Chapter 4
Towards a Pedagogical Theory of Learning

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This chapter describes the early stages of developing a theory of learning, which offers an alternative perspective to those currently underpinning teaching and learning. It is not specific to higher education; indeed, it has been developed mainly from work at school level. However, the ideas are sufficiently general to apply to teaching and learning at university level, and there are already some examples of research in universities based on the theory. As it is still being developed, the status of 'theory' has yet to be attained: what is offered is better thought of as a 'framework,' a way of thinking about learning within educational contexts. Its importance lies in directing the teacher's attention to the specific *object of learning* —the actual content of what the student is expected to learn. The theory also suggests in general terms what is needed to make learning possible, and so is a pedagogical theory which has generally been referred to as *variation theory*, for reasons which will become clear.

The Importance of Variation in the Object of Learning

The work had its roots in the phenomenographic research which described the different ways in which students see and make sense of important concepts, principles or phenomena met in their studying (Marton and Booth 1997). Typically, these investigations identified five or more distinct conceptions existing among the groups of students interviewed. However, at that stage, the research was essentially

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descriptive and did not provide direct help for teachers about the implications of these importantly different conceptions for teaching. The new theory helps to explain how we learn to make sense of the world around us in terms of different phenomena, aspects and categories. It describes how we learn to see the world in different ways and is complementary to both phenomenography and other theories of learning. Above all, it involves teachers in thinking critically about how they present topics and what they have to do to ensure that learning is made easier for the students.

One of the problems with traditional ways of thinking about learning is that human memory has been viewed in too mechanistic a way, imagined as various 'boxes' which can be accessed as required to transfer previously coded material from long-term memory into working memory. Our approach is to think in terms of *awareness*, and to recognize that our perception of past events, and hence our memories, are continuously being modified, by reflecting on those events in the light of new experiences. Therefore, our theory begins by exploring the nature of the awareness involved in coming to see a phenomenon or topic in an importantly new way, and leads to questions about what we need to do in order to learn how to handle new situations in more powerful ways. If we are able to handle a situation in a more powerful way, we must first *see* it in a powerful way, that is discern its critical features and then take those aspects into account by integrating them together into our thinking simultaneously, thus seeing them holistically. In addition, to discern those critical features, we must have experienced a certain pattern of variation and invariance in the object of learning. A medical student, for example, has to listen to the hearts of many different patients before any sense can be made of the differences heard, while to say anything interesting about the taste of a certain wine, we must first have tasted many different wines.

The practical meaning of the theory changes with the specific object of learning. The most fundamental thing about learning is that we learn different things. A pedagogical theory, which is to be practically efficient, must be sensitive to *what* is learned and this is exactly what variation theory provides. It focuses on the significance of experiencing the *variations* in an object of learning without which understanding is logically impossible. To learn about the meaning of democracy, for instance, students have to experience a certain pattern of variation and invariance. They must familiarize themselves with forms of government other than democracy and also with different forms of democracy. To develop empathy, though, a quite different pattern of variation and invariance is necessary. They must have tried to see the same thing from different perspectives and different things from the same perspective, while to understand the idea of the mathematical proof they must have seen two different proofs, at the very least. The aim of our theory is to make theoretical tools available for analyzing the extent to which the necessary conditions for achieving specific aims for learning are present in certain situations. Then, these tools can also be used to create necessary conditions to achieve those aims.

Discussions on learning and teaching in educational institutions are often about what general conditions are favorable, or not, for learning, but variation theory is

different. When questions are raised about why students succeed or not, it is—as a rule—assumed that it is possible, in principle, for all students to learn what is being taught. However, this rarely happens in practice. Nobody can learn to solve new problems if they have never encountered any problem for themselves, without a teacher being there to explain how it is supposed to be solved. Nor can anybody adjust their way of expressing themselves in written language to different situations if they have previously written for only one situation. If the teacher gives a proof of the Pythagoras theorem on the board, and does only that, the students will find it impossible to understand the meaning of 'to prove a mathematical proposition,' as then the *idea* of a mathematical proof cannot be distinguished from a single proof for a specific proposition. At least two proofs are needed to do that, and at least two different proofs are required if the same proposition is to evoke the idea that there might be different proofs for the same proposition.

Learning and Discernment

Learning to discern the critical features of concepts, of problems or situations, is a crucial form of learning in higher education. In addition, it is an ability many students find it difficult to acquire within academic disciplines. Learning to discern, distinguish, make new distinctions, in a metaphorical sense, amounts to learning to 'see,' and more importantly, to see in a different and more revealing way. Our capacity to discern and focus on different aspects of an idea or topic is quite limited. We discern and focus on only a few aspects at the same time, and people differ in the aspects they see as salient. A way of seeing can be defined in terms of the aspects which are discerned and focused on simultaneously, and so people may share the same perception, or may have quite different ones.

