



On the Paradox of Pedagogy: the relative contribution of teachers and learners to learning

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Abstract

When dealing with problems of various kinds, we frequently have to take several features of the problem into consideration simultaneously, such as time and distance in a physics problem, the color of the lips and breathing when making a diagnosis, and distance and wind when kicking a football. This study is about learning to do this with a specific kind of problem. The instructional approach that is adopted gives concrete cases that are then followed by the explicit teaching of general and formalized principles, and a comparison is drawn between two conditions. In one, the students deal with cases that vary in two respects at the same time, and in the other the students first deal with cases that vary in one respect, then with cases that vary in a second respect, and then with cases that vary in both respects at the same time. Both conditions are followed by the same explicit instructions about how to formally deal with this kind of problem. As the first condition represents an attempt to allow the learners to take more charge of their learning, whereas the second condition represents an attempt by the teacher to structure the situation to make it easier for the students to learn, this study can be seen as a specific example of the general problem of the trade-off between the learner's own activity and the teacher's helping hand.

1. Introduction

The word “pedagogy” in the title of this paper does not refer to a field of knowledge, to a discipline, or to “the science of teaching,” but to a set of related acts that are aimed at helping another person, or other people, to learn: that is, the word refers to the practice of pedagogy. The more efficient such pedagogy is, the easier should it be for learners to learn. However, the most widely accepted pedagogical principle today tells us that the more learners themselves can take charge of their own learning, the better that learning will be (see, for instance, Bransford, Brown & Cocking, 2000, p. 12). Thus, we face a paradox: the better the learning, the less need for pedagogy; the more powerful the pedagogy, the less space there is for good learning. In this paper we examine this potential paradox in a rather specific case. The point we want to make is that the potential paradox – or any questions about pedagogy and learner autonomy for that matter – should be framed in more precise terms than is usually the case. We should not only say whether the teacher or the learner is doing most, but we should also make it clear who is doing what and the effect that it has.

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Some very interesting studies of the role of the active engagement of learners with the learning tasks have been carried out by John Bransford, David Schwartz and their associates (Schwartz & Bransford, 1998; Bransford & Schwartz, 1999; Schwartz & Martin, 2004). As Bransford *et al.* (1999) put it: “wisdom can’t be told” – one must acquire it through active engagement. In the study that is reported in this paper we took one of the studies of the Bransford-Schwartz group as the point of departure for a making further differentiation as to what the learners should be doing themselves and what is optional for them or for others to do.

Bransford and Schwartz (1999) refer to the set of transfer studies that they carried out as “preparation for future learning.” The object of research in these studies is to assess the effect of learning in one situation on learning in a second situation, and their point of departure is the standard transfer paradigm. In this paradigm, two comparable groups of students try to learn what is nominally the same thing under two different conditions (say “A₁” and “A₂”), and are tested on what they have learned under conditions that are novel to both groups (say “C”) (see Figure 1).

As we can see from the case that is examined in the next section, the design could also include two groups that are subject to the conditions A₁ and A₂ who take the final test C without participating in the second learning opportunity B (see Figure 3). If we do not find any difference in C between the two groups that were not subject to B, but find a difference in C between the groups that were subject to B, then it would imply that the differences are due to a varying capacity to learn from B that is caused by differences in what the participants learned in A₁ and A₂, respectively.

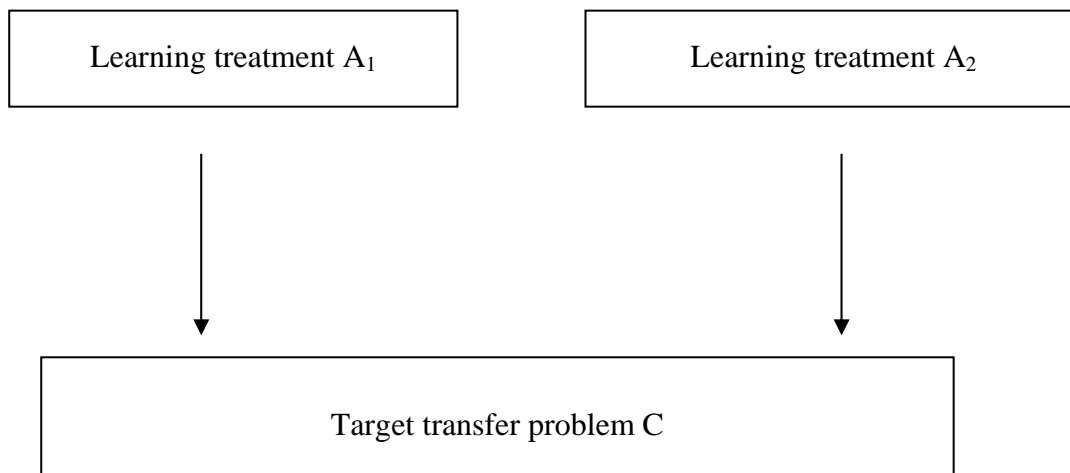


Figure 1 Standard transfer design (after Schwartz and Martin, 2004)

It may be the case that we cannot find any difference between the two conditions, but what if one of the conditions is better at preparing the learners for future learning, even if it does not directly result in superior achievement in a standard transfer design study? To investigate this problem, Bransford and Schwartz suggest the use of the “double transfer” design. In this case the two different conditions for learning (A₁ and A₂) are followed by a second opportunity for learning the same thing that is the same for all participants (B). Finally, there is a test of what the students have learned (C) (see Figure 2)

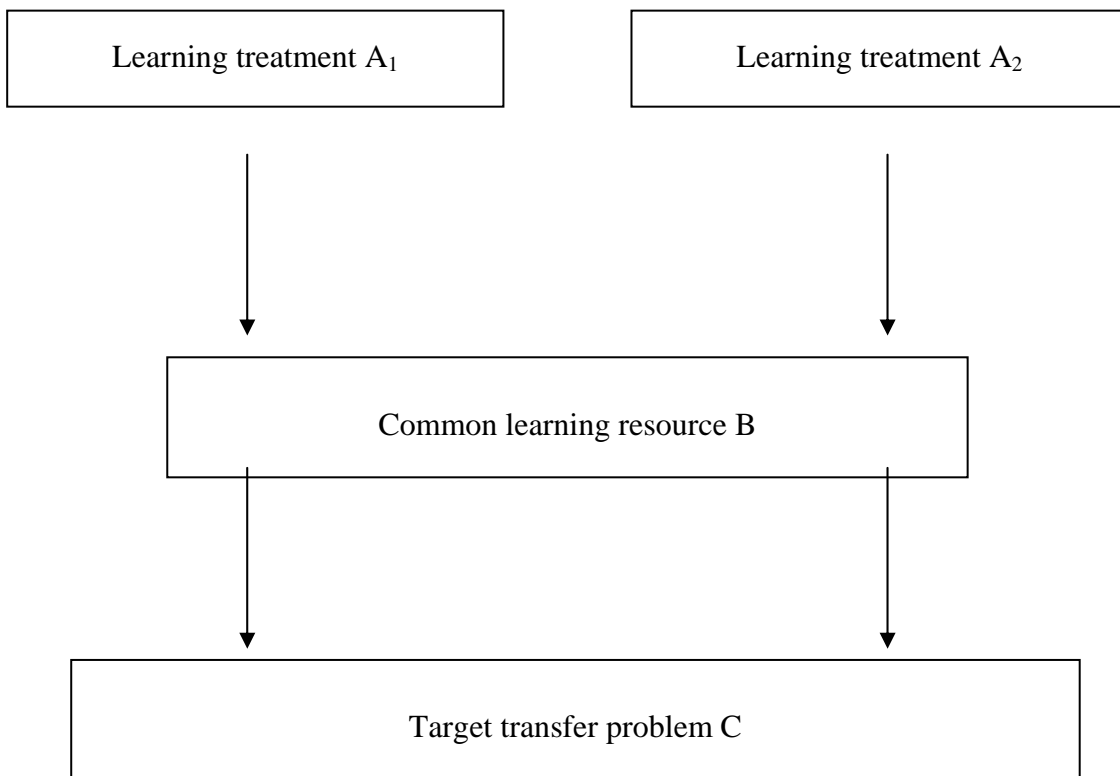


Figure 2 Double transfer design (after Schwartz and Martin, 2004)

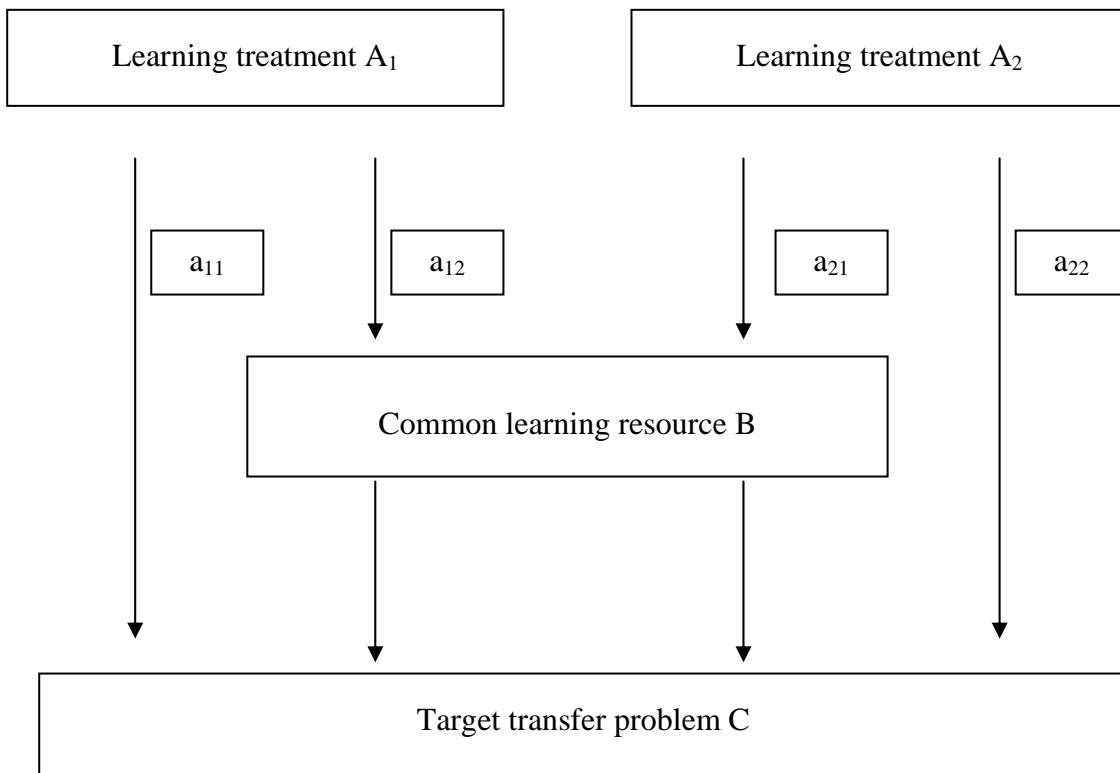


Figure 3 Mixed transfer design (after Schwartz and Martin, 2004)

