Applying Digital School to Design the Geometry Curriculum and Experiments in Teaching

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ABSTRACT

This project was conducted as quasi-experimental design. We assigned two classes of the third grade's students and the sixth grade's students into experimental group and control group, respectively. Experimental group was taught materials of cube and cuboids for the third grade's students and materials of pillar and awl for the sixth grade's students by taking digital school network learning. The control group was taught by taking classroom learning. The learning effect and the distribution of van Hiele level of geometric thought were compared between these two groups. Moreover, we realized further the geometry concept of the experimental group's students by a structured interview, and surveyed the learning attitude and opinion of the students using digital school network learning.

Keyword：digital school network learning、classroom learning、geometry curriculum、learning effect、van Hiele level of geometric thought

INTRODUCTION

The Internet is spread in Taiwan with an amazing speed. Because of its convenience and integration in World Wide Web, the learning activities with networks are a tendency in the future. Geometric modeling and spatial reasoning offer ways to interpret and describe physical environments, and the Internet can be important tools in mathematics and science. Geometric representations can help students make sense of spatial reasoning and creativity（Clements, Battista, 1992）. Geometry has long been regarded as the place in the school mathematics curriculum. Graph and space is one of the main subjects in the mathematics field of 9-integrated curriculum.

This study applied K12 digital school built by the National Sun Yat-Sen University, to design and teach dynamic web-learning materials of cube and cuboids for the third grade's students, and materials of pillar and pyramid for the sixth grade elementary school. We compared the learning effect and the distribution of the van Hiele Level of geometric thought by researcher-made test. Moreover, we realized further the geometric concept of the sampled students by a structured interview, and surveyed the attitude and behavior of the students using K12 digital school network learning.

THE PROBLEM

1.What is the difference in learning effect of geometry after two different teaching methods?

2.What is the difference in the distribution of the subjects in van Hiele Level of geometric thought at pretest and posttest?

3.How are the situation and attitude of the experimental group for K12 digital school?

HISTORICAL PERSPECTIVE

THE VAN HIELE LEVELS

Three dominant lines of inquiry have been based on the theories of Piaget, van Hiele, and cognitive psychologists （Clements & Battista, 1992）. This project just conferred the theory of van Hiele level of geometric thought as follows.

In 1957, the van Hiele level of geometric thought was first developed by P. M. van Hiele, and his wife, Dina van Hiele-Geldof, the two Dutch mathematics educators, and in 1986, they revised. The development of the students' van Hiele level of geometric thought related to education, after the appropriate teaching, students will move sequentially from the first level to the fifth level: visualization, descriptive, theory, formal deduction, and rigor.

Level 1－visualization. At this level, a geometric figure is seen as a whole. No attention is given to its components. Descriptions are purely visual. The student reasons about geometric concepts, such as simple shapes, primarily by means of visual considerations of the concept as a whole without explicit regard to properties of its components.

Level 2－descriptive. The student reasons about geometric concepts by means of an informal analysis of component parts and attributes. Necessary properties of the concept are established.

Level 3－theory. The student orders properties logically and begins to appreciate the role of general definitions. They can form abstract definitions and distinguish between the necessity and sufficiency of a set of properties in determining a concept.

Level 4－formal deduction. At this level the role of axioms, undefined terms, and theorems is fully understood, and original proofs can be constructed.

Level 5－rigor. The student can compare different axiomatic systems based on different axioms and study various geometries in the absence of concrete models.

K12 DIGITAL SCHOOL

This project applied K12 digital school made by the National Sun Yat-Sen University as the network learning environment. The K12 digital school offered the management and maintenance of main server, operating system, instruction software, and database, so that we could manage our teaching materials, interact with students for discussion, and record the learning progress. There were three main parts in the K12 digital school which were described as followed:

1.The perspective of the teachers

This part offered teachers manage students, teaching materials, assignments, exams, and scores, the teachers would have to inquire and record the basic information and learning progress of the students in order to provide on time and rapid supervision.

2. The perspective of the students

The students could browse repeatedly the time slots and routes of learning materials, evaluate themselves online, synchronous or asynchronous communication with classmates and teacher, test and voting, upload and download assignments.

3. The perspective of the system managers

The system administrator managed the courses, registration, account, the authority of teacher and student, school-established, database, and system data backup.

METHODOLOGY

We conducted as quasi-experimental design and the period was six classes in two weeks.