Variation theory is concerned with learning to see something in a new way, but there are, of course, other important forms of learning. We not only need to learn to tell colors apart, but we must also be able to name them in a consistent way. We not only need to understand the idea of democracy, but we also have to remember what specific forms exist in different countries. Understanding the idea of mathematical proof is not sufficient as we also have to be able to spell 'Pythagoras.' Education involves learning facts and details, but here we are concerned only with the type of learning that involves changing our way of seeing important aspects of the world around us.

Variation and Simultaneity

To be able to discern differences, we must first experience variation. However, that variation must also be experienced in ways which enable us to compare the instances alongside each other, in other words, simultaneously. To experience green

as distinct from red, both colors must be present, together, in our awareness. If we were to focus on them one at a time, without being aware of, or remembering, the other, we could never experience any difference, any variation. If a woman seems tall to us, she does so against the background of all other women whom we have met before and who, so to speak, co-exist with her in our awareness. This kind of simultaneity in experience, a kind of simultaneity over time, is also needed if we are to experience a melody. The different tunes must co-exist in our awareness, otherwise we would hear each tune by itself and not any distinguishable melody.

However, there is another kind of simultaneity which is necessary for seeing something in a certain way. As there are generally several characteristic features that we must discern and focus on in order to see something in a certain way, *simultaneity* is necessary in the experience of those different aspects at the very same point in time, that is not *over* time but *in* time. If two people look at the same thing and discern the same critical features, but one of them is focusing on all these features simultaneously, while the other does so one at a time, the two people see the same thing in two very different ways.

The Object of Learning and the Space of Learning

Learning is always the learning of something. This something, as we have seen, is the *object of learning*. This is often seen simply in terms of content: equations of the second degree, photosynthesis, forms of government, the most frequent religions and so on. These certainly can be objects of learning, but we need to draw attention to different senses in which an object of learning can exist in classroom contexts.

The content of learning can be seen as the *direct object of learning*, but often the teacher expects the student to learn how to use that object or work with it in some way. If the students' attention is to be focused on what they are expected to learn, the teacher has also to be concerned with the capability that the students are meant to develop. What are they expected to be able to do with the direct object? The nature of the intended capability is the *indirect object of learning*. The object of learning as a whole thus comprises the indirect and the direct object—the *how* and the *what* of learning, as described in phenomenography (Marton and Booth 1997). The object of learning brings together capabilities and content, for example, '*to be able to solve* equations of the second degree,' '*to understand* photosynthesis,' '*to be able to see* similarities and differences between different forms of governments,' '*to be able to see* different religions *in terms of* what unites them and what sets them apart.' The capabilities, 'to be able to solve …,' 'to understand …,' 'to be able to see … in terms of…,' are the indirect objects.

At this stage, what we have is an object of learning seen from the teacher's perspective—the *intended object of learning*. However, the intended learning objective has to be realized in practice. The object of learning is not only about what *should* be learned but also what *can* be learned in the situation as it exists in the classroom. Although there is great emphasis these days on formulating precise

learning objectives or 'intended learning outcomes,' it is not the objectives, as words, that affect the students; it is how the object of learning is presented and brought to life within a lecture, tutorial or other teaching-learning activities—what the students encounter is what makes it *possible* for them to learn. We call this the *enacted object of learning*, which is constituted by the teacher and students together, within a teaching-learning event. The actions of the teacher and the students together create a 'space' within which learning can take place, as described more fully in *Classroom Discourse and the Space of Learning* (Marton and Tsui 2004).

In order to find effective ways of arranging for learning, researchers first need to address *what* it is that should be learned in each case, and find the different conditions that are conducive to different kinds of learning. It is only when we have a fair understanding of what learners are expected to learn, what they actually learn in those situations and *why* they learn something in one situation but not in another that pedagogy becomes a reasonably rational set of human activities. In other words, we need to become more analytical and systematic in ensuring that we are setting up situations in which it *really* is possible for students to learn. And for this, it is important that the enacted object of learning can be described in terms of a theory. And that such a theory should make clear for the students what is worth noticing and what is not.

