The design study of inquiry-based learning space for cultivating k-12 student's scientific literacy

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Abstract: Traditional K-12 class have a limitation of training self-inquiry ability which is very important in today's society. This research attribute to offer a unique solution towards this question by designing and constructing a learning space which could truly support the inquiry-based teaching and learning, matching K-12 student's characteristic and having a positive effect on student's scientific literacy. The new space is a combination of formal and informal space where we could teach in both traditional and novel ways which may promote the cooperation and communication among students. And with the full consideration of the flexibility, comfort, convenience and safety, students may connect the each other more easily and freely choose different approaches and resources to solve problems by their own.

Keywords: Scientific literacy, inquiry, active, learning space, design

1. Introduction

The demand for student's scientific quality has been more and more frequently mentioned since 21st century, and it is also a significant part of the Skills of 21st Century. Cultivating scientific quality is not just only improving student's own ability, but also having a great effect on the development and consummation of the whole society. At present, school is an important place for student's growth, and the science courses like physics, biology and chemistry play a key role to cultivating scientific quality. However, teachers in these classes pay a great attention to knowledge delivery especially in middle school where they should pass the test. Even in the experimental class, students are always asked to following the experiment recipe instead of thinking creatively which would lead to surface understanding toward what they are doing (Huang, 2014).

Comparing with the lecture mode of knowledge delivery, inquiry-based teaching method has enough advantages in developing scientific attainment (Li, 2006). In order to compensating the drawback of the lecture mode of teaching, more and more classes in k-12 are beginning to try inquiry-based teaching method to guide students exploring science issues. Whereas, outcomes of new teaching and learning method are limited by the traditional classroom with inflexible desk, unpleasant atmosphere and so on, so there is an urgent need of a brand new space for new teaching and learning method (Huang, 2014).

Hardware device, educational resources, media material, cognitive tools and management service should be included in a learning space to support learning activities. Learning space can be divided in two aspects ——physical space and virtual space. The word of "Learning Space" came out to public since 2006 when the book of Learning Space was published by EDUCAUSE. In 2011, University of North Carolina established the Journal of Learning Space focusing on the topic of space research (Xu, Yin & Zhang, 2014). Numerous investigations and project constructions have been done by many researchers what typically include SCALE-UP project in North Carolina State University, the TEAL project in MIT, the TILE project in University of Iowa, the ALCs project in University of Minnesota, and the ALTC transformation university learning space project in Australian Teaching Committee. It is worth noting that all those successful practice cases were taken place in colleges with a focus on informal learning space design like library instead of middle and primary schools (Zhang, Liang, Sun. & Chiang, 2015).

Based on the consideration of scientific literacy cultivating, inquiry-based teaching for K-12 students, we blend the proper basic design theory into the specific procedures, and fix our design by evaluating whether it is rational and scientific through scales and interviews, and then complete the space design. This is an attempt to design an exploring-style learning space for cultivating K-12 student's scientific quality and accumulating more experience.

2. Research Design

2.1 Research Procedure

There are three steps of our research: preliminary investigation, space design and post evaluation. The preliminary investigation includes field investigation, interview with teachers and literature research through which we could accumulate space-designing experience, find out what teachers and pedagogy need. Space design includes drawing sketch, drawing two-dimensional blueprint and drawing three-dimensional blueprint. Before the construction we do the evaluation one more time to ensure that everything is on board. The flow chart is as follow.