O1	X (K12 digital school learning)	O3 (Experimental group)
O2		O4 (Control Group)

O1：the pretest of experimental group   O3：the posttest of experimental group
O2：the pretest of control group   O4：the posttest of control group
X：K12 digital school learning

SUBJECTS

The subjects of experimental group included 35 3rd grade students and 39 6th grade students. The subjects of control group included 34 3rd grade students and 40 6th grade students. They were sampled from an elementary school in Kaohsiung City.

MATERIALS

1.Dynamic web-learning materials

We developed the dynamic web-learning materials of cube and cuboids for grade 3, pillar and pyramid for grade 6 according to course content. The materials included virtual reality of solids made with 3Dcanvas and Cosmo Worlds, lecture recorded with Media Master Recorder, and perspective drawing process captured and recorded with Anicam.

2. Achievement test

The achievement tests included three parts: 1.to test the van Hiele level 1, 30％; 2. to test the van Hiele level 2, 40％;3. to test the van Hiele level 3, 30％. According to the criterion-referenced if students passed 60％ on which part, then they achieved the level or not (Usiskin, 1982). We used the test to measure the learning effect and the van Hiele level. We constructed the two-way specification table (Table 1) with instructional Objectives and course content as content validity. The Pearson correlation coefficients of pretest and posttest of grade 3 and grade 6 were .8054 and .736 as alternate-form reliability, and the Cronbach α coefficients were .8289 and .8482.

Table 1

Two-way specification table

Course content	Instructional Objectives	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
Grade 3 Cube and Cuboids	Identify and denominate	6					
	Components	4			6		
	Perspective drawing			2		4	
	Discriminate		2				2
Grade 6 Pillar and Pyramid	Identify and denominate	6					
	Components	4			6		
	Perspective drawing			2		4	
	Discriminate		2				2

3. Perspective drawing

We sampled 6 students of each group in each grade, asked them perspective drawing solid geometric shapes.

4. Questionnaire

We adapted the multi-media computer assisted learning questionnaire（Wen, 1998） to make the hyper-media network digital school assisted learning questionnaire, to investigate the situation and attitude of the experimental groups.

RESULT

THE COMPARISON OF LEARNING EFFECT AND METHODS

1. Grade 3

Table 2

The t-test and one-way ANCOVA for Grade 3 Equality of Means 99％

t-test

Test	Statistics	Experimental Group（n=35）	Control Group（n=34）	F	t-value
Pretest	Mean	66.86	71.94	.112	-2.071*
	SD	10.42	9.96		
Posttest	Mean	78.03	80	.019	.539
	SD	13.36	16.89		
Paired-Samples t value		-5.833*	-2.921*		

One-way ANCOVA

Statistical test	SS	df	Mean Square	F
Homogeneity	16.38	1	16.38	.087
Contrast	37.061	1	37.061	.2

*p＜.05

The .05 alpha level was selected to test for statistical significance. The F-value and independent-samples t-value of pretest were .112 and –2.071, so the learning effect of pretest between two groups was significant difference. The F-value and independent-samples t-value of posttest were .019 and .539, hence the learning effect of posttest between two groups was not significant difference .

The paired-samples t value of experimental and control groups were –5.833 and –2.921, so the learning effect from pretest to posttest was significant difference both in the two groups. The one-way ANCOVA was used to compare the difference between two teaching methods; the F-value of ANCOVA was .2, so the K12 digital school learning method did not produced significantly achievement difference than the classroom learning method in grade3.

2. Grade 6

Table 3

The t-test and one-way ANCOVA for Grade 6 Equality of Means 99％

t-test

Test	Statistics	Experimental Group（n=39）	Control Group（n=40）	F	t-value
Pretest	Mean	46.77	46.98	.605	.050
	SD	18.99	17.88		

Posttest	Mean	72.21	61.93	.635	-1.802
	SD	23.23	22.54		
Paired-Samples t value		-8.468*	-4.755*		

One-way ANCOVA				
Statistical test	SS	df	Mean Square	F
Homogeneity	97.402	1	97.402	.282
Contrast	1756.824	1	1756.824	5.136*

*p＜.05

The .05 alpha level was selected to test for statistical significance. The F-value and independent-samples t-value of pretest were .605 and .05, so the learning effect of pretest between two groups was not significant difference. The F-value and independent-samples t-value of posttest were .635 and –1.802, hence the learning effect of posttest between two groups was not significant difference too.