The enacted object of learning should thus indicate what aspects of the object of learning are possible to learn under given conditions. Therefore, following our previous argument, for every object of learning it must be possible to identify a certain pattern of variation and invariance that the learners must experience in order to learn effectively. This does not imply that this is the *only* necessary condition, as there is a mutual responsibility in teaching and learning between the teacher and the students. It is also necessary that the students actively focus their attention on the object of learning. These two conditions are not independent of each other: students are able to focus their attention better on the object of learning if the conditions provided make it possible for them to make sense of it, to 'appropriate' it. However, here we are concentrating on just the pattern of variation which is a necessary, but not sufficient, condition for learning to happen.

The enacted object of learning has been described, so far, from the point of the view of an outside observer who is looking at the scenario from a theoretical perspective. However, we must also ask what the object of learning is like from the point of view of the students, in other words the *lived object of learning*. If we are to discover how certain ways of seeing develop, we must consider what aspects of the object of learning the students discern and focus on simultaneously. In other words, it is a description of how the researcher aided by these theoretical tools perceives the students' ways of experiencing the object of learning (i.e. what aspects they discern and focus on simultaneously).

As we have seen, learners can discern a certain aspect of the object of learning if they experience variation in a dimension of that aspect. When students discern and focus on those critical aspects of the object of learning, which are possible to recognize in a particular situation, their lived object of learning becomes equivalent to the enacted object of learning. Such an identity is far from always the case,

however, as students do not always make use of all the possibilities that the situation affords.

We have now pointed to three different forms of the object of learning and their equivalents:

intended object – learning objective;

enacted object – the space of learning;

lived object – outcome of learning.

Of course, we might try to do without the term 'the object of learning,' but we want to emphasize that we have to deal with three distinct forms of this same thing. But what is this 'same thing'? The object of learning comprises all the possible dimensions that in principle could be discerned, but, as we can never specify all the different ways in which something can be seen, 'the object of learning' remains a theoretical concept of which the different forms are just parts.

What Is Critical for Students' Learning?

Pedagogical discussions are often about how learning is organized. What is the best way of going about lectures, group work, individual studies and so on? How good is project work, problem-based learning? By now it should be obvious that, first, a certain way of organizing learning cannot be the best for all forms of learning, that is the best regardless of the purpose. Secondly, it should be obvious that it is important *how* the content is taught. In problem-based learning, even with the same learning objectives, the quality of the problems and thereby the student's learning, may vary a great deal. That is true also of other forms of teaching, such as the lecture, where the same content may be dealt with in entirely different ways, with consequent differences in the students' learning.

We have carried out a large number of studies in Hong Kong schools since 1998 (Chik and Lo 2004; Marton and Tsui 2004). In all of these, we have studied how the same object of learning is handled in different classrooms (two or more) and in most cases we have also investigated the learning results and made comparisons between classes, trying to understand the differences found. In every study, we managed to establish a close relationship between how the object of learning was handled and what the students learned from the lessons, that is between the enacted and the lived objects of learning. In some classes, the lessons proved to have a higher 'learning value' for a certain object of learning than in others, as the students could appropriate the object of learning much better. When we compared lessons with the same intended object of learning but which differed in terms of learning value, we found that the variation in results is a function of the *variation provided* in the pedagogical dimension of the content or subject. We can never say that a lesson is better than another lesson in any absolute sense, but we can say that one is a better resource for a specific learning aim than the other.

Although most of the work using variation theory has been carried out in schools, we can give two illustrations of studies in higher education which have

made use of at least some of the evolving principles. The first comes from research into medical education, while the second is drawn from a doctoral thesis that looked at differences among university teachers of accounting.

Medical Education

This study was not based on the variation theory itself, but the method used involved comparing and contrastingcritical features of an object of learning. Hatala et al. (2003) compared two conditions for learning interpretation skills for ECGs. Following a sequential presentation of three typical ECG diagnoses (myocardial infarction, ventricular hypertrophy and bundle branch blocks), illustrated by two examples each, two groups of students engaged in the practice of those diagnoses under two different conditions. One of these was called 'non-contrastive': the students had to examine 4 new cases exemplifying each diagnosis, for one diagnostic category at a time (12 cases all together). In the other condition, called 'contrastive,' the same 12 cases were mixed and the students were encouraged to compare them. In the non-contrastive condition, the students were primarily focusing on what was common for each diagnostic category, while in the contrastive condition the students focus was necessarily on how the diagnostic categories differed. When using six novel cases to be diagnosed as a test, students from the contrastive group clearly outperformed those from the non-contrastive group.

[In the contrastive practice], students were encouraged to compare and contrast the difference in the features between the competing diagnoses … [and this proved relatively] more effective in helping students notice the types of features that discriminate between competing diagnostic alternatives … The contrastive approach should be applicable to other perceptual and/or diagnostic domains where noticing features is an important component of the task, and the list of competing alternatives for a given diagnosis is limited (Hatala et al. 2003, pp. 23–24).