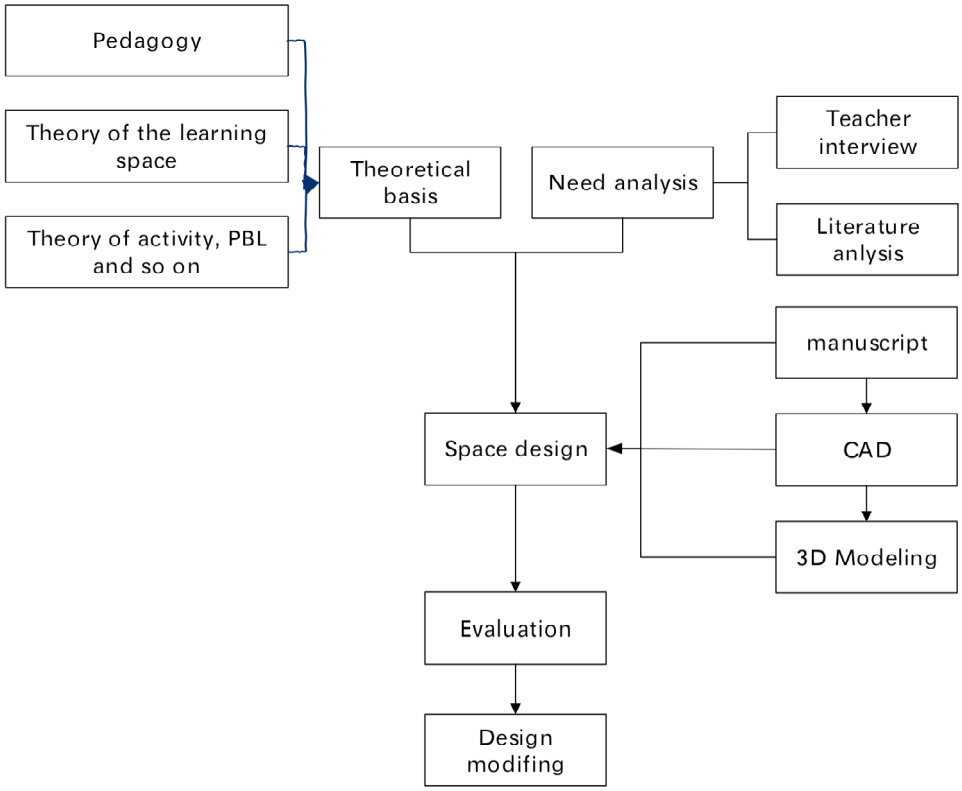

Figure 1 Research Procedure

2.2 Preliminary Investigation Result

Table 1 Investigation Result

Method	Result
Field investigation (School, Museum, Exhibition Hall)	1. the design and the characteristics of students are matched 2. The flowing design are more dynamic and positive to draw students' attention. 3. Students may feel more comfortable. 4. The traditional space are not flexible

Teacher's interview	1. Students prefer flexible place. 2.students are limited by unmovable desks and chairs, so we reduce the desks and chairs and in some space there are even no desks and chairs. 3. Students follow the menu to do experiment and have little innovation. 4. Students are difficult to communicate and express to each other with the unmovable sequence of computers.
Literature Research	1. The inside establishment of science laboratory (Lu Q., Yu B., 2010)0. 2. It is not easy to team-work with the unmovable desks and chairs. 3. The water tank and electric power are not effectively and efficiently used, so we set up those equipments around the classroom and we do not want to limit the movement of the desks and chairs. (Li Y., 2006) 4. The display desk which could move up and down is very effective. 5. The display zone could inspire students to learn. 6. Make the classroom colorful, set up some bookshelves and biology corner. 7. Set up material zone, students could collect daily resources.

3. Space DesignIllustrations

The Yanjiao learning space covers an area of one thousand and two hundred square kilometers. We co-work on the basic theory and design experience summary from home and abroad learning-space studies, analyze the current situation of the laboratories, and set up the Yanjiao learning-space construction goal to design the model of learning-space by using Sketchup 2015, Phtotoshop CS6.

Radcliffe referred to the Pedagogy-Space-Technology (PST) design frame, and he thought space design, pedagogy and technology connect and effect to each other, and there is an iteration circle among them in which one of them definitely effect the other two. (Cheng, Wu & Zhang 2010)

3.1 Design Purpose

This design of learning-space is a place where teachers could use exploring-style pedagogies and students could cooperate to each other, so it could drive students to positively learn and critically think, and then reach the accomplishment-cultivating goal.