1.1. Schwartz and Martin (2004)

The example that we use to advance our line of reasoning is the study of Schwartz and Martin (2004). The object of learning in this study was to compare (high) scores on different scales from different distributions that were operationalized in terms of the target task given after the issuing of instructions, for example, “which of two students, with a score of X and Y, respectively, who were in different biology classes and took different tests did better on their respective test?” Such problems are commonly solved in statistics by using standardized scores, in which the difference between the actual score and the mean of the distribution to which the score belongs is divided by the standard deviation for the same distribution. The critical features of this problem (those that make the difference between whether the subject matter is mastered or not) for the year 9 students that participated in the study turned out to be the central tendency and variability. After having dealt with statistics for two weeks (all in the same way) the students were given two scenarios, such as “Who broke the world record by the most impressive amount, John in the high jump or Mike in the javelin throw?” In one of the conditions (A_1) the students were asked to find out how to solve the problem on their own on being given the raw data for the distribution of the best results during the year. In the other condition (A_2) the students were shown a graphical method for standardizing scores by using histograms and a method for comparing the derived standardized scores, which they practiced under the supervision of the teacher. After these two different treatments, both of which lasted for 30 minutes, one half of each group in the two different conditions (a_{12} and a_{21}) worked on the same two examples in the same way. In these examples, which were intended to be a learning resource for dealing with the target problem, the students were instructed in how to compute and compare standardized scores (for example, “is Betty better at assists or steals?”). The other halves of the groups from the two conditions (a_{11} and a_{22}) did not participate in any further learning activity. Finally, all of the students in the four subgroups received the aforementioned target problem (comparing the scores of two students in two Biology tests). Not all of the raw data was given, but the mean and standard deviations for the two tests were given together with the raw scores of the two students (cf. Figure 3).

For the subgroups who did not receive the examples that were already worked out (a_{11} and a_{22}), we can follow the standard transfer paradigm and simply compare the transfer effect of the two treatments on the target problem to conclude that there is no difference between the two treatments in this respect (see Table 1).

Table 1

Post-test percentages of acceptable solutions to target transfer problem by condition (after Schwartz and Martin, 2004)

	Invention-based instruction (A1)		Tell-and-practice instruction (A2)	
	No resource (a_{11})	Learning resource (a_{12})	Learning resource (a_{21})	No resource (a_{22})
Acceptable solutions (%)	30.4	60.8	29.2	32.0

However, we can compare the subgroups from the two treatments that did receive the worked out examples (a_{12} and a_{21}), and we can see that the difference between the two treatments is striking, as should be obvious from Table 1. The two different designs can then be combined, which was actually the case in the study that is discussed here (see Figure 3). We can learn from the experiment that although the attempt of the students to invent a solution to the first problem did not give them an advantage in solving the second problem over the students who had been told a way to solve it, the attempt had a definite advantage when it came to *learning* to solve the second problem. Thus, the differential effect on the second problem was neither due to the first part of the experiment (the attempt to invent a solution) nor to the second part (as the effect is absent for the other group), but to the *relationship* between the first and second part. The effect of the first part is thus contingent on the second part. If we again denote the three parts A (this is where we find the independent variable, the treatment, for which the “invention approach” can be denoted A_1 and the “tell and practice approach”

can be denoted A_2 , B, and C, then we can conclude that neither the effect of A on C or of B on C can be identified, because it is contingent on the other tasks that the learners may encounter. So, the effect of certain tasks (appearing, for instance, in A_1 , A_2 or B) on other tasks (appearing, for instance, in C) can only be determined specifically in the context of the whole set of tasks (in, for instance, A_1 and B or A_2 and B). Changing the set may mean that the effect of any given task on any other task will also change.

An important feature of A_1 , or the “invention approach,” is the use of contrasting cases. The students were supposed to compare the raw scores and the distributions to which those scores belonged. By doing so, the students were trying to find out how the scores and their distributions differed from each other, which led them to notice the important quantitative aspects, or “critical features”, even if they could not capture these features and their relationship with each other explicitly using technical language. If the differences between the cases provided the students with one kind of contrast, the juxtaposition of their own vague ideas about central tendency and variability with the standard statistical versions of the same phenomena provided them with another contrast.

1.2. What is learned when preparing for future leaning?

In trying to account for the superiority of the more innovative conditions when it comes to preparing for future learning, Bransford and Schwartz (1999) argue that the engagement with contrasting cases aids the emergence of a certain kind of knowledge, that of “knowing with” as distinct from “knowing that” and “knowing how.” Our understanding of the way in which Broady’s (1988) notion of “knowing with” is used by Bransford and Schwartz is that it refers to the development of sensitivity toward critical features that distinguishes between contrasting cases. In the case of the study of Schwartz and Martin (2004) the critical features in relation to which the learners have to distinguish between the two distributions of the raw scores to compare the two scores from those different distributions are central tendency and variability. The learners are taught in the learning phase how to use standardized scores, or to compare the specific score X with a measure of the central tendency M that is the mean $(X - M)$, and to relate the difference to a measure of variability S that is the standard deviation $(X - M)/S$. If the learners have noticed and tried to take into account the two ways (central tendency and variability) in which the distributions of the raw scores critically differ from each other, then when they are actually taught how these two features should be taken into account, then they will learn more readily than the students who have not developed this particular sensitivity before the learning occasion.

We find the development of this sensitivity to be very interesting. Unlike most other studies of the transfer paradigm, in this study the effect does not originate from the experience of the learners of sameness or similarity, but from their experience of difference. In our own framework for the study of learning (Marton, Tsui *et al.*, 2004), learners learn to attend to the two critical features of the task in which the distributions differ from each other. In agreement with Gibson and Gibson (1955), we call these aspects *dimensions of variation*. To discern a dimension of variation, there must, of course, be experienced variation. The second necessary condition is that there is no experienced variation in other features. This second condition can be met in one of two ways: either the other dimensions of variation could be temporarily kept invariant through arrangement (by the teacher, for instance), or they could be “blocked out” by the learners themselves by temporarily not attending them.

We have now reached the precise question that we want to investigate. Does the teacher’s effort to create the necessary conditions for learning have a positive or negative effect on learning? According to what we have already discussed, if the teacher does not create these conditions, then the learners have to create them themselves. As far as the discernment of a particular dimension of variation is concerned, the learners must, of course, do the discerning themselves. No one else can discern things for you, but when it comes to creating the necessary conditions for this to happen, it still might be an advantage for the teacher to create these conditions. This is our conjecture, which is based on the simple assumption that discernment (which the learners must do themselves) must occur for learning to happen. The necessary conditions, which can be created either by the learners themselves or by others, must be present for discernment to occur, and if it is up to the learners to create the conditions themselves, then inevitably some will do so successfully and some will not. However, if the teacher creates the conditions for the students, then they will be there for everyone. The teacher should thus

create the necessary conditions for learning to take place. In the following, we put this conjecture to the test in a content domain that is new to Schwartz and Martin.

1.3. *The object of learning*

The object of learning, or what the students are supposed to learn, of this study is to account for a change in the market price of a commodity by taking into consideration the relative magnitude of the change in demand for and supply of the commodity, which comes from the Hong Kong economics curriculum for Secondary 4-5. This topic was chosen for the following reasons. First, it includes some of the most difficult concepts for students at this level, and it has been reported that many candidates in public examinations are unable to discern that both the supply of and the demand for a commodity are affected in questions that require the comparison of the magnitude of changes in both demand and supply (Hong Kong Examinations Authority, 1992; 1995). Second, it is one of the most fundamental concepts in economics, and is vital if students are to develop an understanding of the economic aspects of the world around them.

Market prices change due to supply changes, demand changes, or both. Based on commonsense understanding, quite a number of people see a change in the market price of a commodity as an effect of a change either in demand or supply, but few people consider that price changes may be caused by a simultaneous change in both demand and supply.

In economics, when both supply and demand change simultaneously in the same direction, whether the price goes up or down depends on the relative magnitude of the change in demand and supply. In general, there are three possible scenarios. First, when the increase (decrease) in demand is greater than the increase (decrease) in supply, then the price of the commodity will go up (down); second, when the increase (decrease) in demand is smaller than the increase (decrease) in supply, then the price of the commodity will go down (up); and finally, when the magnitude of the change (increase/decrease) of demand and supply is the same, then the price will remain unchanged.

To derive the effects on price that are caused by a simultaneous change in demand and supply, we attempt to decompose the two effects and consider separately how each has an impact on price. Take the simultaneous increase in demand and supply as an example. An increase in the demand for a certain type of good when the supply is kept constant leads to a rise in price, whereas an increase in supply when the demand is kept constant leads to a fall in price. It is obvious that the effects on price of these two changes are opposite, and that they counteract each other. Thus, to determine the combined effects of a simultaneous increase in demand and supply on price, one needs to look at which has the greater magnitude of increase. If the magnitude of the increase in demand is relatively greater than that of supply, then the price of the commodity will rise, and vice versa. In the reverse case, when there is a decrease in both demand and supply, the result will also be reversed, that is, when the decrease in demand is relatively greater than the decrease in supply then the price will go down, and vice versa.