Accountancy Education

In this second example, it is possible to interpret the study more directly in the light of variation theory. The focus was on how differences in the ways in which the topic was treated affected what students came to understand about the topic. Rovio-Johansson (1999) followed three lecturers teaching accounting at university level, video-recording three parallel 2-h lectures for each one of the three different topics. After each lecture, she interviewed five students about the topic dealt with. From analyses of the data, she could detect a pattern running through the three teachers' ways of teaching. As Bowden and Marton (1998) explained in commenting on an earlier phase of the study, one of the lecturers addressed the topics at a concrete, technical level, aiming at the development of the students' capability to

solve certain types of problem, defined in advance. The second tried, throughout the lecture, to situate each topic within a theoretical framework, aiming at a deep understanding of the concepts and principles used, while the third lecturer moved between general formulations and specific instances of the same problems, aiming at developing students' capabilities for making and grounding rational economic decisions.

These differences can be illustrated in relation to the first topic investigated—the limiting factor in production. This refers to the factor in the production process, which limits the total capacity (given that there are relatively greater resources available as far as the other factors are concerned). The three teachers planned the lecture together. After an introduction, a problem was presented and worked through by the teachers. Discussion, mainly carried through by the teacher, followed and the lecture was concluded. In the problem, the limiting factor, which in this case was the machine hours available, was identified. Then, a decision had to be made about how to decrease the demands on machine hours by buying something ready-made instead of producing it 'in-house.' The choice had to be based on optimal contribution to profit.

There were clear-cut differences found among the three teachers, even though the content of the lecture was well defined, and the staff had planned it together and worked through the very same problem. Furthermore, the content of the lecture could be considered fairly elementary and straightforward. Still, the differences were striking. The first teacher talked about the problem, while going through the solution on the board, concentrating on the problem in isolation. The teacher moved between the actual production process referred to in the problem and the method for dealing with the problem. The focus was thus on the problem-solving process, rather than on a specific solution within a defined context.

The second teacher opened up several dimensions of variation in the introduction and talked about different cost concepts, not only the ones immediately relevant to the actual problem, and about different ways of deciding what costs to allocate to different component parts in the production process. This teacher also pointed out the relativity of the system of accounting itself, explaining that different systems will give you different kinds of information, and therefore 'opening up' a dimension of a variation corresponding to how the system for calculating the outcome was set up, by showing that it could be done in different ways.

The third teacher gave a variety of different examples from several companies (this is certainly a dimension of variation) and opened up a dimension of variation corresponding to the way in which costs are determined. Like the second teacher, he also went through the different cost concepts and not only those which applied to costing in the actual case. Furthermore, he made the point that there are other ways for setting prices in addition to calculus, and that finding the appropriate way may vary from case to case.

Therefore, there were differences in what was taken for granted and what was opened up as a dimension of variation. These differences were reflected in the interviews with the students. While four out of the five students who had listened to the first teacher focused on the specific example given, when discussing the limiting

factor, they all talked about 'machine hours.' In contrast, the students who had listened to the other two teachers dealt with the question in more general terms. Also, there were distinct differences in how the students went about solving the problem about the limiting factor during the interview. Although, to solve the problem, it was essential to discern the effect of the limiting factor on the relationship between profitability and profit, students who had been listening to different lecturers approached the problem differently. Students of the first teacher saw the problem from a point of view of the effect of the limiting factor on the relationship between the process of production and the contribution to profit; students of the second teacher concentrated on the effect of the limiting factor on the relationship between costs or expenses (such as variable and incremental expenses) and on contribution to profit, while students of the third teacher were more concerned about the effect of the limiting factor on the relationship between costs and pricing and on contribution to profit (Rovio-Johansson 1999).

From this example, we can argue that it is not so much how the *teaching* is organized (in lectures, project work, problem-based learning, etc.), but how the *content* is organized that is of decisive importance for the students' learning. The point is not, however, that a particular form of organization (pattern of variation and invariance) is better than another in general, nor that more variation is better than less variation. The point is that *what varies, and what is invariant*, are the most important aspects of how the content is organized; and how the content is organized decides on what conditions learning might or might not take place (For a detailed treatment of the actual theory of learning, see Bowden and Marton 1998; Marton and Tsui 2004).

