

Variation for More Powerful Teaching and Learning

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Abstract

The research project ‘Variation for the Improvement of Teaching and Learning’ (VITAL) was set up in 2005 with the support of the Education Bureau (EdB) of the Hong Kong SAR Government. It was a three-year project involving 120 schools. During the period that the project was being carried out, we helped each of the participating schools and their teachers to develop a lesson study project using the Learning Study model which was developed from Marton’s Variation Theory. The model has proved to be an important and effective means for improving teaching and learning. In this speech, I will report on the impact of the project on three levels: students, teachers and researchers. At the student level, the result is consistent with the findings of previous projects, that it is possible to narrow the gap in learning outcomes between the high and the low achievers in a class. At the teacher level, the Learning Study has proved to be a good platform for teachers’ professional development that focuses on improving student learning. At the researcher level, new insights have been gained in various aspects and, in particular, how Variation can be used as a guiding principle of instructional design.

Introduction

In 1998, a group of researchers in Hong Kong became intrigued with the question: “Why are some teachers better at bringing learning about than other teachers?” They began a project in which they compared pairs of lessons of different teachers who were teaching what they perceived to be the “same thing” to different classes of students, and found that the students in fact had learned ‘different things’. On careful analysis of the lessons, it was found that even in the lesson enactment, the teachers were, in fact, teaching different things and, as a result, the students learned what the teachers enacted, rather than what the teachers intended. It was also found that the quality of the learning could be accounted for by how teachers understood the object of learning and its critical features, and by how teachers helped students to discern those critical features that were required for a particular way of understanding the object of learning. They also discovered that certain patterns of variation were able to facilitate better student learning (Morris and Marton, 2002; Marton & Tsui, 2004). This marked the beginning of the empirical testing of the Variation Theory (Marton and Booth, 1997) in Hong Kong. Next, the group proceeded to apply this theory to lesson planning. The line of thinking was as follows:

In all the classes that we have used as examples, the lessons were allowed to run their own course without any input from (or intervention by) the researchers, who simply described what they had observed. However, if we really know what is critical in order for learning to take place, should we not try to make use of our insights to help shape the lessons for better learning? (Lo et al., 2004: p.189).

Thus began the work of the Learning Study research team in Hong Kong. The Learning Study approach was created in 1999 with the pioneering project “Catering for individual differences – Building on Variation” by a research team comprising school teachers, and academics from the University of Hong Kong and the Hong Kong Institute of Education. Through 7 years of continuous improvement, the research group developed a systematic research process. The design of the process is underpinned by the Variation Theory and has the improvement of teaching and learning at its core. It is also underpinned by the recognition, based on considerable evidence, that teachers' professional development is greatly enhanced when their classroom practice is made the focus of collaborative investigation (Putnam & Borko, 1997, 2000; Cochran-Smith & Lytle, 2001).

In designing the theoretical framework of the Learning Study, we paid attention to three types of variation. Firstly, we began by trying to find out the variation in students' understanding of the object of learning (V1). In this, we fully acknowledged the individual constructivists' emphasis on the learner's active role in the acquisition of knowledge. Secondly, we recognized that a significant change in education occurs when teachers engage in professional discourse with other teachers and with teacher educators, focusing on classroom teaching and learning. Thus, we have adopted an arrangement similar to the Japanese lesson study (Stigler & Hiebert, 1999) whereby we value the variation in teachers' ways of understanding and dealing with the object of learning (V2). In this way, in helping teachers to learn, we also acknowledge the social constructivists' emphasis on the importance of cultural practices, language and other people, in bringing knowledge about. Finally, the Variation Theory is used as a guiding principle of pedagogical design (V3).

The research team has, in various projects, developed over 260 Learning Studies in which the Variation Theory was tested. These Learning Studies have covered all major key learning areas. We have found the Variation Theory useful as a guiding principle for pedagogical design. Work undertaken by the research team in various projects has also indicated that the Learning Study is able to act as a main component in the building of learning communities which have the potential to effect change. The VITAL project is the largest project in which the team has been engaged. In this project, we have aspired to use the Learning Study as a platform for constructing a professional learning community for teachers. We hope that after having participated in a Learning Study project, experienced teachers will have become more sensitive to their pupils' learning needs, be able to learn together as a community of learners to improve their teaching, be able to engage in mentoring beginning teachers and conducting peer review more effectively and be able to generate knowledge about teaching and learning together, thus contributing to the professional knowledge base in Hong Kong. We believe that engaging teachers in action research that focuses on the lesson is the best way to minimize the gap between theory and practice.

The project has now been completed. 120 Learning Studies have been developed with teacher teams from 120 schools, covering all major subjects of the curriculum in primary, secondary and special schools. The following table shows the number and types of Learning Studies that have been developed.