In summary, to develop an economic way of understanding how the price of a commodity will change as a result of a simultaneous change in its demand and supply, one must focus on and discern the critical feature of the object of learning, *the relative magnitude of simultaneous changes in demand and supply*.

2. Method

2.1. *Design*

Two secondary school economics teachers worked together to develop an instructional means for students to appropriate the agreed upon object of learning. The aim was to develop the ability of students to take into account the relative magnitude of the changes in demand and supply in determining the change in the market price of a commodity (the object of learning). The specific and measurable aim was to develop in the students a qualitative understanding of the object of learning and the necessary skills to handle the problem and present it graphically. In this paper, we report on the first aspect only.

According to the variation framework that is adopted (Marton, Tsui *et al.*, 2004), to enable students to focus on the critical features simultaneously, students need to discern the critical features first, one at a time (“separation”). Most students need help to discern the various critical features separately at the start, which can be undertaken by letting certain dimensions of variation be discerned, while keeping the others invariant. Thereafter the students should be asked to deal with simultaneous variation in different features (“fusion”). This was shown in a recent study by Marton and Pang (2006), in which the same object of learning embedded in the same task is used as in this study. The two teachers together with the researcher attempted to subject this conjecture of the variation framework to another test by working out the following two lesson designs.

According to our theoretical framework and also to the line of reasoning of Bransford and Schwartz (1999), there is reason to suspect that it was the use of contrasting cases, or a specific form of variation, in “the innovative method” that made the difference between the two conditions in the study of Schwartz and Martin (2004), rather than the distinction between the more and less student active approaches. By making use of the same task with the same inherent pattern of variation and invariance in both conditions, we aimed to keep the potential contrasts and variation/invariant across the two conditions and to vary the role of the teacher and the students in structuring that potential variation.

“Condition A₁” thus starts with the “separation” of the critical aspects, which are then subject to “fusion” later. In other words, in this particular case, which uses the example of the market for face masks during the SARS outbreak in Hong Kong, the idea is to isolate the effect of a change in demand or supply on price separately (separation) first, and then to put them together by exemplifying the combined effect of a simultaneous change in demand and supply on price (fusion). This is followed by the formal teaching of the effect of a simultaneous change in supply and demand on price (the common learning resource B in Figure 2). Conversely, in “condition A₂” the teacher does not take responsibility for the “separation” part of condition A₁, but replaces it with a group discussion among the students on four complex scenarios of the face mask market during the SARS outbreak in Hong Kong that are based on some real-life information that was extracted from news clippings and embedded with types of simultaneous changes in demand and supply of face masks. The time-price graph depicts the variation in the price of face masks during the SARS outbreak. As the students are invited to make comparisons between prices (and the factors that affected them) at different points in time under both conditions, contrasting cases are used. This is followed by the same formal teaching of the effect of a simultaneous change in supply and demand on price as in condition (B).

Thus, although both conditions use the same sets of materials and arrangements for the formal teaching, the major difference between the two conditions is in the first part of the lesson design. In other words, condition A₂ aims to allow the students to extract the information from the face mask data on their own, whereas in condition A₁ the teacher provides the students with guidance through questions that point the students to the separation of a change in demand and the magnitude of change in demand first, which is then followed by the separation of a change in supply and the magnitude of change in supply. Finally, the fusion of the magnitudes of the changes in both supply and demand are introduced. Both teachers are to carry out the two lesson designs with their own classes in such a way that both conditions are conducted by the *same* teachers (in one class each).

During two preparatory meetings, the two teachers discussed how the object of learning could best be handled in each condition. To assess the initial understanding of the students, a pre-test was conducted in which the qualitatively different understandings of the students of the economic phenomena were explored. This was supplemented by pre-test interviews with ten randomly chosen students. The results of the pre-test written task and interviews were used in the course of designing the lessons, and the two teachers combined these results with their collective experience to develop two lesson plans for a series of three lessons, which were then taught in the different classrooms. All of the lessons were videotaped and the enacted objects of learning subsequently analyzed (referring to how the object of learning was taught – or enacted – in the classrooms).

After the series of lessons, the understanding of the students of the economic concept was evaluated. All of the students were required to complete a post-test written task, which was identical to that which was used in the pre-test, and the same ten students who were interviewed during the pre-test were interviewed again to chart their progress of understanding. Finally, to evaluate the extent to which the students had retained the targeted way of understanding, six weeks after the post-test all of

the students were required to complete a delayed achievement test that contained the same questions as in the pre- and post-tests, and again the ten students were interviewed. Based on the data that were obtained about the teaching and learning, inter- and intra-condition comparisons were conducted to explore the qualitative differences in the ways that the teachers handled the same object of learning, and the qualitatively different ways in which the students made sense of the phenomenon in question.

2.2. Participants

Two teachers participated in the study, both of whom were very experienced in teaching economics at this level. The teachers themselves were undecided about the relative efficiency of the two conditions before conducting the lessons, but supposed that we (the researchers) believed that the most student-active condition (A_2) would work best. One hundred and fifty-one students, including 105 boys and 46 girls, participated in this study. They were in the age range of 16 to 18 years and all studied economics as a school subject. All of the students belonged to the Band One category (which represents the highest level of academic attainment in Hong Kong), and were thought to be relatively more academically able than their peers. No significant difference in academic attainment was found between the students in the two conditions.

2.3. Data Collection and Analysis on Student Learning

This study employed multiple methods to collect data in the areas of teaching and learning. With regard to student learning outcomes, written tasks and interview (pre-test, post-test, and delayed-test) were arranged, and preparatory meetings, lesson plans, class observation, the video-recording of lessons, field notes, and interviews with teachers were used to collect the teaching data.

2.3.1. Written pre-test

To ascertain the initial understanding of the students of the object of learning and to identify the qualitatively different ways in which they made sense of the economic concept in question, all of the students were given a pre-test before the lessons. They were allotted 30 minutes in which to answer two questions that were framed in such a way that both required the discernment of the concepts of demand, supply, change in demand and in supply, the magnitude of the change in demand and supply, and change in the relative magnitude of the two.

The first question was as follows.

“Some years ago, VCDs were rather expensive, and many people turned to buying pirated VCDs. Many shops sold these pirated VCDs. Over the past few years, however, Hong Kong Customs has put much effort into stopping the illegal trade in pirated VCDs, and there are now fewer shops that sell them. However, it is interesting to find that the price of pirated VCDs has not gone up, but has remained more or less the same as in the past. Why? Can you explain this?”

The second question was as follows.

“In 1997, a new bird flu virus, H5N1, was found in humans in Hong Kong. Eighteen cases were reported and six people died. To stop the spread of bird flu, the government immediately killed about 1.2 million live chickens in the territory. However, it is surprising to find that after this move, the price of live chickens in the market did not go up but fell. Why? Please explain.”

The results of the students became the major input for the two teachers in identifying the critical features of the qualitatively different ways of experiencing the learning object that distinguished one way from the other.

2.3.2 *Written post-test*

To ascertain the extent to which the students had absorbed the object of learning, after the lessons all of the students were required to complete the same written task as was used in the pre-test.

2.3.3 *Written delayed test*

Finally, to evaluate the extent to which the students had retained the targeted way of understanding, six weeks after the post-test all of the students were required to complete a delayed achievement test that contained the same questions as in the pre-test and the post-test.

The researcher explained the task of the written test to each class before they started to work to enable them to grasp the question adequately. They were told to elaborate their ideas as much as possible, and to feel free to use whatever language they liked, including slang, spoken Cantonese or even pictures, to answer the question and articulate their ways of understanding. They were strongly encouraged to use diagrams to assist their explanation.

2.3.4 *Pre-test interviews*

In addition to answering the written questions, ten students were chosen randomly from each class to attend an individual interview during which they were asked to elaborate the answers that they gave in the written task. The analyses of the data from this interview facilitated the analysis of the written data, and all of the answers of the students were analyzed phenomenographically to reveal their conceptions of the economic phenomenon in question (which will be elaborated in the data analysis part of this paper).

2.3.5 *Post-test interviews*

The ten students who were randomly chosen from each class for the pre-test interviews were interviewed again after the written post-test. During the interviews, students were asked to elaborate the answers that they gave in the written task, talk about the teaching approach of the teachers, and handle a new task that aimed to ascertain their ability to make sense of an authentic case using the economic concept that had been learned in the lessons. The new task concerned the price change of a very popular game named “toy rocket” during the 2004 Lunar New Year period, in which a simultaneous change in demand for and supply of the commodity in question was embedded. This case was strongly related to the experiences of the students, as it is a very fashionable item for most youngsters. To facilitate the understanding of the case, photos and newspaper clippings were displayed. The translated text of the task is as follows.

“It was reported that the trendy item “toy rocket” (as shown in the photo) was so well received by the public that one of the stalls in the Victoria Park Flower Fair sold 2,000 pieces and earned \$15,000 on January 20, 2004. The toy is a symbol of a great improvement in the year to come, and both adults and children like it very much. You might find people playing with this fancy item everywhere in Hong Kong, and the price of the toy rocket soared over these few days. The owners of other stalls also felt its popularity and immediately imported the item from mainland China to reap a profit. (News extract from a local newspaper).

Read the news extract and the price chart of the toy rocket during the period January 10 to March 11 2004. Try your best to explain why the price of the toy rocket changed in such a way. You may use the information that is contained in the news clipping as well as your own personal experience to support your answers.”

2.3.6. *Delayed-test interviews*

After the delayed written post-test, the students who had been interviewed earlier were interviewed again. They were asked to elaborate the answers that they gave in the written task, compare the three written answers that they produced for the study, and finally express their views on some issues related to the object of learning in question.

The meta-awareness, the presence or absence of which we expected to reveal by asking the students to compare their answers, is indicative of the capability of the students to separate the generalized relationship between changes in price on the one hand and simultaneous changes in demand and supply on the other hand from the specific examples. The task that asked the students to compare their answers to the three tests aimed to solicit whether the students *consciously* knew the method of experiencing the learning object that they had developed during the lessons and to see whether the students could be *mindfully reflective* of the economic way of seeing the phenomenon. Furthermore, to ascertain whether they had developed the capability to apply the economic concepts that they had learnt to make sense of some novel everyday issues, the students were invited to express their views on some local current issues. Examples of the questions are as follows.