Differences Between Conditions and Between Individuals

In the detailed studies in school classrooms in which we had deliberately set up conditions to test variation theory, not all students in the experimental groups managed to learn effectively, while some students in the comparison groups, in which, according to variation theory, it ought to have been impossible to learn, still managed to learn. This is hardly surprising, of course, but it does seem problematic for the theory. And yet, we must remember that the expression 'impossible to learn' is used in the sense of 'impossible to discern,' and 'impossible to discern' means 'impossible to discern from what the learner could experience and discern *in that particular situation*.' Still, it is of course, entirely possible that some students have already been able to discern a certain aspect which is invariant in the specific situation. For example, someone who has seen different colors before would, of course, notice that everything has the same green color in a room without any contrasts at all. The contrast resides in previous experiences which are present in awareness together with all the green here and now.

It is also possible that a learner can discern something which has never been discerned before and which is not possible to discern in the actual situation. Take, for instance, the object of learning 'to understand the idea of mathematical proof,'

at its most basic level. Obviously, it takes two instances at least to separate the idea of mathematical proof from the specific proof that the student has happened to encounter. Imagine, for instance, a lecture in which only one proof is presented and thus the separation of the idea of proof from the actual proof is not made possible. However, think of a student who has seen only one mathematical proof before and thus never been aware of the idea of mathematical proof. Now if that student encounters another example and if, at the same time, is aware of the proof seen before, all of a sudden it becomes possible to separate the proof from the idea of the proof. This oversimplified example points to an interesting principle, namely the complementarity between the variation experienced by the students previously and the variation they can experience in a certain situation. If, after a lecture, a student can discern a certain critical aspect of the object of learning, that could be because it had been done before, because it had been learned during the lecture or because a combination of experiences before and during the lecture had created the necessary conditions.

Making Learning Possible

If we can tell whether or not learning is possible under certain given conditions, then we should also be able to create the conditions that make learning of a certain kind possible. Doing so also implies putting the theory to the test. Some such attempts have been made and with remarkable results. These studies (Holmqvist et al. 2005; Lo et al. 2005; Marton and Pang 2006) show, first, that when the learners have the opportunity to experience the pattern of variation necessary for learning something, they are successful to a much greater extent than when the necessary pattern of variation has not been provided. This may sound tautological, but it did show, first, that there is a certain necessary pattern of variation for every object of learning to which students are introduced, and secondly, that an appropriate pattern of variation has been found in each particular case.

   The theory should be useful in all situations where the learning objective is of the kind we are discussing here. However, the problem is that the implications of the theory vary with the object of learning. Its meaning has to be interpreted for every particular case and for every specific object of learning. And the only way of doing so is by ensuring that the teachers themselves are engaged in the work of finding the necessary patterns of variation for the different objects of learning.

   An approach similar to this can be seen in the Japanese 'lesson study' which Stiegler and Hiebert (1999) drew to international attention when they suggested it as a possible explanation for the uniquely high achievements of Japanese students in mathematics and science. 'Lesson study' is a traditional form of in-service training of teachers in Japan. A group of teachers, who teach the same subject and who work together, choose a specific object of learning (learning target) and try to find the best way to help the students to appropriate it. They design a lesson or a series of lessons for this purpose and produce collaborative lesson plans. A member

of the group then carries out the lesson in his/her own class, while the others observe the lesson, analyze and discuss what has happened, before developing a new design and lesson plan, which another member of the group carries out, again observed by the others. After yet another analysis and discussion, they document their experiences in such a way that other teachers can profit from them. Even if 'experts' from the outside have been invited to join the group, the work with lesson study is rooted in teachers' own experiences, rather than in any theory. In addition, as a rule, there is no external systematic evaluation.

The idea of 'design experiments,' introduced by Collins (1992), and Brown (1992), was based on the premise that you cannot use scientific experiments (varying one factor at the time, while keeping the other constant) to test conjectures about teaching, as factors in teaching cannot be disaggregated. There is a whole set of interacting factors within the design. We have then to look for the effects of such a design, through comparisons with other designs and through the accumulation of experience through a systematic series of adjustments to the teaching. A design experiment is theory—based and aimed at testing theoretical conjectures about the complex situations of pedagogical reality.

By combining the ideas of lesson study and design experiment, we have found a new way of developing pedagogical insights, namely *learning study* (Lo et al. 2005). It is carried out by a group of teachers, preferably together with a researcher, with the aim of achieving a certain pedagogical goal or object of learning. The group tries to find a powerful way to achieve this aim through several cycles of improvement along the lines of the lesson study model but, in this case, the work is based on a specific theory. Moreover, the lesson is preceded by a test of what the students already know, followed by a test of what they have actually learned. All this is like a design experiment approach, except that here the teachers 'own' the study themselves; they choose the object of learning and the way to handle it, but are guided by the theory and supported by a researcher.