3.2 Design Principles

- **Integration of formal and informal space.** Our new learning-space could support various styles of learning actives, besides the normal class-teaching and self-supporting study discussion and exploration. There are many specific zone (formal) for different majors teaching. On the other hand, we would like to provide a cozy and open learning space to promote the informal learning on the basis of ensuring less noise.
- **Compatible between lecture-based class and inquiry-based class.** We will ensure the flexibility of the desks and chairs in the teaching zone, to make the panel discussion, group work and traditional teaching-style class convenient.
- **Interdisciplinary integration.** In middle school, science class is separated into three parts: physics, biology and chemistry, but they all belong to science field that means they are kind of integration. Considering the cultivation of students interdisciplinary thinking ability, we integrate the interdisciplinary theory into our design.
- **Flexibility**. The flexibility of the new style space reflects in different aspects: different sections could merge and split flexibly; desks and chairs could do the puzzle based on different requirement and adjust the height of desks and chairs according to the age of students. (Zhang Y., Liang A. A., Sun H. P. & Chiang F. K., 2015)
- **Comfort, convenience and safety.** The design of new-style learning space need to cater the demands of users and to make them feel more comfortable and convenient.

3.3 Function Needs according to inquiry-based learning

There are six processes of exploring-style learning: discovering, analyzing problems, assuming, collecting evidence, solving problems, communicating and sharing. The function of the space is designed as follows:

Table 2 Function Needs

Inquiry-based Learning process	Requirement of Function	Space Function	Related Space
Discover	Collect plenty of science	Lecture/ Read/ Teaching	Multimedia hall, hallway, Peaceful room
Analyze and Assume	/	/	/
Collect Data and Solve problems	Explore experiences and Surf the internet	Experimental zone, discussion zone and surfing zone	Experimental zone, discussion zone, surfing zone and hallway
Communicating and sharing	Expression and lecture	Expression and lecture	Multifunction room, hallway and wall

We think teacher play an important role in Analyze and Assume period while physical classroom has a very limited effect on it. Therefore, we will not take it in to our design.

3.4 Design Elements and Functions

There are chemistry classroom, biology classroom, physics classroom, STEAM classroom, multimedia hall and a peaceful room. The main shape of our design is hexagon, and almost every classroom is a hexagon, and so do the decorations, the honeycomb inspires us about this design: students may feel more connective to the real nature, and we would like to cultivate their multiple intelligence.

3.4.1 Integrated classroom

The integrated classroom integrates the teaching zone, discussing zone, activity zone and exploring zone together, and it reflects the interdisciplinary integration characteristics.
Teaching zone and the activity zone are separated with other rooms in case the interference of noise and people steam. In the discussing zone and exploring zone, the exhibits and tools are not classified by different majors, aiming to make it convenient for students to choose what they need. In the discussing zone and experimental zone, there is a movable whiteboard for expression, and the movable desks and chairs are easy to carry out the group works.

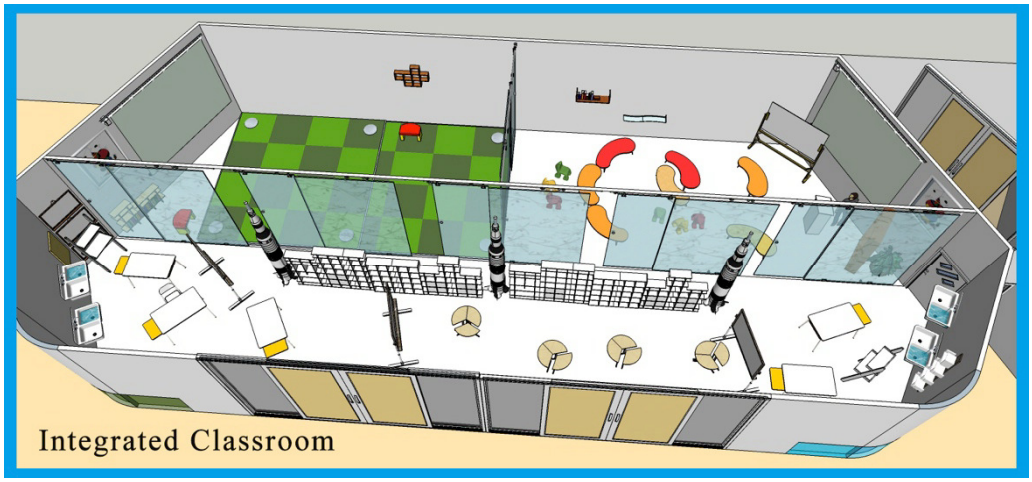

Figure 2 Integrated Classroom

3.4.2 Major classrooms

Each classroom integrates the teaching zone, discussing zone, expressing zone together, and it reflects the step by step progress. And each classroom has its special characteristics. Chemistry classroom emphasizes the convenience for conducting an experiment. Triangle tables in teaching area are easily for cooperation and sharing experimental materials. Discussion area and special experimentation area where contain a storage rack for material storage are adjacent to teaching area.