The paired-samples t value of experimental and control groups were –8.468 and –4.755, so the learning effect from pretest to posttest was significant difference both in the two groups. The F-value of ANCOVA was 2.136, so the K12 digital school learning method produced significantly higher achievement than the classroom learning method in grade 6.

THE COMPARISON OF DISTRIBUTION IN EACH VAN HIELE LEVEL

1.Grade 3

Table 4

The Distribution of the Grade 3 Subjects in Each van Hiele Level at pretest and posttest

Test	van Hiele Level	Experimental Group （n＝35）				Control Group （n＝34）			
		Cube		Cuboids		Cube		Cuboids	
		n	Percentage	n	Percentage	n	Percentage	n	Percentage
Pretest	1	17	48.6	16	45.7	9	26.5	15	44.1
	2	18	51.4	19	54.3	24	70.6	18	53
	3	0	0	0	0	1	2.9	1	2.9
Posttest	1	3	8.6	4	11.5	1	2.9	2	5.9
	2	31	88.6	30	85.7	27	79.4	26	76.4
	3	1	2.8	1	2.8	5	14.7	5	14.7

In experimental group, there were 48.6％ and 45.7％ in cube and cuboids of subjects their van Hiele level of geometric thought stayed at Level 1 in pretest, but there were 88.6％ and 85.7％ in cube and cuboids of subjects had achieved at Level 2 in posttest.

In control group, there were 70.6％ and 53％ in cube and cuboids of subjects s their van Hiele level of geometric thought had achieve Level 2 in pretest, so there were 79.4％ and 76.4％ in cube and cuboids of subjects at Level 2, but there were 5 subject at Level 3.

2.Grade 6

Table 5

The Distribution of the Grade 6 Subjects in Each van Hiele Level at pretest and posttest

Test	van Hiele Level	Experimental Group（n＝39）				Control Group（n＝40）			
		Pillar		Pyramid		Pillar		Pyramid	
		n	Percentage	n	Percentage	n	Percentage	n	Percentage
Pretest	*	12	30.8	8	20.5	17	42.5	12	30
	1	12	30.8	19	48.8	12	30	20	50
	2	14	35.9	11	28.2	9	22.5	6	15
	3	1	2.5	1	2.5	2	5	2	5
Posttest	*	3	7.7	2	5	5	12.5	5	12.5
	1	7	17.8	11	28.2	6	15	12	30
	2	16	41	13	33.4	25	62.5	19	47.5
	3	13	33.4	13	33.4	4	10	4	10

In the pretest of experimental group, there were 30.8％, 30.8％, and 35.9％ at before Level 1, Level 1, and Level 2 of subjects their van Hiele level of geometric thought in pillar, there were 20.5％, 48.8％, and 28.2％ at before Level 1, Level 1, and Level 2 of subjects in pyramid. In the posttest, there were 41％ and 33.4％ at Level 2 and Level 3 of subjects in pillar, there were 33.4％ and 33.4％ at Level 2 and Level 3 of subjects in pyramid.

In the pretest of control group, there were 42.5％, 30％, and 22.5％ at before Level 1, Level 1, and Level 2 of subjects their van Hiele level of geometric thought in pillar, there were 30％, 50％, and 15％ at before Level 1, Level 1 , and Level 2 of subjects in pyramid. In the posttest, there were 62.5％ and 10％ at Level 2 and Level 3 of subjects in pillar, there were 47.5％ and 10％ at Level 2 and Level 3 of subjects in pyramid.

THE RESULT OF STRUCTURAL INTERVIEW

We sampled 12 students in each grade, and gave them a code, the 1st number represent score interval （1－high score preceding 27％, 3－low score 27％ afterward, 2－middle score for the else）, 2nd number represent group （A－experimental group, B－control group）, 3rd number represent a serial number, for example, 2B2 represent the number 2 of middle score in control group. We recorded each interview and translated to typescripts.

Note: ***－No response or I don’t know. P－response through implication
G－response through guidance S－response straight
*－before the Level 1 1－Level 1
1-2－between Level 1 and Level 2 2－Level 2
2-3－between Level 2 and Level 3 3－Level 3
Jn－Jump at Level n, n=1, 2, 3

1.The result of identify activity with vision and touch of grade 3

We placed 4 cubes（S1-large, S2-medium, S3-small, S4-little）, 4 cuboids（R1-with two squares, R2- slender, R3-flat large, R4-flat small）, A1 pentagon pyramid, T1 right triangle pillar, A2 pentagon pillar, L1 trapezoid pillar, K3 quadrilateral pillar, let students to classify and asked the number of components, and compared the difference between cube and cuboids.

