was then modified 5 times based on results of each pilot test. The final version of TCI had a high reliability based on the following Cronbach's alpha coefficients of internal consistency: 0.802 for the general TCI, 0.798 for the word test, 0.809 for the drawing test, 0.908 for fluency, 0.846 for flexibility and 0.897 for profundity.

B. Background questionnaire

A background questionnaire was used to collect data regarding the Chinese school environment and student academic performance. This study focused on three aspects: teaching practices, students' academic performance and student participation in extra-curricular activities. Teaching practices include two components: One was on whether teachers make their students feel that they like students with high scores and whether students are afraid of their teachers; and the other was on teaching strategies that refer to whether teachers spend most of class time lecturing while students listen, or whether there are group discussions and free speech in classes. Students' academic performance is reflected by their last semester test grades. Participation in extra-curricular activities includes visiting science venues and museums as well as participating in science-related competitions. Students rated participation as 'frequently', 'occasionally' or 'never'. Student responses regarding participation in science-related competitions included choices of 'have won prizes', 'have participated', 'know about', and 'have no idea'.

The background questionnaire was developed from a creativity test in China and England developed by Shen, Hu and Peng [8]. It was revised through consultation and group discussions with creativity research experts.

C. Sample

A nationwide stratified sample was used. According to the China National Statistics Bureau, the Chinese mainland is divided into three areas: east, middle and west. We chose three provinces in each area by convenience sampling. The survey was conducted in four middle/high schools (two urban and two rural) and four primary schools (two urban and two rural) from each province. A class was chosen randomly from each grade in each school and administered the test, with more than 18,000 students participating. However, because of time limits and the large amount of data to be analyzed, only ten students were selected from each class by systematic sampling, which involved the selection of certain students from an ordered sampling frame [9]. Thus, there were 4,320 students nationwide of which 4162 provided valid responses.

D. Data collection Procedure

All participants were invited to attend group assessment sessions in their classrooms to complete the TCI and background questionnaire. Members of this research project were divided into several groups and each group spent a month travelling and visiting all selected classes. With the help of a local officer of education bureau, the group members working together with local teachers administered the test and the survey. Students completed the test and survey anonymously and were assured that the data they provided were confidential and would be used for research purposes only. The TCI had a time limit of 30 min, and students were required to finish the test within that limit, as fast and effectively as possible.

E. Data analysis

The data were analyzed using SPSS version 16.0. One-way analysis of variance (ANOVA) and post-hoc comparison were used to answer research questions 1, 2 and 3. In this study, the dependent variable, i.e. creative imagination was interval/continuous, while independent variables (teaching practices, student academic performance, etc) were categorical /ordinal. Hence, analysis of variance was justified.

III. RESULTS

A. Students' creative imagination continued to grow with an increase in grade level

The means and standard deviations for scores of creative imagination in different grades are shown in Table 1. A one-way ANOVA for 9 grades was conducted using the total score of the creative imagination test as the dependent variable. We used least significant difference (LSD) post-hoc comparisons. Results showed that the main effect of grade was significant ($F[8,3075] = 54.633$, $p< 0.05$). There was no significant difference in total score between students from grades 6 and 7 ($F[8,3075] = 54.633$, $p > 0.05$). There was also no statistically significant difference between students from grades 9 and 12 ($F[8,3075] = 54.633$, $p > 0.05$). There was a statistically significant difference between students of the other grades ($p < 0.05$). Table 1 shows that the total score continued to grow from grade 4 to 11. It reached its peak at grade 11 and began to decline at grade 12.