The different lessons are, ofcourse, carried out in different ways. This variation in the enacted object of learning can then be related to the lived object of learning, that is to the students' results. In the end, a document is produced, which is useful both for teachers' practice and for continued research. Every study is a way of trying out the conjectures that originate from the theory on which the experiment was based.

'Learning study' is advantageous for all three groups involved: students achieve a better grasp of the object of learning, teachers understand how an object of learning can be handled and researchers find out how the theory works in concrete instances. Learning study is not defined in terms of a certain object of learning or a certain theory, but presumes *some* object and *some* theory. The advantage of the theory of variation is that it changes with the object of learning and if it can be formulated in a sufficiently clear and comprehensive way, it constitutes a powerful resource for the teachers (and for the researchers too) in handling the many varying objects of learning.

No research findings about learning study are yet available for higher education, but the idea of lesson study is currently being used as the main vehicle for the

improvement of the quality of learning and teaching at the University of Wisconsin (see http://www.uwlax.edu/sotl/lsp). There are, nevertheless, good reasons why lesson study—or even better, learning study—in higher education could have a marked impact on student learning. If the way in which the content is dealt with is the single most important factor that constrains the effectiveness of learning, then alerting university teachers to the idea of 'different ways of dealing with the content' must be beneficial. In addition, to recognize the importance of that idea they must be able to see the effects of variation in ways of dealing with the same content. When university teachers start looking at their colleagues' ways of dealing with the same content that they themselves have taught, and when ways of dealing with content become a topic of conversation for them, then an important step towards the improvement of university teaching and learning will have been taken Lesson studies and learning studies are just two of the ways of making this happen.

The Variation Theory of Learning

As stated at the beginning of this chapter, variation theory aims at making theoretical tools available for the teachers themselves. The theory is not seen so much as a set of eternally true statements about reality, but as an instrument for handling that reality for specific purposes and in more powerful ways than it can be done without using these tools, other things being equal. The aim is to make a form of learning possible, learning, which means that new and more powerful ways of seeing certain phenomena, or certain classes of situations, are developed. This form of learning is considered fundamental to how the meaning of different things develops and changes in people. However, are our examples actually about this form of learning?

To see something in a certain way depends on discerning certain critical features and bringing them together in awareness simultaneously. That awareness is not of the totality of the world we experience, but what is necessary and critical for our specific purposes in relation to an object of learning. It is the discernment of critical features which distinguishes one way of seeing something from another and—as a rule—provides a more powerful way of seeing the same thing. Unlike phenomenology, the theory neither aims at capturing the experienced world in all its richness nor seeks to describe the structure and workings of the human intellect, as cognitive psychology does. The theory is driven by an interest in pedagogical knowledge, the question of why someone learns what someone else fails to learn. The reasons can lie, in part, in genetic predispositions, prior knowledge, motives and so on, but variation theory describes the conditions which are needed for appropriating specific objects of learning. We do not want to argue that these conditions are the most important factor, but we do say that they are necessary and that to create them is, has been, and is going to be, central for teachers, whether in schools or higher education (cf. Carlgren and Marton 2000).

Hence, in the end, variation theory is about differences in capabilities between, and within, human beings. And we argue that the differences in capabilities have to

do with people's opportunities for discerning aspects of the world around them through experiencing variation, that is differences in these aspects. This is what Pang (2002) calls the 'two faces of variation.' He alludes to the fact that what we call the theory of variation describes how people experience variation in different aspects of the world around them and therefore experience that world in different ways. And it has sprung from the research program of phenomenography, which also describes variation (i.e., differences) in people's ways of seeing and experiencing their world. The strictly descriptive research approach of phenomenography is thus being transformed into a theory, which explains the earlier descriptive results. This means, hopefully, that we have taken some steps towards the development of a *pedagogical* theory of learning, which should be valuable to both teachers and researchers, and which can be used to encourage collaboration between teaching colleagues in exploring the critical features of important concepts, and the variations in those features that need to be made explicit for students if the quality of their learning is to be improved.

Summary

- If we are able to handle a situation in a more powerful way, we must first see it in a powerful way, that is discern its critical features and then focus on them simultaneously. To do it, we must have experienced a certain pattern of variation and invariance in the object of learning. To learn about the meaning of democracy, for instance, students have to familiarize themselves with forms of government other than democracy and also with different forms of democracy.
- The object of learning has three forms: the intended object of learning, the enacted object of learning, and the lived object of learning. These correspond to the learning objective, the space of learning, and the outcome of learning, respectively. At the same time, the object of learning comprises the indirect and the direct object—the how and the what of learning. For example, 'to understand photosynthesis,' 'photosynthesis' is the direct object, while 'to understand …' is the indirect object. Thus the concept of the object of learning brings together content (what) and capabilities (how).
- The variation theory is the theory of variation and invariance in the object of learning. What variation and invariance students experience is the most important aspect of how the content is organized, and thus it is a necessary condition of learning. However, instructors cannot control all the variations students experience. They are dependent on the complementarity between the variations experienced by students before and during the class.
- We have created the method of learning study by combining the ideas of Japanese lesson study and design experiment. We are now on the way of developing the variation theory as a pedagogical theory of learning by cumulating the findings from diverse learning studies.