“Yesterday, as you may know, the government officially announced that a ban had been imposed on the importation of live chickens from mainland China with immediate effect due to the outbreak of bird flu in China. Only chickens that are raised by local farms are allowed to be sold in the markets. If you were interviewed by a TV reporter about your views on this policy and how it would affect the price of live chickens, what would you say?”

“From the TV and the press, we know that the government will start to import live chickens from mainland China starting from next Monday, as the bird flu outbreak in mainland China is over and government officials believe that it is the right time to do so. It is proposed to import 5,000 chickens a day at first, and then gradually to raise the number if no more problems are found. Do you think the price of live chickens in the market will change at all next week? Why or why not?”

In the interviews, initial questions were used to thematize the experiences of the students, after which they were allowed to take their own course. The interviews were tape-recorded, and each interview lasted between 15 and 30 minutes. Supplementary questions were asked for clarification. The questions were mostly made up spontaneously, depending on the responses of the interviewees, to help the students to clarify or elaborate the remarks that they had made earlier. The questions that were asked during the interviews were concerned with clarifying the experiences of the interviewees, rather than with the presumptions of the researcher about the phenomenon in question.

2.3.7. *Analyzing the answers of the students*

The answers that the students gave to the test questions (both in written and oral form) were analyzed in an iterative manner by first studying the transcripts holistically and reading through them repeatedly to capture the global meaning of what the students wrote and said. Parts of the written tasks or interview transcripts were then marked as significant quotes, which were brought together to form “a pool of meaning”, with the similarities and differences among them noted down. Sets of quotes were then brought together in categories of description, and the individual quotes were placed back in their original contexts to ascertain whether the categories of description really matched the contextualized meanings. At the same time the quotes were compared to other transcripts, until the critical features that differentiated the various ways of absorbing the object of learning were identified.

Finally, a set of categories that signified the conceptions of the students of the economic phenomenon in question (the differing meanings) was created. In the words of Booth (1997, p. 138), “the set of categories arrived at can be considered to be satisfactory when an internal logical relationship, a hierarchy, is seen to exist between them, which in turn can be related to other descriptions of the phenomenon in question”. It should be emphasized that although the data

encompasses the descriptions of the different meanings as expressed by individuals, the system of the categories of description is supposed to depict the collective structure of expressed meanings, rather than documenting every individual way of experiencing meaning as manifested by each individual participant. Four qualitatively different ways of experiencing the two problems were identified, and four categories were derived to capture the variation in the answers to both questions. Each category is described in more detail in the next section, along with an illustration of the critical aspects of the categories through verbatim quotes from relevant written work of the students.

To meet the criterion of multifaceted understanding and to verify how effectively the categories were explained, inter-judge agreement in the categorization of the data was sought. As Saljo (1988) argued, this reflects “the communicability of categories,” and thus shows the researcher that someone else can see as they have seen. Another two experienced economics teachers with solid backgrounds in education were invited to apply the categories of description independently to the interview protocols. They were provided with a copy of the categories of description, 20 written answer scripts, and 20 interview transcripts, and were then asked to classify the transcripts into the given categories of description. Although there were some minor disagreements in one individual case for the written task and interview, agreement was reached after discussion. To permit informed scrutiny here, sufficient interview excerpts are provided to adequately illustrate and fully describe the categories of description that were identified.

The ways of experiencing that were identified were categorized in accordance with the categories of description or conceptions identified. In the course of applying the categories of description to individual interview protocols, *the most complex conception* that was expressed in answers to the two written questions was counted, as the students had already demonstrated that they possessed the capability to experience the phenomenon in a new light in one of the instances.

2.4. Data Collection and Analysis on Teaching

2.4.1. Planning of the lessons

To enable the teachers to work together to deal with the object of learning, two preparatory meetings were held, and the two teachers met twice for around five hours in total. In the first meeting, they readily agreed that the chosen topic was important but difficult for students. Thus, they had no hesitation in trying to find ways to make it possible for the students to grasp the concept. They were asked to think about the following questions and share their views.

- What are the important points in teaching this topic?
- What common errors and confusions do students have when learning this topic?
- How do students make sense of the topic?

The pre-test results and the different categories of description that had been identified were presented to the teachers. They were invited to use this as an input in their lesson design, and they then discussed how to achieve the object of learning more effectively. They were asked to share with one another how they handled the same object of learning in the past and to reflect on the following questions.

- How did you handle the same object of learning in the past?
- What do you think are the critical aspects of understanding this topic?
- What were the difficult points in teaching this topic in the past?
- How could we make students develop an economic way of understanding this phenomenon?

In the second meeting, based on the discussion in the first meeting, the teachers deliberated on the teaching sequences and plan for the three lessons that they had prepared together before they came to the meeting. After that, they produced the teaching materials for both conditions. To ascertain the prior knowledge of the students, the teachers were asked to submit their teaching schemes for the year.

The teachers implemented the plan in their classes in line with their own personal styles and with any modifications that they considered to be necessary. To understand how the teachers dealt with the object of learning in the actual classroom contexts, the lessons were observed and video-recorded, and

field notes were taken. The lessons were transcribed verbatim by student helpers and checked by a research assistant and the first author of this paper to ensure accuracy.

As has been mentioned, both teachers taught one class according to condition A₁ and one class according to condition A₂.

2.4.2. Analyzing the lessons

The analytical framework of variation was adopted to analyze the teaching data. Attention was paid to the qualitatively different ways in which the teachers handled the same object of learning. Instead of giving a detailed account of the process of teaching, the main focus of the analysis of the classroom data was on the patterns of variation and invariance constituted in the lessons – i.e. those aspects that were focused upon, the aspects that were varied simultaneously, and the aspects that remained invariant. The similarities and differences were identified in the patterns of variation and invariance in the critical features that were found between the two conditions and within each condition in the lessons. The analysis of the teaching data was supplemented by other sources of data, such as from the preparatory meetings, the interviews with the teachers, the lesson plans that were submitted, and the field notes that were made.

3. Results

3.1. Categories of description – pre-tests

Four qualitatively different ways of understanding changes in price were identified before the lesson started, and are ordered here in increasing order of complexity. This is the first qualitative result of the study.

3.1.1. Change in Demand Only

The change in price was related to the change in demand for the good, which was caused by a change in the conditions of the market in which the good was sold. For instance, the commodity became more popular, people become more frightened to buy the goods, or there were more substitutes available in the market. In the case of this conception, the answers that were given by the students were characterized by a concern about the extent to which consumers would change their consumption plans, which would affect the price. The following written answer demonstrates this way of understanding.

“As the H5N1 virus was found in live chickens, people’s desire to eat chicken dropped a great deal, and fewer people bought live chickens. The reason why the price of live chickens fell was psychological. From the newspaper, people learned that there were 18 reported cases and 6 people killed by this new virus. People were very frightened that they might get this disease by buying live chickens. No one dared to eat live chickens and no one bought live chickens in the market, and so their price fell.”

3.1.2. Change in Supply Only

The change in price was related to the change in the supply of the good, which resulted from the change in the supply conditions of the market in which the good was sold, such as there being more suppliers in the market or changes in the cost of producing the good. The answers that were given by the students were characterized by a concern about the extent to which suppliers would change their supply plans, which would eventually affect the price. The following answer illustrates this conception.

“The price of live chickens was high before the new bird virus H5N1 because the supplies were mainly local. Although all of the live chickens in Hong Kong were killed, the new supplies came from mainland China. That means that the cost of production was lower because the price of importing live chickens from China was lower. Therefore, the new price of live chickens was lower.”

3.1.3. Change in Both Demand and Supply (without comparing their magnitude of change)

The change in price here depended on the simultaneous interaction of the change in the demand and supply of the good, without considering the relative magnitude of the change in demand and supply. The simultaneous discernment of the elements that related to a change in both demand and supply characterized all of the answers that indicated this conception. On the demand side, the elements that were discerned were the change in people’s willingness to buy the commodity and the change in the availability of substitutes in the market. On the supply side, the identified elements included the change in the level of stock and the change in the number of sellers. However, students who exhibited this conception did not attempt to compare the change in magnitude between demand and supply. The following is an example that was drawn from answers to one of the two questions.

“Because of the bird flu crisis, many people were afraid of getting the H5N1 virus from live chickens. At the same time, live chicken hawkers also dared not buy much from the wholesalers. Thus, there were fewer live chickens in the market. However, the price did not rise but fell. As many people were scared and did not want to buy live chickens, although there were fewer chicken in the market, the price dropped instead.”

3.1.4. Change in both demand and supply (taking into account the relative magnitudes of change)

The change in price was seen as a function of the simultaneous interaction between the change in demand and supply, as well as the relative magnitude of the change in both demand and supply. The objects of awareness of the students were the three dimensions of variation that had been identified: the change in demand, change in supply, and their relative magnitude of change. The following excerpt provides a good illustration of this.

“Because the government killed 1.2 million live chickens, the supply of live chickens decreased, but people in Hong Kong were unwilling to buy chickens because they were afraid of getting the H5N1 virus, and therefore the demand and supply both decreased. In this case, we need to see what decreased more. Although the supply decreased, the demand decreased more, therefore the price of live chickens did not go up but fell”.

3.2. Pre-test distribution across categories

The frequency distribution of the conceptions between the two conditions in the pre-test is shown in Table 2.

As we can see, all of the students considered the market mechanism, but only three of the students discerned the relative magnitude of the changes in demand and supply (Category D). Judging from the results, the ability to make sense of market price changes by taking into account the relative magnitude of change in demand and supply is a novel but worthwhile ability for practically all students in both conditions.

Table 2
Distribution of Conceptions in the Written Task – Pre-test

Conception	Condition A ₁ and B (77 students)		Condition A ₂ and B (74 students)	
	Occurrence	Percentage	Occurrence	Percentage
A	30	39.0%	25	33.8%
B	1	1.3%	1	1.4%
C	46	59.7%	45	44.6%
D	0	0.0%	3	3.0%

Chi-square = 3.407 (*df* = 3) (*p* = 0.333, i.e., *p* > 0.05)

3.3. The lesson plans

Drawing from their own experience and the results of the pre-test, the teachers developed two lesson plans, one for each condition.