TABLE1 MEANS (M) AND STANDARD DEVIATIONS (SD) OF THE CREATIVE IMAGINATION TEST

Grade		Total Score	Drawing Score	Word Score	Title Score	Richness Score	Flexibility Score	Profundity Score	Originality Score
Grade 4	M	30.39	24.14	6.25	3.68	13.03	6.63	2.78	4.28
	SD	8.19	5.71	5.37	1.16	3.89	2.21	1.64	2.28
Grade 5	M	32.99	24.91	8.08	3.92	14.09	7.09	3.29	4.60
	SD	9.15	5.89	5.86	1.32	4.34	2.42	1.90	2.45
Grade 6	M	35.16	25.26	9.90	4.05	15.14	7.40	3.44	5.13
	SD	9.23	5.94	6.16	1.27	4.20	2.38	2.11	2.57
Grade 7	M	36.02	25.18	10.84	4.07	15.31	7.64	3.85	5.15
	SD	9.08	5.64	6.32	1.39	4.10	2.38	2.17	2.38
Grade 8	M	38.27	25.65	12.62	4.21	16.45	8.31	3.66	5.65
	SD	9.57	6.12	6.29	1.45	3.90	2.78	2.12	2.74
Grade 9	M	39.66	25.51	14.15	4.30	16.74	8.55	4.12	5.96
	SD	9.76	6.59	6.62	1.48	3.96	2.91	2.38	2.79
Grade 10	M	40.17	26.59	13.58	4.51	16.50	8.81	4.12	6.22
	SD	9.32	5.85	6.58	1.50	3.83	2.65	2.32	2.54
Grade 11	M	40.64	26.30	14.34	4.41	16.93	8.89	4.12	6.29
	SD	8.92	5.96	6.41	1.56	3.66	2.75	2.07	2.54
Grade 12	M	40.25	26.72	13.53	4.54	16.44	8.79	4.06	6.41
	SD	8.60	5.90	5.92	1.56	3.68	2.62	2.12	2.43
Total	M	37.01	25.57	11.44	4.18	15.61	8.00	3.71	5.51
	SD	9.72	6.00	6.74	1.44	4.15	2.69	2.15	2.63

Results presented above revealed that creative imagination continued to grow with an increase in grade level, but the pace of development was different at different stages. Specifically, grades 4 through 6 and grades 7 through 9 were two stages of rapid development. Students in these two stages are influenced by both inborn and environmental factors. Students enter adolescence growing very quickly both mentally and physically, which provides a foundation for the rapid growth of creative imagination. Given that students in grades 4 through 6 are in the later half of their primary education, they are influenced by characteristics of adolescence as well as new teachers, educational activities and increased learning, which may explain why creative imagination of students in this stage develops very rapidly. The rapid development of creative imagination in grades 7 through 9 may have been influenced more by environmental factors such as an increase in subjects of study, expansion of knowledge, more in-class presentations, and growth of experience and promotion of language skills.

B. Influence of visiting science venues

The figure 2 shows that students who "always" go to science and technology museums, science centers, zoos and botanic gardens get the highest scores; students who "sometimes" go to those places get the second highest scores; students who "seldom" go to those places get the lowest scores. The result shows that frequently visiting science venues promotes students' creative imagination.

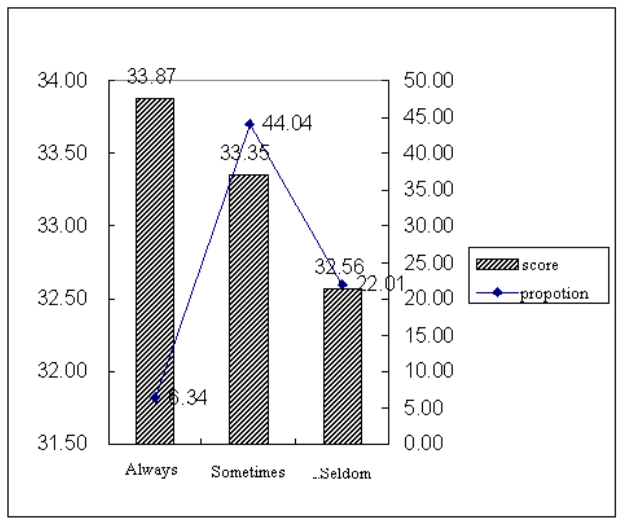


Figure2. Relation between the score of students' creative imagination and their frequency of visiting science venues

The frequency of visiting shows that only 6.34% of the students "always" go to science venues, 44.04% of them "sometimes" go to those places and 22.01% of them "seldom" go. The statistics of this study show that the visiting rate of Chinese youths to science venues is about 50% and the frequent visiting rate is less than 5.2%, which is rather low. The visiting rate of urban youths is 12.4% while the visiting rate of rural youths is 5.2%. Thus, the rate of rural youths visiting science venues such as science museums and other museums is relatively low.

Further survey was conducted on students receiving the test above in order to find out the score of the creative imagination of students who go to different venues (Table 2).

TABLE 2 SCORE OF THE CREATIVE IMAGINATION OF STUDENTS WHO GO TO DIFFERENT VENUES

	Word test	Drawing test	Total score
Science and Technology Museums/Science centers	12.01	21.83	33.84
Aquariums	10.93	21.83	32.76
Botanic Gardens	11.43	21.29	32.72
Natural Museums	11.17	21.27	32.45
Zoos	10.63	21.07	31.70

Students who like to go to "Science and Technology Museums/Science centers" get the highest score in the creative imagination test, followed by students who like to go to "Aquariums", "Natural Museums", "Botanic Gardens", and "Zoos". The examination of variance shows that different venues have different influence on the creative imagination of students. Exhibitions on science and technology have the biggest influence on the creative imagination of students.