Table 1: Number and types of Learning Studies

	Primary school	Secondary school	Special school	Total
Chinese	11	15	3	29
English	6	13		19
Mathematics	16	24	1	41
General studies	9		2	11
Integrated science		12		12
Chinese history		1		1
Chemistry		1		1
Geography		1		1
Physics		1		1
Business studies		1		1
Liberal studies		1		1
Integrated humanities		1		1
Visual arts		1		1
Total	42	72	6	120

Examples of Learning Studies in each key learning area can be found in Appendix 1. In my previous keynote speeches to this Conference, I have presented how the Learning Study can have an impact on student and teacher learning. Therefore, I will not elaborate on this today, but will just select some interesting data to share with you.

Teacher learning

A questionnaire was administered to all teachers and principals who had taken part in the VITAL Project. The results show that the teachers are very positive about the impact of the VITAL Project on their teaching. The principals are even more positive.

Table 2: Survey on ‘The Impact of the VITAL Project’ – Teachers
(as of 17 April 2008)

Questionnaire - close ended section (Scale: 5-Strongly Agree; 1-Strongly Disagree) The teachers reflected that:	Either Strongly Agree or Agree		
	Cohort A (Return rate=31%; 40 respondents from 12 schools)	Cohort B (Return rate=88%; 148 respondents from 36 schools)	Cohort C (Return rate=80%; 146 respondents from 32 schools)
My teaching has improved after taking part in the Learning Study.	80%	89%	94%
I have developed a deeper understanding of the subject matter.	85%	95%	95%
I am more focused on the object of learning and its critical aspects in planning a lesson.	95%	98%	100%
I have become more sensitive to students’ learning difficulties.	83%	89%	93%
I will apply the Theory of Variation in my lesson planning.	65%	87%	90%
I will make more use of formative assessment results as inputs to my teaching.	73%	88%	90%
Learning Studies can improve the effectiveness of collaborative lesson planning.	60%	84%	92%
I am willing to take part in collaboration, e.g. lesson planning, lesson observations.	80%	86%	90%
Learning Studies contribute to teachers’ professional development.	80%	93%	97%
The concepts and procedures of Learning Study are sustainable in my school.	60%	76%	80%
I am interested in conducting further Learning Studies.	60%	68%	73%

Table 3: Survey on ‘The Impact of Learning Study’ – Principals
(as of 17 April 2008)

Questionnaire - close ended section (Scale: 5-Strongly Agree; 1-Strongly Disagree) The Principals reflected that:	Either Strongly Agree or Agree		
	Cohort A (Return rate=26%; 10 Principals)	Cohort B (Return rate=63%; 26 Principals)	Cohort C (Return rate=60%; 24 Principals)
After taking part in Learning Study, the overall capability in teaching of teachers has been enhanced.	90%	92%	96%
Learning Study brought a better atmosphere for lesson observation in my school.	90%	96%	96%
Learning Study improved the effectiveness of collaborative lesson planning in my school.	100%	92%	96%
Learning Study helped to enhance the teachers’ professionalism.	90%	96%	100%
The concept and the mode of practice of Learning Study can be continued in our school.	80%	81%	88%
My school is interested in continuing to participate in Learning Studies.	60%	73%	88%
I have planned to use the Learning Study to promote teacher professional development and improvement in teaching and learning in my school.	70%	80%	88%

From the result of the questionnaire, as well as from our own encounters with the teachers and principals of these schools, we know that some schools are continuing to develop Learning Studies on their own now that the project has ended. Some schools have taken advantage of our various Learning Study projects, partnership schemes and training courses to involve and prepare their teachers, so that they can make Learning Study sustainable in their school. Of particular interest is the school in which the principal took the Learning Study seriously enough to include it in his school’s Development Plan for 2001. He has since avoided the introduction of any other innovation, and the Learning Study has been the only means of teachers’ professional development in the school in the last seven years. He has sought support for his teachers in developing Learning Studies through joining in our various projects, including the VITAL Project, as well as using the school’s funding to buy consultancy

services from us. In 2000, the school went through the Quality Assurance Inspection of the Education Bureau, and one of the components involved observing the teaching of a sample of over 30 teachers randomly selected and giving each a grade chosen from a four point scale: 4 for excellent, 3 for good, 2 for satisfactory and 1 for failure. After engaging with the Learning Study for seven years, in 2008 the school went through a similar inspection, - the External School Review. The turn over rate of teachers in the school has been low. Only about 3 to 4 teachers were replaced by new teachers. The table below shows a comparison of the grades obtained by the teachers on the two assessment occasions:

Table 4: School Improvement

	Quality Assurance Inspection 2000	EdB External School Review 2008
Excellent (4)	4.3%	6%
Good (3)	33.3%	57%
Satisfactory (2)	52.7%	37%
Fail (1)	9.7%	0%
Mean	2.3	2.7

It is evident from the comparison that the teachers in the school have improved. This is also reflected in the students' learning. The principal reported that before the introduction of the Learning Study, the data from the EdB which measured the added-value of school education on students showed that the F.5 students' performance for the best six subjects were at rank 8 (the top 11% of schools in Hong Kong). In 2006, the same data went up to rank 9 (the top 4% of schools in Hong Kong).