3.3.1. Lesson plan for condition A₁

As has been mentioned to provide the students with a meaningful context for the abstract economic concept, the teachers decided to present the case study of the face mask market when SARS hit Hong Kong to exemplify how a simultaneous change in demand and supply would affect the price of a commodity in a context with which the students had direct experience. According to the plan, a worksheet on the face mask market during the SARS period would be distributed to the students.

Having one case study for the different lessons was thought to afford a better focus on how the interaction between a change in demand and supply affects price change, rather than on the product itself.

The first part of the worksheet tried to separate the change in demand from the change in supply. The supply was kept unchanged or invariant, and only the demand was changed. By referring to the various scenarios as portrayed by the relevant news clippings, the demand for face masks was shown to first increase moderately, then further increase greatly, and finally decrease. Thus, a variation could be constructed that highlighted the absolute magnitude of change in demand while the supply was kept constant and in the background. The ultimate aim, of course, was to help students to relate the absolute magnitude of change in demand to the change in price, so that they could discover the principle that given a constant supply, the larger the absolute magnitude of change in demand, the greater the effect on the change in price. The adjustment mechanism would then be presented graphically to the students.

After that, the teacher would introduce a similar treatment to look at supply while keeping demand invariant with the selection of news clippings that related to a change in the supply of face masks only. The supply was shown to change in varying absolute magnitude by first increasing to a small extent, then increasing greatly, and eventually decreasing, so that students could discern how a change in supply of varying magnitudes would affect the price of face masks. This was aimed at drawing the attention of the students to how the absolute magnitude of change in supply affects the change in price. Again, a graph would be used to summarize the adjustment mechanism.

The teacher would then raise the following thought-provoking question for students to think about.

“Read the news extracts below and answer the question that follows.

In the Shatin district where the Prince of Wales Hospital is situated (where SARS broke out), the demand for face masks soared rapidly. A pharmacy shop, which usually sells no more than one face mask a day, recorded a tremendous jump in sales of 40 to 50 face masks yesterday. Some pharmacies even sold more than 200 pieces a

day. The shops had contacted the suppliers to replenish the inventory, but according to the suppliers, it takes time for them to manufacture such a huge amount of face masks to cope with the sharp increase in demand within such a short period. What they did was to supply their existing small amount of inventory to the market to help alleviate the acute shortage problem. As a result, it was found that in one of the shops the price of face masks (the 8210 model manufactured by 3M) had doubled to \$25 a piece.

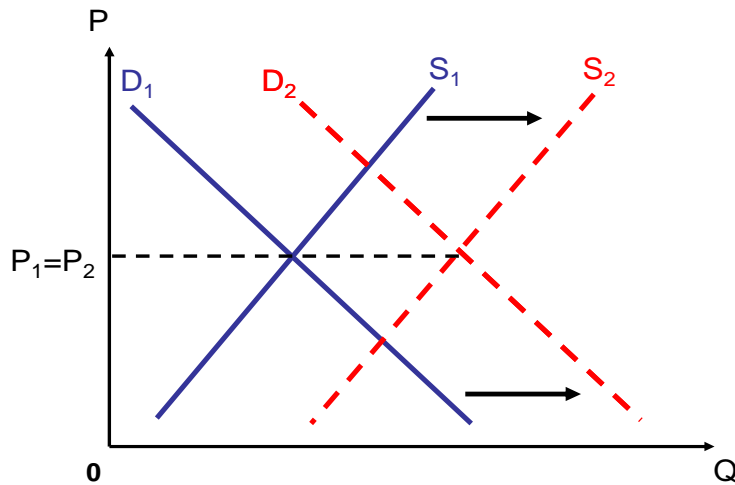
Despite the increase in the supply of masks, the price of masks did not drop, but rose instead. Can you explain the phenomenon with the aid of a supply and demand diagram?"

This paradox would serve to show that a change in supply or demand alone sometimes cannot account for the economic phenomenon that was observed, and this would be used as a springboard to introduce the case in which a simultaneous change in demand and supply is involved. Having introduced the cases in which either the absolute magnitude of change in demand or that of supply varied earlier, the teachers consciously *fused* the variation in both respects simultaneously, with a view to achieving what the teachers had originally discussed, removing the difficulty that students had in conceptualizing the idea of "relativity." This was to help students to understand what was identified as critical in the economic way of understanding this economic phenomenon, namely, the relative magnitude of the changes in demand and supply.

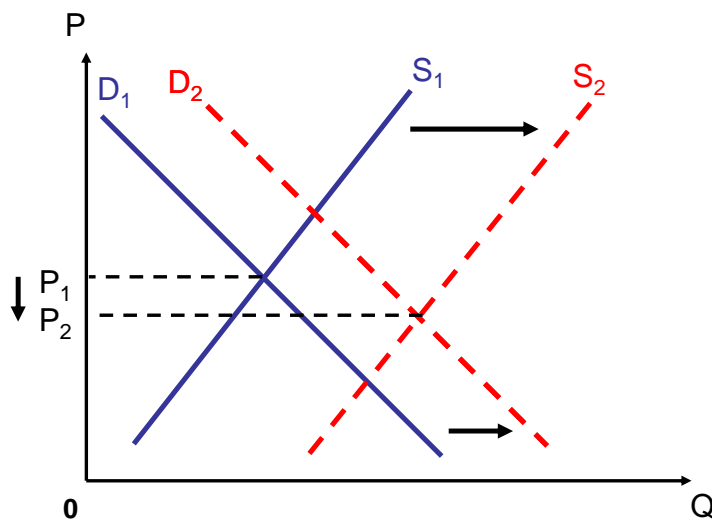
First, the teacher would ask the students to suggest why the price of face masks still rose despite the fact that the supply had greatly increased. Some students were expected to guess that the increase in demand for face masks might be larger than the increase in supply, but that they would not be able to explain it systematically using a supply-demand diagram. The teacher would then present a graphical representation of this particular case to the students and emphasize that when both demand and supply increase at the same time, and the increase in demand is greater than the increase in supply, the price will rise.

The teacher would then present the students with a challenge by asking them whether the price would necessarily increase if both demand and supply increased at the same time. Hopefully, some students would be able to say that when the increase in demand for a good is less than the increase in supply, the price will fall. The teacher would then show a diagram to the students to demonstrate how the mechanism works. Finally, the teacher would ask the students about the conditions under which the price would remain unchanged when both demand and supply increase simultaneously. This would be a bit more difficult for students, and in case they could not answer correctly that this occurs when the increase in demand is equal to the increase in supply, the teacher would supply the answer and show it in another diagram.

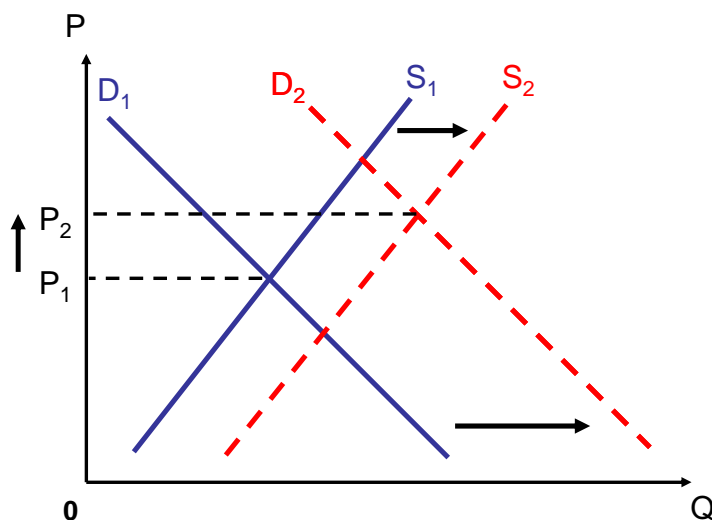
By inviting students to explore the *three contrasting cases* with the aid of three separate diagrams (see Figure 4), it was intended that the teacher would introduce simultaneous variation in the relative magnitude of an increase in both demand and supply to show that when the magnitude of the increase in demand is greater/smaller/equal to the magnitude of the increase in supply, then the price will increase/decrease/remains unchanged. In this way, it is hoped that students will be able to discern the critical aspect of the object of learning, which is the relative change of magnitude in demand and supply by experiencing the variation in this particular dimension.



Note: When the increase in demand (from D_1 to D_2) equals the increase in supply (from S_1 to S_2), the market price remains unchanged ($P_1 = P_2$).



Note: When the increase in demand (from D_1 to D_2) is smaller than the increase in supply (from S_1 to S_2), the market price falls (from P_1 to P_2).



Note: When the increase in demand (from D_1 to D_2) is greater than the increase in supply (from S_1 to S_2), the market price rises (from P_1 to P_2).

Figure 4 Three contrasting cases shown to students

3.3.2. Lesson plan for condition A_2

Instead of following condition A_1 in distributing a worksheet that aims to separate the effect of a change in demand or supply on price, to begin with the teacher would have a very short revision session to help students recap their previous knowledge about demand and supply analysis, that is, that market price is determined by the interaction between demand and supply.

Students would then be assigned to groups of four to discuss how the price of face masks changed over the four periods in accordance with the price trend that is shown in the chart given utilizing the provided news clippings, which would be embedded with a simultaneous change in demand and supply for each period. It should be noted that the news clippings would be the same as those used in the first part of the lesson in condition A_1 , in which the clippings that relate to the demand- and supply-side would be presented to the students separately. Afterwards, each group would be asked to present their discussion results and possibly any diagrams that they have drawn to the whole class and the teacher would give brief feedback on their presentation. After that, the teacher would account for the price changes in these various situations by employing the three separate diagrams (see Figure 4). In this way, the teacher would introduce simultaneous variation in the relative magnitude of increase in both demand and supply: that is, when the magnitude of increase in demand is greater/smaller/equal to the magnitude of increase in supply, then the price will increase/decrease/remains unchanged. The attention of students would be directed to the critical aspect of the object of learning, which is the relative change of magnitude in demand and supply.