IV. DISCUSSION

Generally speaking, school education is significantly related to the level of students' imagination development, as the main result shows that the main effect of grade was significant. Besides, there are many influential factors related to the development of students' imagination, frequently visiting science venues is one of them.

A. The form of Science venues can be flexible and diversified forms

China is a huge developing country, the regional development of culture and economic is not balanced, and therefore the education resources such as science venues are far from balanced allocation. Most qualified science venues are located in big cities; few of these places are seen in towns and countries in China.

In our Background questionnaire, there is an item asking students "Which place you have never been but would very much like to go" , the first six answers are: parks, zoos, Beijing, Aquariums, science and technology museums/centers, cities where mum and dad working as migrant workers. Many students in countries get to know the world only from TV and some books, while some poor families even can't afford TV set and books.

Therefore, the form of science venues can be various in terms of mobile science museums, science wagons, on-line science museums and etc. Mobile science museums can do science exhibitions or tours for students in small towns, counties and villages. Science wagons can bring exhibits for them to even more backwards places. The online science museums have many advantages over traditional science venues; students in backwards places may have no access to computers though.

Thus, the process of developing exhibits and exhibitions should be fully examined by educational knowledge, concerns and expertise. This poses additional requirements for the staff in science venues and other designers, who must also consider many other aspects and constraints of exhibits and exhibitions used in mobile museums and science wagons, including the educational resources, the usability and durability of the exhibits and exhibitions, and whether they are suitable for students in different regions, especially in remote countries and minority living regions.

B. Science venues developing more interactive activities to increase students' experience in order to promote their creative imagination

Creative imagination is related to both knowledge and experience. However, some science venues in China are places where there are just static exhibits and exhibitions, simply with some instructions, while lacking of well-trained staff, interactive seminars and activities designed for students. Actually, more interactive activities can be designed for students in terms of talks and seminars, workshops, hands-on clubs. Visitors self-report a variety of outcomes from interactivities, including learning knowledge and skills, gaining new perspectives, and generating enthusiasm and interest [10].

A key finding from the field is that learners are engaged by experiences that offer interactivity [11]. The interactive learning environments of science venues generate are ideal to promote active science learning, in which students are engaged in inquiry and problem-solving while investigating and experiencing science, technology and society relationships [12].Experience of museum-based learning stimulates the inner motivation of students, and helps them construct new knowledge using their cognition, and finally they can understand new scientific concepts and knowledge.

REFERENCES

[1] Smith, M., & Mathur, R.: "Children's imagination and fantasy: Implications for development, education, and classroom activities," *Research in the Schools*, 16(1), pp.52-63, 2009.

[2] Kind, & Kind, V.: "Creativity In science education: Perspectives and challenges for developing school science," *Studies in Science Education, 43*, pp.1-37, 2007.

[3] Wieslawa, L.: "Creative imagination in science and science education," in *Science education: talent recruiting and public understanding*," P.Csermely and L. lederman, Eds. IOS press, 2003.

[4] National Research Council. *Learning Science in Informal Environments: People, Places, and Pursuits*, Bell, P., Lewenstein, B., Shouse, A. W., & Feder, M. A., Eds. Washington DC: The National Academies Press, pp.32-33, 2009.

[5] Runco, M., Nemiro, J., & Walberg, H.: "Personal explicit theories of creativity," *Journal of Creative Behavior*, *32*(1), pp.1-17,1998.

[6] Torrance, E. P., & Orlow, E. B. *Torrance tests of creative thinking streamlined (Revised)*. Manual Illinois: Scholastic Testing Service Inc, 1984.

[7] Williams, F. E. *Creativity assessment packet*. Buffalo, NY: DOK Publishers, 1980.

[8] Shen, J., Hu, W., & Peng, H.: "A comparative study on the creativity and its nurturing of youths in the east and west," in *International Comparison on the Creativity of Youth*, Ma Kangmei and Zhai Liyuan Eds. Beijing: Science Press (in Chinese), 2003.

[9] Black, K. *Business statistics for contemporary decision making (Fourth Edition) (Wiley Student Edition for India ed.)*. Wiley-India, 2004.

[10] Falk, J.H., Scott, C., Dierking, L., Rennie, L. and Jones, M.C.: "Interactives and visitor learning," *Curator*, 47(2), pp.171-192, 2004.

[11] McLean, K. *Planning for people in museum exhibitions*. Washington, DC: Association of Science-Technology Centers, pp.168, 1993.

[12] Bybee, R.W.: "Achieving scientific literacy: Strategies for ensuring that free-choice science education complements national formal science education efforts," in J.H. Falk Ed., *Free choice science education, how we learn science outside of school*, pp.44–63. New York, NY: Teachers College Press, 2001.