Student learning

In one of our previous projects "Catering for Individual Differences-Building on Variation" (CID(v)), in the two case study schools which had worked with us on the Learning Study for three years, we found that, with respect to the groups of students that had been involved in Learning Studies for all three years, there were overall improvements in their Hong Kong Attainment Test (HKAT) scores in both schools. The HKAT was a standardized test administered to all students in Hong Kong on an annual basis. What was most exciting was that when we tried to compare the gain scores of the high and low score groups (the low score group consisted of students with marks lower than the first quartile, while the high score group consisted of students with marks higher than the third quartile, excluding those who got full marks in the pre-test), we found that, while the performance of all the students had improved, the gap between the low score group and the high score group had narrowed! (Lo, Pong & Chik, 2005)

Unfortunately, the HKAT has since been replaced by the Territory-wide Systemic Assessment (TSA), and so we are not able to make a similar comparison. Also, in the VITAL Project, we only worked with one school for one Learning Study, and so it is not possible to study the long term effect as in the CID(v) project. However, for each Learning Study, we can still compare the pre- and post-test results to compare the learning of the two score groups. However, while the pre- and post-tests of each Learning Study are diagnostic tests, and the items are very carefully designed to test how well the students have acquired the critical features of the object of learning, not every case lends itself to a statistical analysis of the above type. Of the 120 cases, we found 58 cases that satisfied all the requirements for undertaking such a comparative statistical analysis. We found the following results:

Table 5: Comparing the changed scores between the low score group and the high score group.

Category	No. of cases
With significant gain scores in student learning ($p=0.05$)	58
The low score group showing greater gain scores than the high score group ($p=0.05$)	53

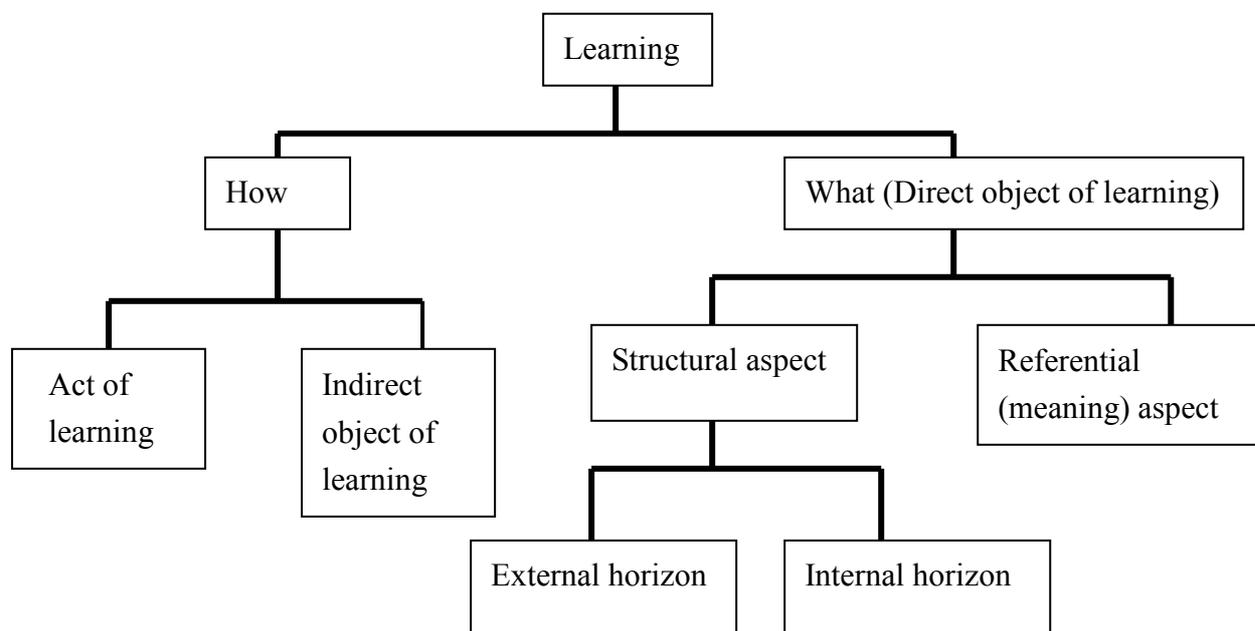
In all 58 cases, there are statistically significant gains in scores between the pre- and post-test of both high and low score groups. In 53 out of 58 cases, we found that the low score group showed greater gain scores than the high score group. So, again we found evidence that the performance gap between the high score group and low score group can be reduced! This is exciting as it shows the possibilities of helping the lower achieving students to catch up. In fact, this did not come as a great surprise to us. Since we planned each research lesson to target at resolving the difficulties that these students were facing, they naturally should be the ones who benefited the most.