3.3.3. Formal Teaching Part (B) - Common to both conditions A_1 and A_2

To enable students to develop a systematic method for handling similar problems, the teacher would start the *formal teaching* of the economic concept. With the use of the table (see Figure 5), the teacher would help students to consider the problem by separately decomposing the effects on price of changes in demand and supply first, and then consider the combined effects of the two forces to determine the overall effect of a simultaneous change in demand and supply on price.

Complete the following table.

	Effect on Price
Supply \uparrow	(Increase/Decrease)
Demand \uparrow	(Increase/Decrease)
Supply \uparrow + Demand \uparrow	a. Price \uparrow if _____ b. Price \downarrow if _____ c. Price remains unchanged if _____
Conclusion: If both the demand for and supply of a commodity increase, then the change in the price depends on the <u>relative magnitude</u> of the increase in supply and demand.	

Figure 5 A table used in the formal teaching phase of an economic concept

As has been described section (see pp. 7-8), the simultaneous increase in demand and supply can be decomposed into the following three steps. First, when only the demand increases, the price increases; second, when only the supply increases, the price decreases; and finally, when both the demand and supply increase at the same time, the effect on the price will therefore depend on the relative magnitude of the change in the supply and demand, because the effects of increases in demand and supply on price are opposite. By examining whether the increase in demand is greater than, equal to, or less than the increase in supply, students would be guided to develop a formal procedure for handling similar problems by considering systematically whether the increase in demand is greater than, equal to, or less than the increase in supply when predicting the direction of a change in price.

Furthermore, to help the students to conceptualize the notion of relative change in magnitude in a more effective manner, the teacher would put the three contrasting cases into one diagram and demonstrate the *simultaneous changes* in the relative magnitude of the changes in demand and supply, as shown in Figure 6. Students would be guided to pay attention to the possible differences between the magnitude of the shifts in the demand and supply curves and to find out that a change in price is a function of the changes in the relative magnitude of the changes in supply and demand by comparing the magnitudes of the shifts of demand and supply curves in the diagram to discern the critical aspect of the “relative magnitude of the changes in demand and supply” graphically.

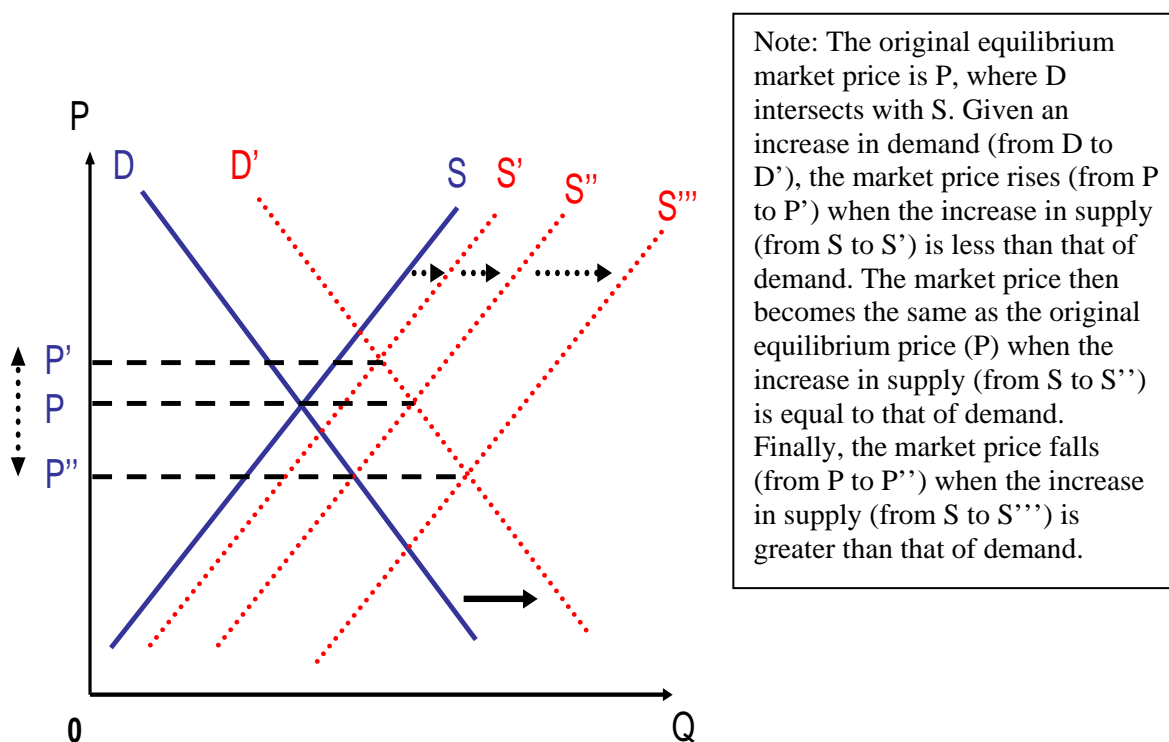
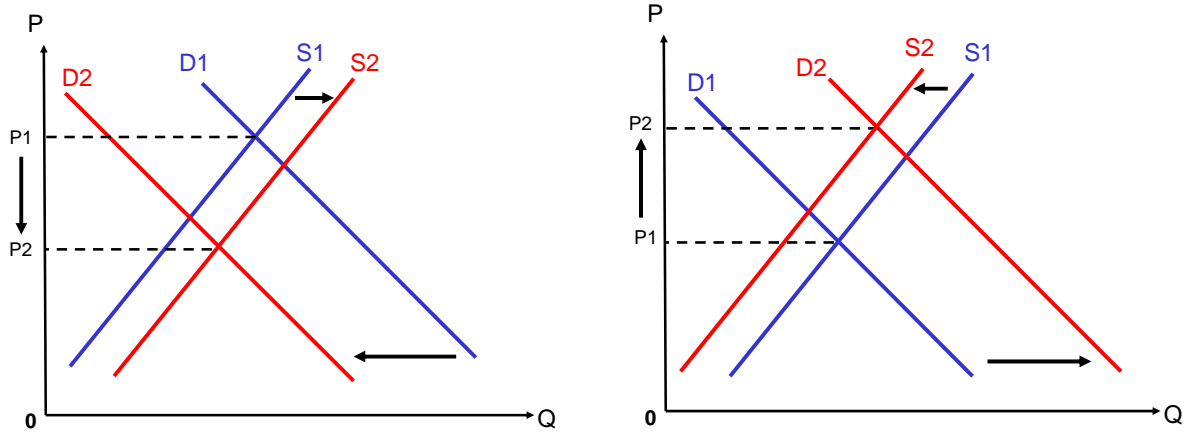


Figure 6 Simultaneous changes shown to students in the formal teaching phase

The teacher would then provide students with the reverse case (when both demand and supply decrease), and would follow the same strategy that was used in the case of a simultaneous increase in demand and supply to demonstrate the various contrasting cases. Furthermore, the teacher would introduce the cases when demand and supply change in opposite directions, that is, when demand increases and supply decreases or when demand decreases and supply increases, in which there is a definite answer as to the direction of the price change (as the changes of the two curves affect the price in the same direction). This serves as a good contrast to the previous cases, in which both demand and supply changed simultaneously in the same direction, which would draw the focal awareness of the students toward the importance of the critical feature of the relative magnitude of the changes in demand and supply when determining a price change. (see Figure 7)

When demand and supply change in the opposite direction:



When demand { decreases / increases } AND supply { increases / decreases } => price { increases/decreases / increases/decreases }

Complete the following table.

	Effect on Price
Supply ↑	(Increase/Decrease)
Demand ↓	(Increase/Decrease)
Supply ↑ + Demand ↓	(Increase/Decrease)
Supply ↓	(Increase/Decrease)
Demand ↑	(Increase/Decrease)
Supply ↓ + Demand ↑	(Increase/Decrease)

Conclusion: If demand and supply changes in the opposite direction, then the change in the price depends on the direction of the changes in the supply and the demand.

Figure 7 Table and figure shown to students illustrating cases when demand and supply change in opposite directions

To consolidate and ascertain the extent of learning, the students would be asked to solve two problems that would be based on the news extracts about the face mask market during the SARS outbreak. One problem would involve a situation in which the increase in demand for face masks is

less than the increase in supply, which would result in a drop in price, and in the other there would be an increase in the supply of face mask together with a decrease in demand, which would result in a fall in price.

To enable the students to apply the economic concepts that they have learnt to other contexts, two novel problems using other examples would be devised in which a simultaneous change in demand and supply would be embedded as follows.

“Due to advances in technology, the cost of producing VCD players has been reduced, but at the same time the use of DVD players has become more popular in Hong Kong. How would the price of VCD players be affected as a result of these changes? Explain the phenomenon with the aid of a supply-demand diagram.”

“In Hong Kong, the price of private housing units dropped after the financial crisis in 1997. To boost the property market, the government stopped the sale of land for residential use. However, property prices have continued to fall over the last few years. Can you explain this phenomenon with the aid of a supply-demand diagram?”

Finally, after checking the answers with the students, the teacher would conclude by restating the key points of the lessons and by drawing the attention of the students to the object of learning.

Above all, the critical difference between the two conditions was that during the first part of the lessons, teachers in condition A_2 would invite students to deal with some complex real-life scenarios without the teacher's help to tease out the critical aspects of the object of learning through the initial separation of the two, whereas the teacher in condition A_1 would introduce the sequential variation of the critical aspects and perform the separation task for the students. For the formal teaching part of the lessons, both conditions would be exposed to the same common lesson design and teaching materials.

3.4. Carrying out the lessons

The lesson plans serve to demonstrate the intended object of learning, but it is the enacted object of learning that affects student learning. Whether the intended object of learning was actually enacted in the classrooms hinged on a number of contingencies, such as immediate feedback from the students and the understanding of the lesson plan by the teachers. When it came to the actual classroom teaching, aside from the lesson plans, some of the teachers did less than was stated in the plan, whereas others expanded the original schedule of work. Consequently, it was not uncommon to identify a gap between the intended and enacted object of learning.