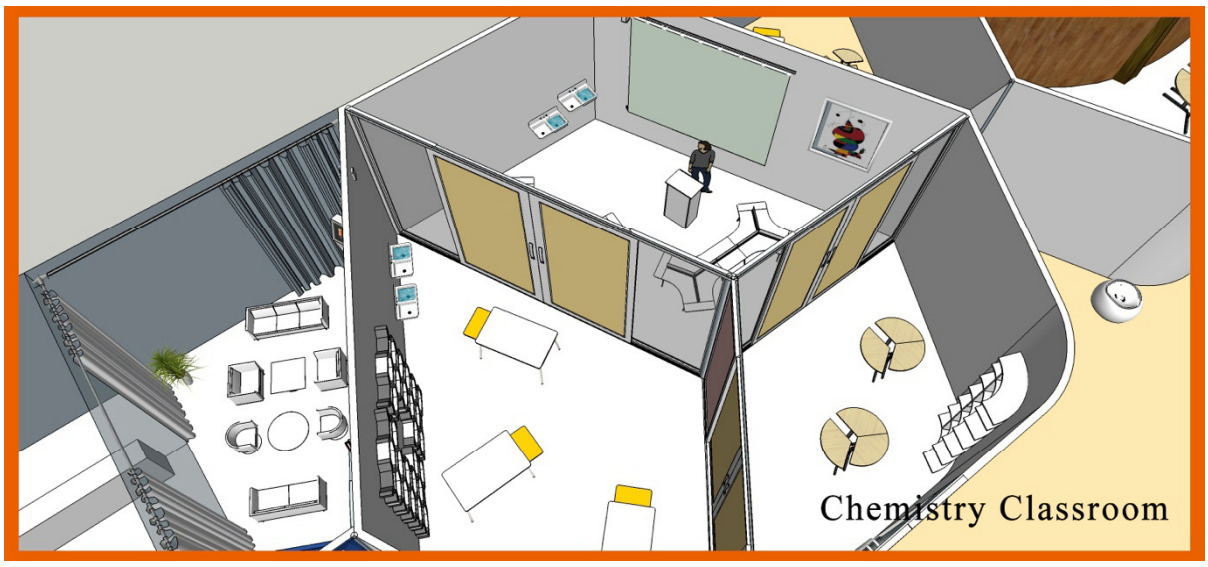

Figure 3 Chemistry Classroom

Biology classroom is trying to be more natural looking. Big tree, some cell model and etc. are used to achieve this propose. An ecological zone used for planting, observing and recording at the corner in this room. And student can easily do some inquiry or discussion at green lawn. Chairs in this room are mushroom look like.

Figure 4 Biology Classroom

Physics classroom have a special demand of electricity result in low flexibility of desk in this room, and each desk have an electric outlet with a small storage rack for material saving.