Researchers' learning

One distinctive feature of the Learning Study is the use of variation as a guiding principle of pedagogical design (V3). The Learning Study is an attempt at linking empirical studies with theoretical and generalizable concepts. In the Learning Study, we have made a genuine attempt to make use of the Variation Theory. In a sense, the Variation Theory is being tested using empirical studies. But, at the same time, each research lesson as enacted should be examined using the Variation Theory. It is only through this two way process that we can take steps to reduce the gap between theory and practice. This was especially important when we scaled up the number of Learning Studies, and we had to involve academics who were not experienced in the Learning Study and its theoretical framework.

There are two aspects of learning, the 'what' aspect and the 'how' aspect. The 'what' aspect deals with the ways that something needs to be experienced in order to arrive at a certain meaning, while the 'how' aspect deals with what it takes for

something to be experienced in a certain way. The quality of the learning depends very much on the ‘how’. In fact, the ‘what’ and the ‘how’ cannot be separated.



(Marton & Booth, 1997: p.91)

In the last few years, we have paid special attention to the ‘what’ aspect, and we have been quite satisfied that every Learning Study had a worthwhile object of learning. We were able to identify the critical features of the object of learning, through student interviews, pre-tests, learning from the literature, and through collaboration between teachers and researchers. We went as far as specifying the pattern of variation to facilitate the discernment of the critical features. However, we still found that some cases were more successful than others. This I would attribute to the fact that we have not paid enough attention to the ‘how’ aspect. In this speech, I would like to explore in greater depth the ‘how’ aspect with you, drawing on data from two Learning Studies.

Example 1 Variation must be experienced by the students as ‘variation’¹

In a Learning Study on the rate of chemical reaction at secondary four level, two teachers were involved in the teaching of the research lessons. Again, following the procedure of the Learning Study, students were interviewed about their understanding of ‘rate of chemical reaction’. Amongst others, it was discovered that students believed that increasing the volume of a reactant will increase the rate of a reaction. Therefore, besides other critical features, this was one critical feature that the teachers wished to deal with in the research lesson: to help the students to see that the volume of a reactant will not affect the rate of a chemical reaction.

¹ This is a Learning Study from the VITAL Project funded by the EdB and led by the author. The author also wishes to acknowledge the contributions of Ms Helen Hung and the teachers of the project school.

The research team decided to use the following experiment for teaching.



Thus, with respect to this particular critical feature, the pattern of variation would be:

Table 6: Intended pattern of Variation

Mass of CaCO_3	Concentration of acid	Volume of acid	Initial rate of reaction	What is discerned
invariant	invariant	varies	invariant	Volume has no effect on rate

In both classes, students were engaged in doing the experiments themselves. Different groups of students were assigned different combinations of calcium carbonate and acid, carefully designed by the teacher, to enable generalizations to be drawn from the result. For example, the following table shows the assignment for three groups of students:

Table 7: Assignment for three groups of students for practical work

Group #	Mass of calcium carbonate (Invariant)	Conc. of acid (Invariant)	Volume of acid used (Varied)
1	1	0.5	5
2	1	0.5	10
3	1	0.5	15

Then, during the debrief, the teachers discussed with the students the effect of volume on rate when the concentration of the reactants were unchanged, drawing on their results, for example, using the results of groups 1, 2 and 3. In both classes, the lesson plan, the experimental arrangement and the pattern of variation employed were the same. However, the table below shows the result of a particular item which tested the students' understanding of the effect of volume on rate (For the test item, see Appendix 6), showing that the students had, in fact, learnt very differently in the two classes:

Table 8: Comparison of pre- and post-test results between the two classes

% of students getting the item correct	4A	4B
Pre-test	48%	11%
Post-test	42%	80%
Gain	-6%	69%

It is evident that in the first cycle (4A), students were not learning this particular critical feature as expected. What had actually happened? If the Variation Theory

is a powerful theory, it should help us to explain and interpret this. So, let us look into each lesson in greater detail.