In accordance with our framework of variation, the lessons are described in terms of what was varied and what was kept invariant in the classroom teaching, and the different relevant dimensions form a space of variation or, to phrase it differently, a space of learning (see Marton, Tsui *et al.* 2004). As there was a difference between the classes within the same condition, intra-condition comparison was made of the enactment of the two lesson plans.

3.4.1. Condition A_1 and B - Teacher 1

Teacher 1 in Class A followed the lesson plan faithfully, and carried out every major step. The only observed discrepancy between the enacted and intended objects of learning was that when the teacher introduced the variation in the absolute magnitude of change in supply he used one more example of a vegetable, in addition to the face mask example stated in the lesson plan, to illustrate how a decrease in its supply after a typhoon would cause a rise in the price, as he realized that some of the students might not have grasped the relationship between a change in supply and its effects on price.

3.4.2. Condition A_1 and B - Teacher 2

Teacher 2 observed Teacher 1's lesson, and there was a discussion afterwards that resulted in some changes in the intended and enacted objects of learning. Nevertheless, the lesson that was conducted by Teacher 2 was very close to that conducted by Teacher 1, who had followed the lesson plan closely. There were only two major differences in the enacted object of learning between the two teachers.

Teacher 2 kept the context of the study invariant by using the same goods (face masks) throughout the lessons without adding any other examples to exemplify the concepts, whereas Teacher 1 had used the extra example of the vegetable to show how a decrease in supply would raise the price of a commodity.

The most important difference that was observed, however, was in how the simultaneous changes in the relative changes of magnitude in demand and supply were represented. After observing the lessons of Teacher 1, Teacher 2 decided to devise a computer program to demonstrate the dynamic changes in the relative magnitude of the changes in demand and supply. Instead of using the blackboard, the teacher used information technology in such a way that the simultaneous movements of the two curves were exhibited in a *dynamic* manner to show the relationship between the relative magnitude of the changes in demand and supply and price changes. The change in price was shown to be dependent on changes in the relative magnitude of the changes in supply and demand, as was shown by the continuous movements of the supply and demand curves (see Figure 8). This representation enabled the students to experience the simultaneous variation in both of the aspects more readily and directly.

3.4.3. Condition A_2 and B - Teacher 1

Teacher 1 carried out the lesson plan successfully without much deviation from the intended object of learning. However, because of the time constraints, only two groups were invited to present their findings to the class. On the whole, Teacher 1 performed more or less in the same way in the formal teaching part of the lessons as he did for condition A_1 , and also used the vegetable example to help students to grasp how a decrease in supply would cause an increase in price.

3.4.4. Condition A_2 and B - Teacher 2

The lesson that was conducted by Teacher 2 was very close to the lesson of Teacher 1, who had followed the lesson plan closely. There were only two major differences in the enacted object of learning between the two teachers.

First, Teacher 2 kept the context of the study invariant by using the same goods (face masks) throughout the lessons without adding any other examples to exemplify the concepts, whereas Teacher 1 had used the extra example of the vegetable to show how a decrease in supply would raise the price of a commodity.

Second, the teacher spent more time on the group discussion and presentation, in which 8 of the 11 groups presented their discussion results to the whole class. As a result, he had a slightly tight teaching schedule, and conducted the formal teaching part more swiftly compared to condition A_1 . He did not make use of information technology to illustrate the dynamic change in the relative changes of magnitude in demand and supply as he did in condition A_1 , but instead he simply used the blackboard to demonstrate this concept to the students.

Judging from the student presentations in these two classes, most of the groups were unable to discern the critical feature of the object of learning from the group discussion task, and a number of students focused on the demand aspect but missed the supply aspect. This may be due to the fact that students are generally inclined to put their focal awareness on the demand-side information but to overlook the supply-side information, as they have a rich experience of being consumers but not of being producers. Surprisingly, one group of students in the class that was taken by Teacher 2 attempted to separate out the critical features of the object of learning from the complicated real-life incidents by themselves, and succeeded in explaining the price changes with the use of a simultaneous change in demand and supply in a supply-demand diagram to some extent.

The following excerpts from the discussion of this group demonstrate how they tried to separate the irrelevant aspects from the critical features to come up with a similar pattern of variation and invariance to that in condition A₁. From the following dialogues, the students were found to have been able to discern the relationship between the increase in the demand for face masks, given a constant supply, and the increase in the price from the news clippings provided.

S1:	During the outbreak of SARS, people began to use face masks, so more people bought face masks. In other words, the whole demand . . . the whole demand curve . . . shifted to the right; that means the demand increased.
S3:	Well, that means because more and more people need to wear masks, but the suppliers . . .
S1:	Actually, the suppliers were setting the price according to . . . people were . . . how to say . . . they were more willing to buy the thing and they wanted more. More people were ready to pay that price.
S3:	It turned out that the demand went up.
S1:	Yes.
S3:	Then, what happened?
S1:	Well, as you can see from the incidents here, some people bought 3-4 face masks and some even bought 40-50 masks a day.
S3:	Yes, people rushed for face masks.
S1:	Then, when more and more came to buy masks, the shops began to find that their inventory was used up . . . But (the manufacturers) could not increase the production (of masks) greatly within such a short period to satisfy the great rise in demand. So the supply curve did not change as a result of the change in demand. Therefore, the price went up.

However, the students seemed unable to draw their focal attention toward the critical feature of the relative magnitude of the changes in demand and supply and their relationship with the change in price by themselves, as is shown by the following excerpts. Although the students were able to identify from the news clipping that both the demand for and supply of face masks increased during this period, it appeared that they did not try to compare the magnitude of the increase in both demand and supply *explicitly* and link it to the increase in price, as was shown in the price chart that was given them.

S1:	Yes, in period 3, here it says every citizen was required to wear a mask . . . In the past, people were afraid of getting SARS and quite a lot of people bought masks (but some might not have bought them at all). However, the government then advised everyone to wear a mask. Everybody needed to buy masks for themselves and their families . . . even though some of them might not have had the money to do so.
S3:	All the schools also needed to buy masks for their students. There was quite a lot of demand there.
S1:	That means the demand rose further.
S3:	Agreed.
S1:	But, here it seems to mention that the supply also increased. The supply should go up . . . It says that they imported 17 million masks into Hong Kong, and therefore the supply increased. More supply of masks indeed.
S2:	Yes, the supply curve shifted to the right.
S4:	. . .

3.5. Written post-test

The learning outcomes in the post-test in terms of the conceptions that were displayed by the students are reported on a group basis, and a comparison is made between the two conditions.

Table 3
Distribution of Conceptions in the Written Post-test

Conception	Condition A ₁ and B (77 students)		Condition A ₂ and B (74 students)	
	Occurrence	Percentage	Occurrence	Percentage
A	2	2.6%	3	4.1%
B	0	0.0%	0	0.0%
C	6	7.8%	17	23.0%
D	69	89.6%	54	73.0%

Chi-square = 7.233 (df = 2) (p = 0.027, i.e., p < 0.05)

As shown in Table 3, a significant difference was found in the post-test. Of the observed conceptions in condition A₁, 89.6% belonged to Conception D, that is, the object of learning that was agreed upon by the teachers. This was higher than the percentage for Conception D in condition A₂, which was 73.0%. The difference between these two groups in terms of student learning outcomes was found to be statistically significant ($X^2_2 = 7.233$, $p < 0.05$), and thus students in condition A₁ on the whole had a higher level of understanding of the economic phenomenon in terms of their capability to discern the critical aspects of the object of learning. They performed better than their counterparts in condition A₂ in the written post-test.

3.6. Written delayed-test

With regard to the written delayed test, the difference between the two conditions was still substantial, as shown in Table 4.

Table 4
Distribution of Conceptions in the Written Delayed-test

Conception	Condition A ₁ and B (77 students)		Condition A ₂ and B (74 students)	
	Occurrence	Percentage	Occurrence	Percentage
A	2	2.6%	3	4.1%
B	0	0.0%	0	0.0%
C	8	10.4%	25	33.8%
D	67	87.0%	54	62.2%

Chi-square = 12.806 (df = 2) (p = 0.002, i.e. p < 0.01)

Students in condition A₁ also outperformed their counterparts in condition A₂. As can be seen in Table 4, when the most complex conceptions that were manifested by the students are counted, a sizeable difference was found. The students in condition A₁ demonstrated Conception D more often (67 out of 77) than those in condition A₂ (54 out of 74). This difference between the two groups was found to be statistically significant ($X^2_2 = 12.806$, $p < 0.01$).

Above all, the results of this study show that students that belonged to condition A₁ demonstrated a better understanding of the topic after the lessons than their counterparts in condition A₂, in terms of their ways of experiencing the topic. In the written post-test, about 89.6% of the students who were taught using condition A₁ showed that they held Conception D, in which the relative magnitude of the changes in demand and supply are taken into account when looking at the price change. In condition A₂, 73.0% of the students reached this level of understanding, and similar results were obtained from

the delayed achievement test. Around 87.0% of the students in condition A₁ manifested Conception D, whereas only 62.2% of those in condition A₂ acquired this level of understanding.

3.7. Frequency distributions in the interviews

After each written test (pre-test, post-test, and delayed-test) ten students from each class, or 20 from both conditions, were selected for individual interviews. During the post-test interview, a new question was introduced to the students about a toy rocket that was popular during the 2004 Lunar New Year period, the price change of which was caused by simultaneous changes in both demand and supply (see p. 13). This part of the interview was thus *a transfer test*. Similarly, during the delayed-test interview, new questions (see p. 14) about current everyday issues that were related to the effect of simultaneous changes in supply and demand on prices were introduced as *a second test of transfer*.

The answers of the students to these questions can again be categorized using of the categories that were detailed earlier (see pp. 17-20). The following excerpt of the post-test interview with a student regarding the novel task demonstrates the desired way of understanding, that is, Conception D.