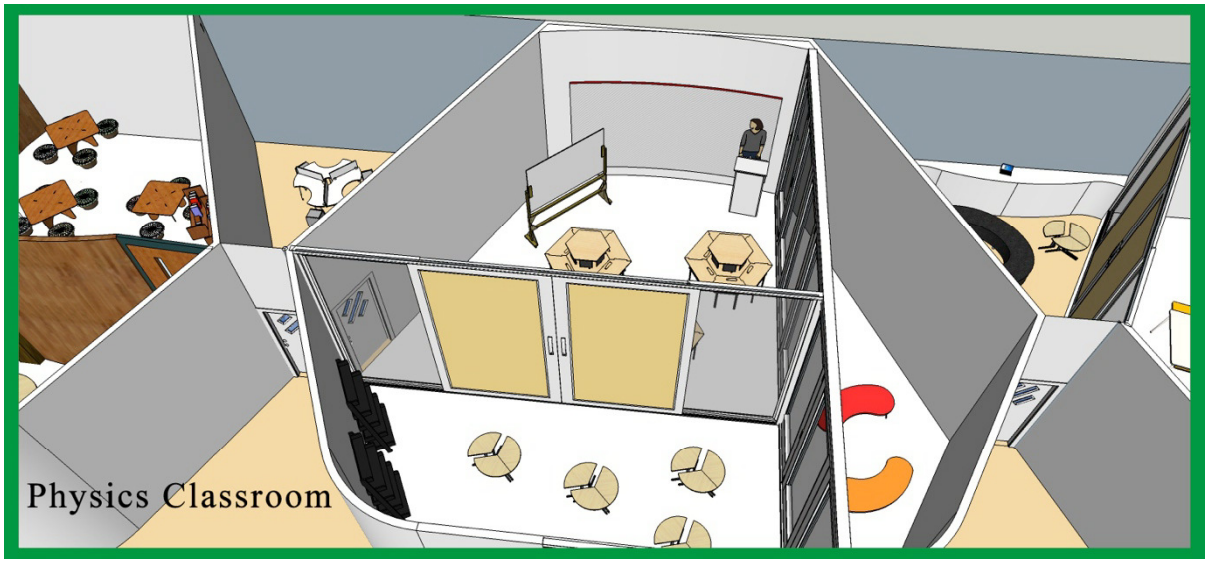

Figure 5 Physics Classroom

STEAM classroom emphasizes to learn step by step. Three area are consisted in this room. First area covered by ground mat with some soft low desk. Student can do some model build at this area which is designed for younger kids. Second area contains some big table and movable desk for model design and discussion respectively. The last area has more computers than other. This area focuses on model programming.

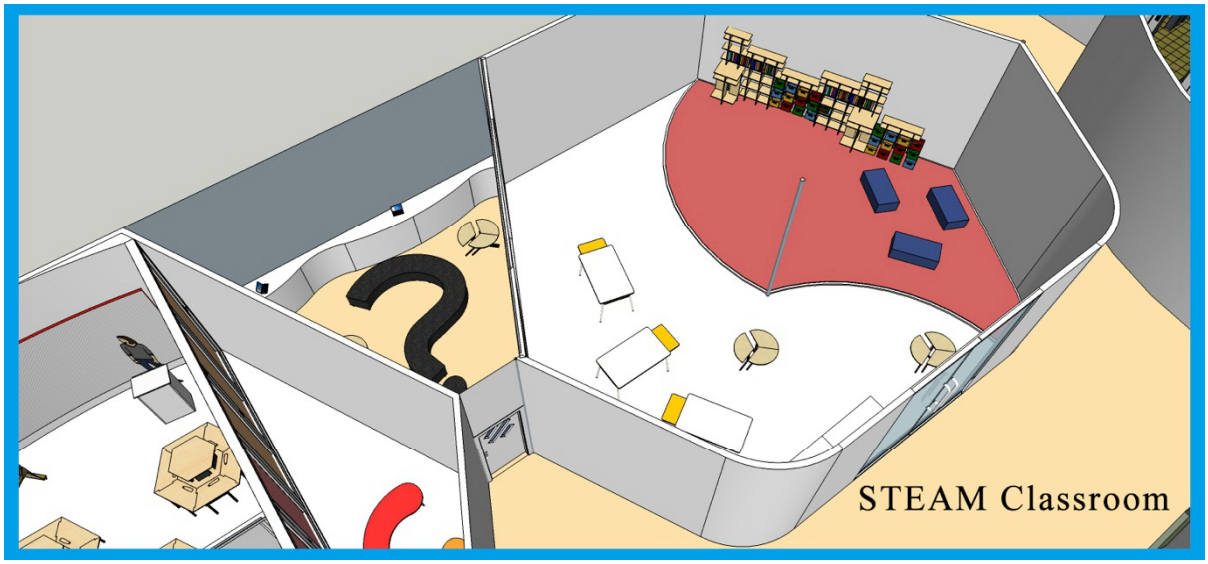

Figure 6 STEAM Classroom

3.4.3 Computer classroom

The location of computer classroom is suffering zone and computer teaching. This classroom is separated into two parts: teaching zone and suffering zone. We set up the high level configuration computers at the red zone for specific professional demands. And the red circles are soft sofa and movable desks and chairs which are used for information searching and discussion.