The teacher of the first cycle followed the lesson plan very closely. He was an experienced teacher with a good knowledge of chemistry, and explained the concepts very clearly to the students. The debrief was carried out to help the students to draw a generalization, and the answer was not provided by direct transmission. The lesson had been designed with the best practice of science teaching in mind, in that students were given the opportunity to undertake experiments using an inquiry approach. Since doing experiments take time, each group was required to plot the rate curve for only one set of data. The results of each group were then pooled in the debrief session. Each group was asked to plot the rate curve on a transparency. Then the transparencies from all the groups (i.e. groups 1, 2 and 3) with the same concentration but different volumes of acid were overlaid. The teacher then showed the class that the initial rate of all the reactions was the same, as shown by the gradient of the rate curve at the start of the reaction.

Why did the teaching not lead to the expected student learning outcomes? Was it because the pattern of variation had not been experienced by the students? The students were all actively engaged in doing the experiment and in plotting the rate curve, but did they experience the variation in the volume? Well, not in their own groups when they were doing their own experiment, because each group was only working on its own set of data. The intended pattern of variation were only experienced when the results of the groups were pooled by the teacher during the debrief. Perhaps that was where the problem lay. In the second cycle, we made changes to the 'how' aspect. While all other planned activities remained the same, in order for the students to experience the pattern of variation for themselves, before the group work, the students were asked to seek an answer to the question as to whether the volume of a reactant affects the rate of the reaction. They had to decide which groups' data to compare in order to find the answer. Thus, after the students had finished the experiment, they had to actively take their results and find the groups with the appropriate data that would help them to answer the question. In this way, the students were forced to experience the variation pattern as intended, i.e. they had to figure out that they should compare the groups using the acid with the same concentration but with a different volume. When the post-test was carried out for this class, we found that whereas only 11% of students got the items correct in the first class, in this second class, 80% of students got the items correct at the post-test, an increase of 69%!

Thus, it is important to articulate the teaching and learning activities with the critical features. What really counts is not whether students are actively involved and fully participating in class activities, but whether they are engaged in activities that open up the opportunity for them to experience the variation pattern that would lead to the intended discernment!

Example 2 The quality of learning is affected by the act of learning²

Cantonese Opera is an art especially appreciated by the people of Hong Kong. On stage, the artists make use of the graceful movements of eyes, fingers, hands, body and legs to bring the virtual into reality in the minds of the audience. The main purpose of teaching about Cantonese Opera in school is to help the students to appreciate and treasure this art, which is part of our cultural heritage. In a Learning Study on the Cantonese Opera, the teachers used a number of video clips of Cantonese Opera episodes to introduce the various critical features of Cantonese Opera, including:

- the standard ways of showing certain actions, e.g. opening a door, riding on a boat, etc.
- the lack of scenery and equipment on the stage. The actor has to help the audience to see the changes in time and space, the furniture, etc. through detailed movements of finger and body gestures
- the movement of the actors are always exaggerated, yet they are graceful and elegant, and pay great attention to detail

We will just look in detail at the last concluding episode, in which the teachers helped the students to appreciate the elegance and grace of the actions of the Cantonese Opera actors.

Transcript of the last episode of Lesson 1

Teacher: I want you to get into groups of three, think about how you get on a boat. Now the pier is here. Later I'll ask you to show us how to get on a boat and ride on a boat from here to there.

The students carried out the activity in groups of three as asked. Then the three groups of students were asked to perform in front of the whole class.

Teacher: Pay attention to their every move. I'd like to ask, what's the difference between them?

Student 1: One student pretended to be taking an oar.

Teacher: So, this group has included more detail, like using an oar to row the boat.

Now I'll show you a video, see how these people get on a boat.

The teacher showed the video of part of a Cantonese Opera, showing a boatman rowing a boat to the shore, then three men boarded the boat, and rode off together. As there was no actual boat, the actors had to act as if there was a boat and the boat was floating on water as they rode away.

Teacher: Now you saw them get on a boat. After they got on the boat, their bodies moved up and down. Why?

Student 2: Because there were waves.

Teacher: How did they move?

² This is a Learning Study developed jointly by Dr. Raymond Yuen, Ms. Lai Meng Choo and the teachers of the project school.

Students: They moved slowly.

*Teacher: In fact all the actions are very important. In Cantonese Opera (because there is no furniture or equipment), the actor depends only on their actions to show whether they are indoors or outdoors, the distance they have traveled, and their movements are slow. Have you thought of all the actions involved in rowing a boat just now (when you were rowing)? No, because we have not thought in enough detail. But in Cantonese Opera, there are very detailed movements, **and the actions are very graceful.***

In this lesson, the teacher focused the students' attention on the details of the movement, and she mentioned that '...the actions are very graceful'.