S:	Here it mentions that on January 10 the toy rocket was sold at \$20, but within the next few days the price had soared to a very high level. Well, it really rose a lot. I think this was related to fashion, as at that time people liked to play with this kind of thing. People . . . many kids saw others playing with this fancy thing, and also wanted to possess one. Well . . . you know, when you watched people playing with the item, it seemed to be very interesting, so they urged their parents to buy one for them. You know, the inventories of the sellers were usually quite limited, and it would take some time for them to replenish their inventories, maybe a few weeks. So I think the supply remained unchanged and the demand increased sharply over the period. So the price continued to rise.
I:	Good. But why did the price of the toy start to fall from here?
S:	Well, from January 27 onwards, I think the demand for the toy may not have increased so much, or in fact it may have dropped. The fashion was just about over. Maybe the sellers had put in extra orders earlier and the items had just arrived, so the supply increased, but the demand dropped or at least the increase in demand was not as much as the increase in supply, so the price began to fall.
I:	What about the price after the Lunar New Year?
S:	From here, you can see that the price returned to the original price around February, when the Lunar New Year holidays ended. It should be the case that both the demand and supply dropped to a level that was more or less the same as at the very beginning, so the price was about the same as the starting point.

Similarly, the following excerpt that was drawn from a student interview that was conducted after the delayed test shows how the student managed to apply what he had learnt to a novel problem in a new context and still displayed Conception D.

I:	Yesterday, as you may know, the government officially announced a ban on the importation of live chickens from mainland China with immediate effect because of the outbreak of bird flu in China. Only live chickens raised by local farms are allowed to be sold in the market. If you were interviewed by a TV reporter about your views on this policy and how it would affect the price of live chickens in the market, what would you say?
S:	Well, I think the supply of live chicken will drop a lot, for sure. This is because most of our live chicken imports come from mainland China. Generally speaking, the price of live chickens will rise because the supply of live chickens will drop, and at the same time the demand will remain more or less the same . . . Nevertheless, it also very much depends on the reactions of consumers in the market.

I:	What do you mean by “it depends on the reactions of consumers in the market”? Can you elaborate?
S:	The supply of live chickens will definitely drop, right? However, it is possible for the price of live chickens to fall if demand drops more than supply. For instance, if there is a rumor that it is unsafe to eat local live chickens because they might contain bird flu, then the demand for local live chickens will fall drastically and immediately. In that case, the extent to which the demand drops may be bigger than the extent to which supply drops, and the price of live chickens will then decrease.
I:	But, do you really believe that the price of live chickens in the market will fall?
S:	Well, to be quite honest with you, I don't think so. I believe that the price of live chickens will rise quite a bit because of this import ban. Firstly, the supply of live chicken will drop a lot. Secondly, I don't think there will be such a rumor that I just made up. Furthermore, as the Ching Ming Festival is approaching, and more people will buy live chickens to worship their ancestors; in other words, the demand for live chickens may actually increase. Well, given that the supply of live chickens will fall and at the same time the demand may increase or at least remain more or less unchanged, I predict that the market price of live chickens will increase, especially over the period of the Ching Ming Festival.

As can be seen in Table 5, the students who had participated in condition A₁ did better than students from condition A₂ and performed at the same level in the delayed transfer test as in the immediate transfer test, whereas the performance of the students from condition A₂ fell by 10%.

Table 5

Distribution of Conceptions in the Pre-test, Post-test, and Delayed-test Interviews

Categories	Condition A ₁ and B (Separation with Fusion – 20 students)			Condition A ₂ and B (Fusion – 20 students)		
	Pre-test	Post-test	Delay-test	Pre-test	Post-test	Delay-test
A	4/20 (20.0%)	3/20 (15.0%)	1/20 (5.0%)	4/20 (20.0%)	3/20 (15.0%)	3/20 (15.0%)
B	1/20 (5.0%)	0/20 (0.0%)	0/20 (0.0%)	0/20 (0.0%)	0/20 (0.0%)	0/20 (0.0%)
C	15/20 (75.0%)	4/20 (20.0%)	6/20 (30.0%)	15/20 (75.0%)	6/20 (30.0%)	8/20 (40.0%)
D	0/20 (0.0%)	13/20 (65.0%)	13/20 (65.0%)	1/20 (5.0%)	11/20 (55.0%)	9/20 (45.0%)

To find out the extent to which the students had developed a generalized understanding of the relationship between changes in price on the one hand and simultaneous changes in demand and supply on the other hand, we probed their meta-awareness of their own conceptions and the extent to which they were able to be *mindfully reflective* of the economic way of viewing the phenomenon. The students were invited to comment on their answers to the same set of questions that were asked on the three occasions. Sixty percent of the interviewed students from condition A₁ and forty percent from condition A₂ were able to make such a comparison, but the others could not.

Most of the students who belonged to the condition A₁ cohort expressed that they found their answers to the pre-test to be quite naïve and simple, to be largely based on their common sense, and to be focused very much on the nitty-gritty of the phenomenon. However, they perceived the answers that they provided in the post-test and delayed-test to be better, as they found the economic concepts

that they had learned useful in helping them to focus on some critical features of the phenomenon that afforded them a clearer understanding of the underlying factors. Through good abstraction of the complex economic reality, the economic analysis that they learned was regarded as being more succinct, which helped them to sieve out the irrelevant and less critical aspects of the economic phenomenon. They were aware of the new economic way of seeing that they had developed, which were considered to be more powerful in explaining and predicting human behavior. However, quite a number of those who could display Conception D thereafter but could not tell the difference among their three differing answers held the opposite view that the economic concepts that they had learnt did not offer them much when compared with their own common sense. Comparing the answers that they provided in the post-test and the delayed test, they thought that their pre-test answers as correct as the answers that they gave using the economic concepts. They did not see any substantial difference between their answers, and seemed not to have developed the reflective awareness of the economic way of seeing the problem.

On the whole, the students from condition A_1 did better than the students from condition A_2 , which indicates that having the teacher arrange the necessary conditions of learning was an advantage. The most obvious explanation for this is that *most of* the students in condition A_2 seem to have failed to discern the critical features of the face mask problem by themselves during the group discussion part of the lessons. As we mentioned earlier, one group of four students that participated in condition A_2 managed to partially discern the critical features by alternatively letting them vary and keeping them invariant, and did by itself what the teacher did for the students in the other condition. In Table 6 we can see the categories in which the answers of the students in this group to the three written questions were placed. We can glean two things from this table. First, one of the students had a full understanding of the problem before the lesson, and second, the participants in this group did not perform better in the post-test or the transfer test than other students in the same condition, and performed even worse than the students in the other condition.

Table 6
Distribution of Conceptions among Students in Particular Groups

Students (in this group)*	Pre-test	Post-test	Delayed test
S1	Conception D	Conception D	Conception D
S2	Conception C	Conception D	Conception C
S3	Conception C	Conception D	Conception D
S4	Conception A	Conception C	Conception A

*No students in this group were randomly chosen for interviews.

4. Discussion

Schwartz and Martin (2004) compared the effects of taking part in an innovative learning condition using contrasting cases of a given topic and subsequently being exposed to formal teaching on the same topic on the one hand, with being exposed to formal teaching on a topic followed by formal teaching of a different kind on the same topic on the other hand. They found that the first combination was more powerful than the second from the point of view of learning. In our study, the students dealt with contrasting cases (comparing different points on the time-price graph can reasonably be viewed as dealing with contrasting cases) in both conditions. In one of the conditions (condition A_1) the teacher let one feature vary at a time while the other was invariant, and then switched the two and subsequently let both aspects vary at the same time. Afterwards, the students were taught how to handle this kind of problem formally. In the other condition (condition A_2), the students dealt with the same problem as the students in condition A_1 , but in this case both of the critical features were varied at the same time. We can say that condition A_2 corresponds to the condition of contrastive cases in the study of Schwartz and Martin. If the experimenters in that study

had invited the students to compare distributions that differed in central tendency but not in variability, followed by a comparison of distributions that differed in variability but not in central tendency to allow the students to subsequently compare distributions that differed in both respects, then they would have created a condition that corresponds to our condition A₁. We expect that such a condition would have yielded an even better outcome than their innovative/contrasting cases condition.

Rather than employing the “mixed transfer design” of Schwartz and Martin (see Figure 3), we used a “double transfer design” (see Figure 2), and thus we cannot separate “the preparation for future learning” effects of conditions A₁ and A₂ from the direct learning effects. We can, however, compare the differences in achievement between the students who participated in condition A₁ and B and the students who participated in condition A₂ and B with the corresponding differences in the study of Schwartz and Martin.

Although one of the conditions in our study left more to the students to do, in that they had to create the necessary conditions to discern the critical aspects themselves, none of the effects of the more active engagement of learners that were reported by Schwartz and Martin (and in other studies that were carried out by the Bransford and Schwartz group) showed up. Condition A₁ and B together had a better short-term, long-term, and transfer effect than condition A₂, which can be seen as the more “innovative” of the two conditions, and B together. Students who participated in condition A₁ and B also showed a more generalized understanding of the object of learning and a higher level of conceptions than the students who participated in condition A₂ and B. We believe that the reason for this is that although the learner’s active involvement in making the discernment is absolutely critical, the arrangement of the necessary conditions for such discernment to take place is something that can be done either by the learners themselves or by the teacher. That the conditions are brought about is much more important than who brings them about.

The research of the Bransford and Schwartz group shows very convincingly that getting the students to deal with cases, and especially contrasting cases, followed by explicit instructions results in better learning than explicit instructions followed by explicit instructions, because learners must be able to discern the critical features of the object of learning and must undertake this discernment themselves. You cannot simply tell students what the critical features (the dimensions of variation) are: this can only be done if students are dealing with cases, or wholes, the critical aspects of which are easy for the students to discern. Students can only discern the critical features if they experience variation in one aspect at a time, while variation in all other aspects is prevented. By establishing the necessary pattern of variation and invariance, the teacher can contribute to making learning happen, and this is exactly how the paradox of pedagogy can be solved. Learners must learn for themselves, but there are necessary conditions for learning to occur, and it is exactly these conditions that the teacher should be responsible for bringing into being.

The most important implication of this study is that we should perhaps make finer distinctions when we discuss the relative contribution to learning in schools that is made by teachers and by learners themselves. The question is not so much that of who should be active and who should be passive, but rather of what teachers should do (create the necessary conditions for learning) and what learners should do (make use of the necessary conditions for learning).

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