Table 6
The result of identify activity with vision and touch of grade 3

Level		Verbal responses	1A1	1A2	1B1	1B2	2A1	2A2	2B1	2B2	3A1	3A2	3B1	3B2
1	Cube	Identify	1	1	1	1	1	1	1	1	1	1	1G	*
		Denominate	1	1	1	1	1	1	1	1	1	1	1G	*
	Cuboids	Identify	1	1	1	1	*	*	1	1	1	1	1G	*
		Denominate	1	1	1	1	*	*	1	1	1	*	*	*
2	Cube	Number of surfaces	2P	2	2	2	2	2	2	2	2	2	1	J1
		Number of sides	2	2	2	2	2	2	2	1	2	2	1	J1
		Number of corners	2	2	2	2	2	2	2	2	2	1	2P	J1
	Cuboids	Number of surfaces	2	2	2	2	J1	J1	2	2G	2	2	2G	J1
		Number of sides	2	2	2	2	J1	J1	2	1	2	1	1	J1
		Number of corners	2	2	2	2	J1	J1	2	2	2	2	2	J1
3	Cube and cuboids	Discriminate of surface	3G	3P	3P	2-3S	2-3	2-3P	2-3P	***	***	2-3P	***	2P
		Discriminate of sides	3G	2-3P	3G	2-3S	2	2-3G	2-3G	***	***	***	***	2P

2.The result of identify activity with vision and touch of grade 6

We prepared 5 realities and molds of pillar and pyramid, the procedure of structural interview was: 1.classification; 2.identify and denominate; 3.count the number of components; 4. discriminate the shape, component, and geometric property of pillar and pyramid.

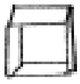
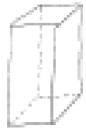
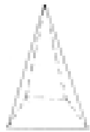
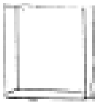
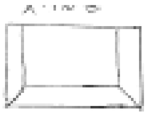
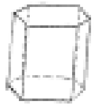
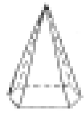
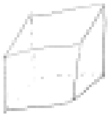
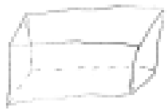
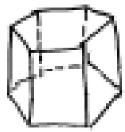
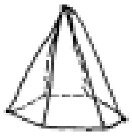
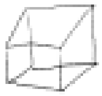
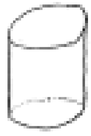
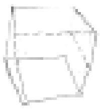
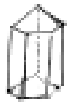
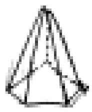
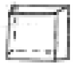
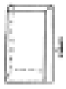
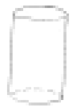
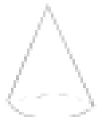
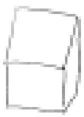
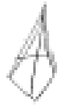
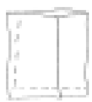
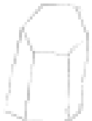
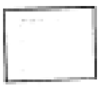
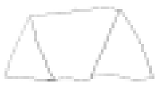
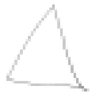
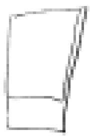
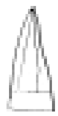
Table 7
The result of identify activity with vision and touch of grade 6

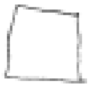
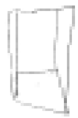
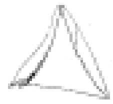
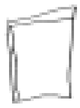
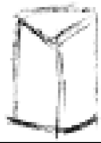
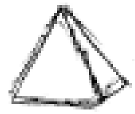
Level		Verbal responses	1A1	1A2	1B1	1B2	2A1	2A2	2B1	2B2	3A1	3A2	3B1	3B2
1	Classification of pillar and pyramid		1	1	1	1	1	1	1	1	1	1	*	*
	Pillar	Identify	1	1	1	1	1	1	1	1	*	*	*	1
		Denominate	1	1	1	1	1	1	1	1	1	1	*	*
	Pyramid	Identify	1	1	1	1	1	1	1	1	1	*	*	1
		Denominate	1	1	1	1	1	1	1	1	1	1	*	*
2	Pillar	Number of corners	2	2	2	2	2	2	2	2	2	2	J1	1-2
		Number of sides	2	2	2	2	2	2	2	2	2	1-2	J1	1-2
		Number of surfaces	2	2	2	2	2	2	2	2	1-2	1	J1	1-2
	Pyramid	Number of corners	2	2	2	2	2	2	2	2	2	2	J1	1-2
		Number of sides	2	2	2	2	2	2	2	2	2	1-2	J1	1-2
		Number of surfaces	2	2	2	2	2	2	2	2	2	2	J1	1-2
3	Pillar and pyramid	Discrimination of shape	3S	3S	3PG	3PG	3G	3S	***	2G	***	J2	J2	***
		Discrimination of component	3S	3S	3S	3S	3S	3S	***	2S	***	***	***	***
		Discrimination of property	3S	3S	3PG	3PG	3G	3S	***	2G	***	***	***	***