In the second cycle, the teacher taught in a slightly different way. Three students were invited by the teacher to do the performance: one to row the boat and the others to get on to and ride on the boat. They were first asked to discuss among themselves how to arrive at a plan and then to perform it. After the performance, some students were asked to comment on whether the performance was good. Then the teacher showed the same video of the boatman and the three gentlemen riding on a boat. After showing the video, as in the first lesson, the teacher discussed with the students how the actors showed that they were riding on a boat. Then, the teacher continued ...

Teacher: Which part is elegant and graceful?

Student 1: One of the actors picked up his clothes before getting on to the boat.

...

The teacher then asked the class to try to carry out the same performance in groups of three, but to note that there were some criteria they had to bear in mind: first, they must show through detailed movements that they are riding on a boat; second, they must show change of space; third, they must show, through their actions, that the boat is actually present; finally, their action must be graceful and attention must be paid to details. They were given three minutes to think about how they would do it. Then all the students carried out the activity. Afterwards, the same students that had performed at the beginning of the class were asked to perform in front of the class again, and the teacher asked the whole class to comment on their performance, based on the four given criteria.

*Student 2: I appreciate them getting over the pier and getting on to the boat.
The rocking ...*

Teacher: What's the difference (between the first act and this one)?

Student 3: They have used some of the movements we saw in the video.

Teacher: Which movements are similar to those in the video?

Student 4: It feels very real to me, very good.

*Teacher: Is there any change in space? **Any graceful parts? How can you make the movements more graceful or elegant?***

Student 5: Go lighter, not so heavy.

*Teacher: Yes, their movements are a bit rough. **How can we make it more graceful?***

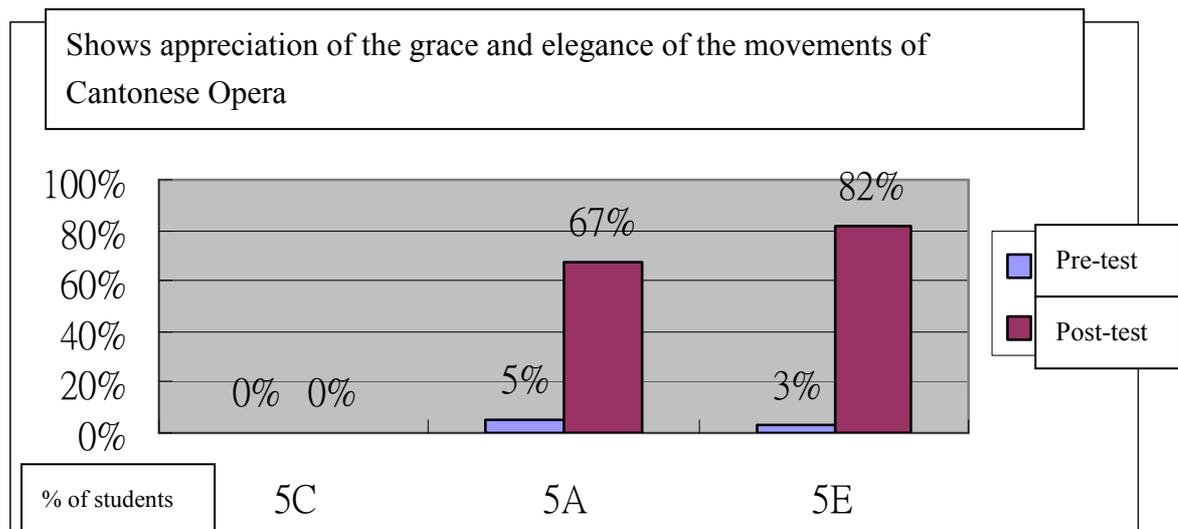
Students volunteered answers, then the teacher referred to the video again in the discussion.

In the third lesson, the teaching was very similar to that in the second one. The video was shown first. Then the class practiced the rowing act together. One group was elected to perform. The only difference was that the whole class was asked to give marks to the performance using the four criteria mentioned in lesson 2. Then the video episode was discussed in detail as in lessons 1 and 2. The same group was asked to perform again. The whole class was asked to comment on the acting, and again to give marks to the performance on each of the criteria.

In both lessons, the teachers taught using very similar activities and the same video clip, with only very minor differences? Did it matter?

Using an open question, we asked the students to compare the way the actors acted with what we would normally do in our daily lives. We found the following. In the first class, in both the pre- and post-tests, none of the students mentioned that the movements of the Cantonese Opera actors are graceful and elegant, although in the post-test, some students mentioned the details the actors attended to in trying to turn what is virtual into reality in the audiences' mind. However, in the second class, there was an increase of 62% of students who mentioned or conveyed the idea that the movements of the Cantonese Opera actors were graceful and elegant. In the third lesson, the increase was even greater - 79% (from 3% to 82%).