Appendix: Reinterpreting Approaches to Learning

The main focus of this chapter has been steps towards a pedagogical theory of learning primarily from the perspective of teaching. But this research builds on earlier studies of qualitative differences in learning at university level. In this appendix an attempt will be made to briefly illustrate that the variation framework outlined so far is also applicable to such differences (cf. also Marton 2015).

Deep and Varied Approach to Learning

Marton and Säljö (1976) made a distinction between two ways of going about learning, the deep approach and the surface approach. The former refers to the learner focusing on the text being read ("the sign"), the latter refers to the learner focusing on the meaning of the text ("the signified"). The distinction was based on the learners' own accounts of how they went about learning, i.e., how they experienced their own attempts to learn. In one case they seemed to direct their efforts to be able to retell the text, in the other to tell what the text was about, in their own words. Those adopting a surface approach did not seem to search for the meaning of the text actively when reading, while those adopting a deep approach did so. The meaning dimension of variation was not opened up in the former case, but was so in the latter. When answering the question what the text was about, those adopting a surface approach tried to stick to the text as closely as possible, i.e., keeping it as invariant as they could, while those adopting a deep approach opened up the dimension of wording, but keeping the meaning found invariant. The distinction between the two approaches to learning can thus be depicted in terms of differences between two patterns of experienced variation and invariance. Silén (2000) investigated medical students' ways of learning in the context of a problem-based learning program, from the point of view of the students' responsibility for, and independence in, their own learning. She concludes:

> Challenging one's own perspective, looking for alternative explanations, comparing different ways of seeing the same thing, searching for novel angles and trying out understanding and doing things in different ways, are acts that the students take the initiative to themselves. This implies that this is an important and fundamental constituent part of learning. It is interesting that in the present context (the students own responsibility for their learning), seeking variation becomes to a great extent something that the students have to do (p. 265, translation mine).

This study was followed up a few years later, in the same context, with the same kind of students, by Fyrenius et al. (2007). In this case, 16 medical students were interviewed about their understanding of certain physiological phenomena and about their approach to the learning about those phenomena. In 10 of the 16 cases, the researchers found that the students strived for changes in perspectives and for deliberately creating situations or actions rich in variation (p. 156). This is often expressed metaphorically: talking about turning around, twisting, looking at the

object of knowledge from different perspectives (In the transcripts below, S11 indicates Student #11, S20–97 Student #20 of the 1997 class, and so on).

> (S11) It [the tutorial] contributes to what you should use the knowledge for, it is like the clinical, 'why is that treatment better than this one? Why doesn't it work? The same kind but it ought to work'… then you have more, like, applied it, even more like twisted and turned it, and applied it more and dissected it even more, so to say … (p. 157).

In the next quote, we can see the same "turning and twisting" metaphor in the context of "repetition with variation":

> (S12) If you work through one thought several times so that you sort of get familiar with it in a way, it sort of, that you can twist and turn it in various ways and then it sticks better (p. 157).

The need for coming up with different options (or opening up a dimension of variation) was expressed by another student in the following way:

> (S7) [facts] are tested against other facts and there's questioning work in progress all the time, how can this potentially be related to this? And then maybe you come up with some alternatives, some of which are more likely than others, some feel as they have potential (p. 157).

The above quote from S12 resembles a way of going about learning found among Chinese students. They combine learning for understanding and learning for remembering (variation and repetition). They are reading different accounts of the same thing and they read the same account several times, but different ways.

Comparing studies of high school students with their own study of university students, Marton et al. (2005) argue that while understanding and memorization are not differentiated in young high-school students' accounts, they are frequently separated and even contrasted by older high-school students, to be brought together in a complementary relationship by many university students. Twenty students from various fields of study, at an elite Chinese university, were followed during the first one and half year. Many of them referred to the importance of variation in gaining understanding, and to an increasing extent to the central role of differences.

Some students pointed to the pattern of variation and invariance called *generalization.* The focused aspect of the object of learning is invariant, while other aspects vary:

> Extracting what is general from different cases (S20–97).