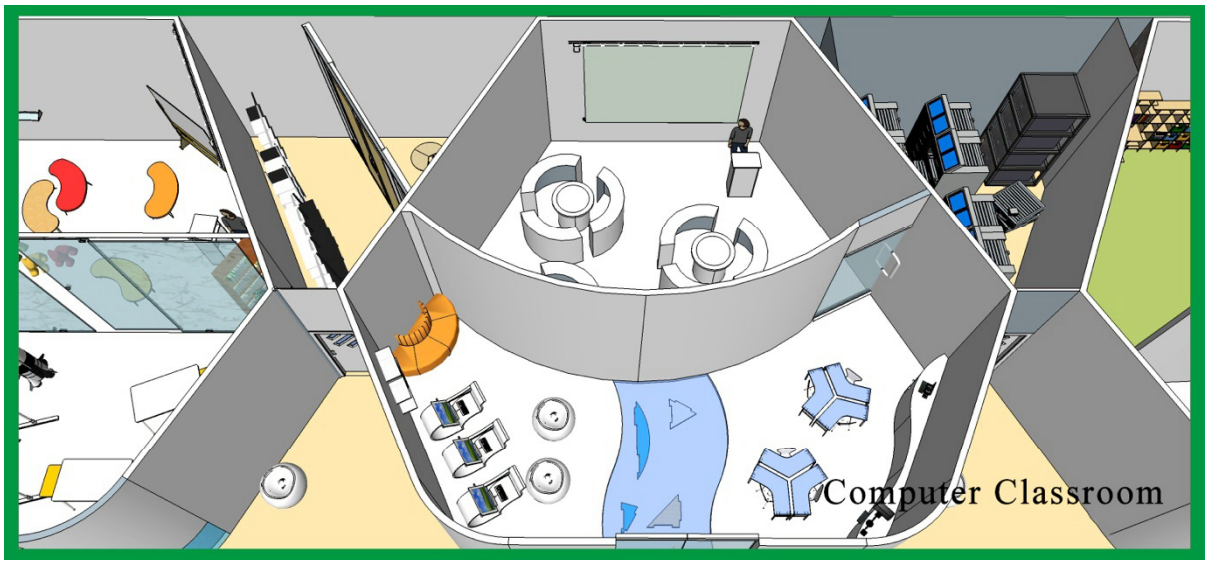

Figure 7 Computer Classroom

It is worthy to note that we design a new desk used in this classroom as follow.
Computers are laid on the round desks, and students could turn around for discussion and at the same place they also could turn back and communicate with teachers.

Figure 8 Unique Desk

3.4.4 Multimedia hall and a peaceful room

The main function of this room is self-learning and reading, we would like to offer students a quiet zone for thinking. In this classroom, there are also the movable desks and chairs
Multimedia classroom, in which students could watch demoes, express their works and teachers could have a workshop. This classroom is adjacent to the Peaceful room， and they could connect into a huge classroom meanwhile it also could be separated by sliding door.