Table 9 Comparison of pre- and post-test results of the three classes



How can we explain this difference in student learning outcomes? In this case, the direct object of learning is to understand the movements of the Cantonese Opera actors in a “riding on a boat” scene. The movements of the actors, the very detailed enactment formed the internal horizon. It included such acts as boarding the boat, moving up and down as the boat rocked due to the weight of the person, coming to an equilibrium, rocking again as a second person boarded the boat, taking into account the movement of the boat and the position of the person, e.g. the person standing at the head of the boat will go up while the person standing at the tail will go down, etc. Thus, noting the different acts (parts) and seeing their relation to each other (part-part) gives one meaning to the whole (riding on a boat), and each of the parts became meaningful. The awareness that the people were riding on a boat came almost

instantaneously through an understanding of their movements. The indirect object of learning was for the students to appreciate the graceful and elegant finger gestures and body movements of the actors in giving meaning, and turning what was virtual into reality in the audiences' minds. In order to appreciate that the movements are graceful and elegant, one must compare them with movements that are awkward and clumsy. The movements of the students will provide the necessary contrast to help the students to discern what is graceful, elegant and artistic from what is not (the external horizon). Unfortunately, in the first lesson, the teacher did not make the variation explicit. Never in the discussion did the teacher refer back to the students' acting and make any comparison between the movements, so as to intentionally open up the opportunity for the students to experience the variation *simultaneously*. By focusing on the acting of the three gentlemen, one may not be able to discern that the acting is elegant. Although there were fine distinctions between the movements of each actor, including the boatman, who, in my opinion, acted most elegantly. The pattern of variation that was opened up to the students would probably lead to the conclusion that there are standard ways of showing boarding and riding on a boat because the actors acted in very similar ways. Thus the intended indirect object of learning was not achieved.

The pattern of variation:

Variant	Invariant	What is discerned
Actors	The action of boarding and riding on a boat	There are standard ways of boarding and riding on a boat

In the second lesson, the teacher asked the students to act out riding on a boat before and after the teaching involving the video. She explicitly asked the students to compare the movements of the actors in the video with that of the students. Also, she explicitly asked the students what contributed to the movements that were seen to be elegant and graceful, thus bringing up the variation and bringing the critical feature to the fore. In the third lesson, not only did the teacher compare the students' acting with that of the Cantonese Opera actors, she also asked the students to grade the two performances of the group of students on the four criteria, one of them being whether it looked graceful and elegant. She also asked the students how they could improve the movement to make it look more graceful, again bringing this critical feature to the fore through exposing the students to the appropriate variation. Therefore, the effects of the second and third lesson were that a higher percentage of the students were able to acquire the intended indirect object of learning.

Pattern of variation enacted

Varies	Invariant	What is discerned
Those who acted – Cantonese opera artists v.s. students The quality of the performance – Awkward v.s. elegant	The action of boarding and riding on a boat	The acting in Cantonese opera is elegant and graceful

Of course, the lesson can be further improved by drawing the students' attention to the movement of each of the four actors in the video. In fact, each of them performed with different degrees of grace and elegance. In this way, a dimension of variation will be opened up, with different degrees of grace, including the clumsy and awkward movement of the students at the one hand, and the very sophisticated and artistic movement of the boatman on the other. Of course, such fine distinctions would not be possible if the students cannot even make crude differentiations, i.e. graceful and not graceful.

Pattern of variation

Varies	Invariant	What is discerned
Cantonese Opera artists showing different degrees of mastery of the art	The action of boarding and riding on a boat	The subtle differences in the acting that makes it look graceful and elegant

Conclusion

In our experience, we have found that the Variation Theory is a powerful guiding principle for developing Learning Studies for better teaching and learning. Learning Studies are empirical studies that apply the Variation framework to develop research lessons. However, the gap between theory and practice can only be revealed when we study what happened in the lesson carefully (Nuthall, 2004). Thus it is important that the resulting research lessons should be analyzed very carefully using the Variation Theory to discover gaps in interpretation and understanding as the theory was applied. This two way process – testing the theory with empirical studies, and testing the empirical studies against the theory - is necessary to close the gap between theory and practice. What really matters is sometimes subtle and cannot be represented easily by dichotomies and rough categorizations like individual work or

group work, student investigation or teacher demonstration, small class or large class, and even what patterns of variation are planned. Only by studying very carefully the enactment can we make sense of what has actually happened in the lesson, and be able to explain its effect on the quality of learning of the students, so as to advance our knowledge on teaching for learning.