> You and the thing are in the same world. It has already been in your mind. I might not be able to speak it out, but if I encounter this word, a picture will appear in my mind and I know the general idea (S3–99).

> … you know something about what you have learned, extend this knowing and draw inferences about other cases from one instance (S6–97).

> … getting deeper and deeper, from the superficial to the essence (S7–99).

> … you cannot stay on the surface of what you learn. You should mix in your own ideas while you learn it. So you can further digest what you learned … to have your own idea after you learned it (S5-97).

Other students referred to the pattern of variation and invariance called *contrast*. The focused aspect of the object of learning varies, while other aspects are invariant:

> … to change to another point of view, or another side, and try to think from that person's point of view (S6–99).

> You will approach it from different angles, and then go deeper into it, and at last draw a conclusion (S14–99).

> I will first grasp its intention and extension, then grasp its characterization, find the difference between it and other things.

> The difference is of great importance …

> Through comparison, for example when I get a concept, I will first read through it to find its general idea and its key points, then compare the key points with the difference between this concept and others (S20–99).

> For example, I need to understand three kinds of knowledge, A, B, C. A is the learned knowledge while B and C are the unknown knowledge. Then I will use A to analyze B. After understanding B and comparing A and B, I have got knowledge AB. Then I can use AB to analyze C and thus get the knowledge ABC. In this continuous process, there is neither a clear end, nor the clear starting point. Understanding and memorization are mixed and this enlarges our knowledge (S20–99).

> Try to think from other people's perspectives (S8–97).

> … knowledge becomes deeper. … If I want to understand something, at first I should generate interest in it. Then I will seek for its features and why it has such features that makes it different from others (S18–99).

> (If you want to understand something, what would you do?) I will first think, look up references, and then discuss with classmates, comparing mine with their opinions ... (S15–99).

> (Marton et al. 2005, p. 310)

Experienced patterns of variation and invariance in learning illuminates what a deep approach to learning is like.

In order to develop a powerful way of seeing something, the learner must decompose the object of learning and bring it together again. Such decomposition happens in two ways: through delimiting parts and wholes, on the one hand, and through the discernment of critical aspects, on the other hand. Towards such an end, the learner has to create the necessary patterns of variation and invariance. This is deep approach to learning in terms of the Theory of Variation.

Surface and Less Varied Approach to Learning

What is then the alternative to deep approach, in such terms? Marton et al. (2005) found three students in the beginning of the study, one of them also at the end representing such an alternative. The most common answer to questions about his

way of studying was 'I will read it over and over again' (S12–99). When he was asked about if he had a particular method of preparing for argumentative (as opposed to short answer) questions, he said:

> I will memorize the key points, such as those beginning with "First," "Second," and discussion and exposition.
>
> (Do you think that you have some special methods to memorize things?)
>
> No. I only read them many times.
>
> (For example, if you read something three times, is it the same every time? Does the meaning change?)
>
> The same. I just repeat it until I can memorize it.
>
> (No difference?)
>
> No. (S12–99) (Marton et al. 2005, p. 300).

The repetitive (invariant) way of handling the learning task can also be illustrated by some interview excerpts from Boulton-Lewis and his colleague's (2004) study how a group of Australian students with comparatively weak academic background, tried to cope with the demands of the university;

> I: So what actually does study mean to you?
>
> S: Probably just actually learning the material. Actually sitting there and for an exam … if I have to study for an exam I'll be copying out the sheet and rereading it over and over, you know, start doing that a week before the exam or something so I can be familiar on that.
>
> I: So after you rewrite what you are actually studying, what's the process after that?
>
> S: I find the easiest way for me to do it is probably writing it out again and reading it to myself and then reading it, reading it, reading it (S1–97).
>
> I: Did you try and memorize them?
>
> S: Yes. I wrote them over and over again on a piece of paper, the science word for it and the meaning for it. I used to write out a whole sheet before I'd get it in my head. I used to try that method before as well, just getting there and saying the bold words and the definition and read it over, I used to do both, like read the other ones and the ones I don't get through I write over and over until I get it (S2–97).
>
> I: How do you actually memorize it?
>
> S: Read it over and over, then I come back and then I cover it up and I see if I remember it then I'll have a look at it, if I'm right I'll keep going but if I'm not I'll read it again and again and again until I get *it* (S10–97) (Boulton-Lewis et al. 2004).

These quotes illustrate Brousseau's (1997) thesis about the paradoxical nature of the "didactic contract," from the learner's perspective: by trying hard to fulfill the didactic contract, in the sense of becoming able to answer the teacher's questions, the students make it impossible for themselves to fulfill the didactic contract, in the sense of making the ideas taught or read about, their own.

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