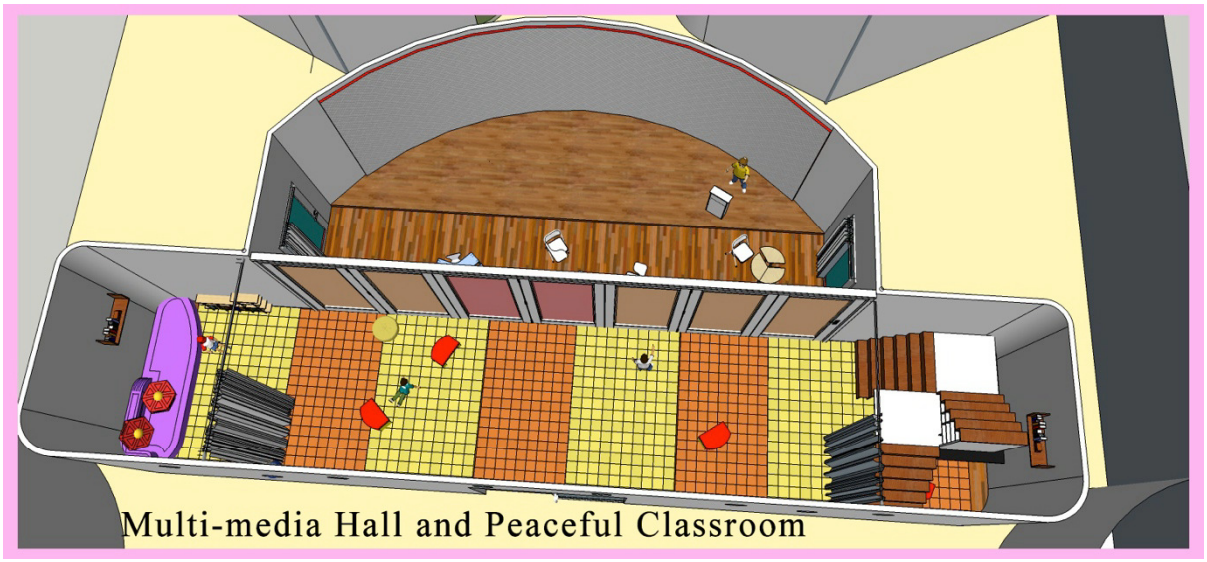

Figure 9 Multi-media Hall and Peaceful Classroom

3.5 Three-dimensional Modeling

Figure 10 3D Modeling

3.6 Evaluation Principle

Inquiry learning space design aims to improve student development and scientific literacy. In order to testing the quality of the design model, this research invites relating person, including one expert in the field of Educational Technology, one interior design specialist and eight k-12 school teachers, to evaluate this design, following the principles of direction, comprehension and feasibility.

1) *Directional principles*: as developing scientific development, in order to promote the all-round development of students.

2) *Comprehensive principles*: Educational environment is a system, which might contain a variety of related factor that would influence education outcomes, like space, equipment, activities, interaction, parents, teachers and so on. Therefore, we can't ignore the relationship between every factors, and take it in to consideration while doing a design job.
3) *Feasibility*: Educational environment is created to conduct educational activities, so it's important to take educational purpose, learning needs and local education development level in order to ensure the education can be implemented smoothly Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

3.7 Evaluation results

Evaluations are made by 10 expects though three field including a professor of Educational Technology, an interior design specialist and 8 K-12 school teachers.

Based on the feedback of professors, the current model may already meet the requirement of inquiry-based learning space for cultivating k-12 student's scientific literacy, every score evaluated by expert in Educational Technology and interior design specialist are over 4. Every average score of each items are also over 4, especially the creativity which is the highest 4.9.

Table 3 Evaluation Result

Evaluate dimension		**Expert in Educational Technology**	**Interior design specialist**	**Mean**
General arrangement	Rationality	5	4	4.1
	Utilization rate	5	4	4.1
	Practicability	5	4	4.2
Plastic	Multi-media	5	5	4.5
	Aesthetic and comfort	4	5	4.0
	Flexibility	5	5	4.7
	Safety	4	5	4.4
	Participation	5	4	4.4
Function	Integrity	5	5	4.5
	Situationality	5	5	4.3
	Diversity	5	5	4.7
	Easy Operation	5	5	4.5
	Humanization	4	4	4.5
Educational application	Pedagogy flexibility	5	5	4.8
	Initiative	5	5	4.6
	Enthusiasm	5	5	4.5
	creativity	5	5	4.9

* Mean represent the average score of 10 expects though three field.

4. Summary

This study is the first try for accomplishment-cultivating of K-12 students, which is supposed to integrate the K-12 students, accomplishment and learning –space efficiently. This is a new method to research, and the outcome enriches the theory of learning-space in China, and support the accomplishment-cultivating in a brand new way. We are not just doing the analysis and theory study, but also apply those for real. So that our study is more convinced after the test of practice and other researchers could use for reference.

Space design is complicated, and it is based on the theoretical attainments and artistic attainments, but it is a pity that we did not pay more attention to the artistic of space design, so what we learn from this study is that we should blend multi-major members to cooperate for the

learning-space design. Furthermore, more evaluation and empirical research is need in the future to find the influence on student learning and teacher teaching and how does it work.

Acknowledgements

Our work is supported by the Fundamental Research Funds for the National Engineering Research Center of Educational Technology, and Faculty of Education in Beijing Normal University (CXTD201401).

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