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Appendix 1: Examples of Learning Studies in different key learning areas

Chinese Language Learning Studies

Special schools	Story telling
	Understanding questions
	Learning Chinese characters
P. 2	Story telling
	Improving students' reading ability by inferring the meaning of words/phrases
P. 3	Writing contemporary poems with metaphor
P. 5	Writing: analysing the topic and content
P. 4	Reading prose
	Writing: analysing the topic and selecting supporting materials
P. 6	Writing: analysing the topic
	Reading strategies
S. 1	Association in writing
	Writing the 1st paragraph of expository essays
	Reciting
	Setting the theme and selecting supporting materials
	Writing the 1st paragraph of narrative essays
	Pausing when reading aloud
S. 2	Written Chinese language
	Correcting pronunciation
S. 3	Reading aloud
	Argumentative essays
	The use of topic sentences
	Writing: describing a scene
S. 4	Writing: describing a person
	Basic grammar knowledge
	Group discussion

Examples of English Learning Studies

P.2	“Wh” Questions
P.2	Writing
P.3	Reading Strategies
P.4	Writing Sentences and Paragraphs (with Conjunctions)
P.4	Past tense with auxiliary verb.
P.4 , P.5, S1	Past Tense
S.1	Descriptive Writing (sentence)
S.1	Use of Tenses
S.1	Improving the written evaluation of an (abstract) entity
S.2	Indirect Reported Speech
S.2	Subject Pronouns, Object Pronouns, Possessive Pronouns, Possessive Adjectives
S.2	Defining a Relative Clause
S.2	Reading
S.2	The function of pronouns in English sentences
S.2	Passive voice
S.3	Oral Skills
S.4	Although & But; Because & So

Examples of Mathematics Learning Studies

P. 2	The concept of fractions
	Understanding the concept of fractions
	The remainder after division
P. 5	Mathematical Equations
	Multiplication of fractions
	Fraction-based questions
	Division of fractions
P. 4	The eight directions
	The perimeter of shapes
	Understanding the reduction of fractions to a common denominator
	Comparing fractions with different denominators
	HCF & LCM

	Zero-padding strategies in doing division
S. 1	The application of angles on straight lines
	The conditions of congruent triangles
	Percentages
	Congruent triangles
	Indices
	The Rotating Transition of points on a plane
	Ratios
	Symmetry and Transformation
	Factorization
S. 2	Cumulative frequency polygon
	Numerical Estimation: Significant Figures
	Algebraic Identities
	Compound interest
	Pythagoras's Theorem and its inverse theorem
	Rate and ratio
	Approximation and Error
	Elimination Method (Simultaneous Equation)
	Proving two lines are parallel
	Polynomial addition and subtraction
S. 3	Probability
S. 4	Proving four concyclic points

Examples of General Studies and Science Learning Studies

P. 5	GS	The four seasons
P. 6	GS	The classification of life
P. 4	GS	The mystical air
P. 4	GS	Air pressure
P. 4	GS	The production and transmission of sound
P. 4	GS	Water
P. 4	GS	Light
S. 1	Science	Air pressure
S. 1	Science	Particle theory
S. 2	Science	Eye defects SEE BELOW
S. 2	Science	Electric current
S. 2	Science	Eye defects SEE ABOVE
S.2	Science	Acids and Alkalis
S. 2	Science	Action and reaction
S. 2	Science	Forces
S. 3	Science	Scientific enquiry skills
S. 3	Physics	Optics
S. 4	Chemistry	The Electrochemical Series
Special school	GS	The functions of food
Special school	GS	The transmission of heat

Examples of Learning Studies in other subjects

s 1	Chinese history	The division of Wei and Jin Dynasties, Southern and Northern Dynasties: the Feishui Battle
s 1	Geography	Map reading skills
s 1	Business	Keeping meeting minutes
s 1	Liberal studies	My information booklet
s 3	Visual arts	The signs of drama
s 4	Liberal studies	The reform in China's countryside

Appendix 2

Test Item:

When 20 cm^3 of 1 M HCl is added to 10 g of Zinc (in excess), hydrogen is given out. How would the following situations affect the rate of the initial reaction?

- A. Use 10 cm^3 of 2 M HCl instead of 20 cm^3 of 1 M HCl (testing both effect of volume and concentration on rate)
- B. Use 20 cm^3 of 3 M HCl instead of 20 cm^3 of 1 M HCl (testing effect of concentration only)
- C. *Use 30 cm^3 of 1 M HCl instead of 20 cm^3 of 1 M HCl (testing effect of volume only)*
- D. Add water to the mixture (testing both effect of volume and concentration)

-end-