3. The Perspective drawings

Table 8

The Perspective drawings of grade 3and grade 6

Code	Grade 3		Grade 6	
	Cube	Cuboids	Pillar	Pyramid
1A1				
1A2				
1B1				
1B2				
2A1				
2A2				
2B1				
2B2				
3A1				
3A2				

3B1				
3B2				

The students need both spatial and drafting ability, the drawings showed the students have good learning effect and higher van Hiele Level, then they have better geometry composition representation, but on the contrary, it is not consistence for example 3B2.

THE RESULT OF QUESTIONNAIRE

After experimental teaching, the experimental group wrote the hyper-media network digital school assisted learning questionnaire, there were 34 copies valid and 1 copy invalid of grade 3 and 39 copies valid of grade 6. There still were 51％ and 46.2％in grade 3 and grade 6 of subjects could not connect the network at home, that was a problem about e-learning.

According to self- evaluation of subjects, there were 40％ and 51.3％ in grade3 and grade 6 of subjects considered their information ability was insufficient. Therefore, there was another problem to promote information literature of elementary students with network-assisted learning.

Table 9

The percentages of the hyper-media network digital school assisted learning questionnaire

Percentage / Aspect	Grade 3				Grade 6			
	4	3	2	1	4	3	2	1
Learning lesson	59	32	7.5	1.5	19.23	56.4	20.5	3.87
Operation of the system	66.25	30	3.75	0	29.45	46.18	19.87	4.5
Learning with digital school	53.75	39.5	5.25	1.5	17.3	54.3	22.4	5.8
Participation in learning	53	33.5	11.75	1.5	24.32	43.6	26.28	5.8
Condition in digital school	50	32.5	14	3.5	29.9	50.42	15.38	4.3
Interaction	40.5	30	21.5	8	32.05	44.87	19.2	3.88
Learning materials	61.25	34.25	3	1.5	19.23	51.25	23.05	6.47
The role of teacher	35.3	34	17	13.7	18.8	55.6	20.47	5.13
Attitude	51.5	30.5	10.5	7.5	38.5	42.35	15.35	3.85

Note：4-greatly agree,3-agree,2-disagree,1-greatly disagree

CONCLUSION

1. Both of the two different teaching methods could promote the learning effect and the van Hiele level of geometric thought to grade 3 learned cube and cuboids, grade 6 learned pillar and pyramid.

2. The comparison of the two different teaching methods was not significant difference in grade 3, but the K12 digital school learning method produced significantly higher achievement than the classroom learning method in grade 6.

3. If students have good learning effect and higher van Hiele Level, then they have better geometry composition representation, but on the contrary, it is not consistence.

4. It still existed two problems of learning with network, popularize network and information ability of elementary students.

5. In this study, there were about 80％ and 70％ in grade 3 and grade 6 positive identify the K12 digital school assisted learning.

IMPLICATION FOR TEACHING AND LEARNING WITH NETWORK

1. The students must possess curriculum knowledge and information ability when using network-assisted learning, to raise the information ability can forward the ability and interest of initiative learning, but the effectiveness of information technology is not satisfied the expectation, it need to further develop for satisfying the requirement and application of learning.

2. It is the future tendency that the materials digitize and interaction with network in the digital learning times, teachers should possess the ability of self-design materials, and the web-learning materials are easily and convenient to create.

3. There are still many geometric lessons needed to research the learning effect, such projects are not too much in internal country.

4. A good online instruction platform could provide the need and the teaching resources of teachers; the education administration and the research organization should establish more e-learning systems.

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