6 Variation Theory
An Organizing Principle to Guide Design Research in Education

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Introduction
In this chapter, we present a study based upon a theory about learning that focuses equally on what teachers do and what students learn. We assume that what teachers do in an educational situation is crucial for what students learn at school. By concentrating on the enacted object of learning (what teachers do and what students experience), we try to capture what is needed for learning to take place. The enacted object of learning can be affected by what the teacher does or says, the student’s own reflections, other students, or the learning materials. But what matters and what does not matter?

The project described in this chapter was carried out in cooperation with two groups of Swedish teachers in a nine-year, compulsory school (ages seven to 16). The point of departure was that the combination of what teachers do, how students learn, and theories about teaching and learning is crucial for attempts to improve education. The primary focus is on an object of learning as it is shaped in an educational situation, not on teaching methods. By applying a theory about learning (variation theory), which can be used by teachers both in planning instruction and in assessing students’ learning outcomes, even more powerful educational situations can be developed. The method used is inspired both by lesson study (Lewis, 2002; Stiegler & Hiebert, 1999; Yoshida, 1999) and by design study (Brown, 1992; Cobb et al., 2003; Kelly & Lesh, 2000). A fusion of these approaches, using variation theory, is called a learning study (Holmqvist, 2006; Marton, 2003), which seeks to build innovative learning environments and to conduct research into innovations in theory. It also tries to pool the valuable experience of teachers while continuing to emphasize an object of learning, instead of teaching methods.

The execution of the learning study is flexible, but a theory must be associated with the approach to the learning study. We have chosen to use a theory of variation, which focuses on the distinction between an intended object of learning (what the teachers are striving for), an enacted object of learning (what happens during the lesson and what it is possible to learn), and the lived object of learning (what the students learn). To make learning take place, a way of understanding an object can be defined in terms of the critical features that must be discerned and focused on simultaneously (Bransford et al., 1989). To find those critical aspects, microanalyses are conducted, which result in patterns of variation used by the teachers.

An individual must experience variation in order to be able to discern a particular feature. To develop a certain way of seeing something, the pattern of variation that they must experience has to be constituted. However, these patterns are often demonstrated unintentionally and unconsciously by the teachers, who are unaware of which critical aspects they offer the students and which they do not. The microanalyses are guided by
variation theory, which makes the patterns visible to the teachers and provides the potential to predict forthcoming instruction. No matter which methods a teacher uses, he or she first has to examine what it takes to learn the desired learning object, then try to find the best method to reach that goal.

This chapter starts by highlighting the theoretical framework. Then, two examples are presented of how variation theory is used in two different learning study cycles.

The Theoretical Framework: Variation Theory

The theory of variation has its roots in phenomenography, which is a research specialization that was developed by researchers in the Department of Education at Göteborg University, Sweden in the 1970s (Marton et al., 1977). The object of this research—human experience—is shared by phenomenology, but phenomenology has a set of specific theories and methods that are shared only partly with phenomenography. The term phenomenography comes from the Greek words “phainomenon,” which means “appearance,” and “graphein,” which means “description.” Thus, phenomenography deals with descriptions of how things appear to us. Its goal is to describe qualitatively different ways of looking at, or experiencing, the same thing; variations in different ways of experiencing things are studied (Marton, 2003; Marton & Booth, 1997; Marton & Fai, 1999).

The purpose of this chapter is to describe different ways of seeing phenomena in order to plan successful learning situations. Although phenomenographic analysis can be used to describe students’ previous knowledge, we needed to find which critical aspects of the learning object can be contrasted to this. One development of phenomenography is the ongoing building of a theory about learning, called the theory of variation (Holmqvist, 2004, 2006; Marton & Trigwell, 2000; Runesson, 1999). This theory is built upon research about discernment (Gibson, 1986; Rubin, 1915; Wertheimer, 1959), simultaneity, and variation (Bransford & Schwartz, 1999; Bransford et al., 1989; Schwartz & Bransford, 1998). Thus, instead of trying to find the right method to teach based on an expert view of how learning develops, variation theory examines different learning objectives in order to ascertain how learning develops in different ways connected to that objective. From this basis, the most powerful ways to teach can be proposed.

The question that institutionalized learning is faced with is: How can we prepare ourselves for the future when we do not know what the future holds? In other words, what are we to prepare for? How can we learn when we do not know what we have to learn?

In all phenomena, in every situation, certain aspects are discernible. If every aspect could be discerned and focused on at the same time by everyone, everything would be experienced in exactly the same way. However, only a limited number of aspects can be discerned and focused on simultaneously. The discerned aspects differ among different people, as pointed out nearly a century ago by Thorndike:

All man’s learning, and indeed all his behaviour, is selective. Man does not, in any useful sense of the words, ever absorb, or re-present, or mirror, or copy, a situation uniformly. He never acts like a tabula rasa on which external situations write each its entire contribution, or a sensitive plate which duplicates indiscriminately whatever it is exposed to, or a galvanometer which is deflected equally by each and every item of electrical force. Even when he seems most subservient to the external situation—most compelled to take all that it offers and do all that it suggests—it
appears that his sense organs have shut off important features of the situation from influencing him in any way comparable to that open to certain others, and that his original or acquired tendencies to neglect and attend have allotted only trivial power to some, and greatly magnified that of others.

(1914: 157)

Thus, we may experience the same situation differently. To experience means to discern something from a given context and relate it to this context or to another one. It also means discerning parts of what we experience and being able to relate the parts both to each other and to the whole (Carlgren & Marton, 2002; Wertheimer, 1959). Experience has both a structural and a referential aspect. To discern a structure, we must know its meaning; to know the meaning of something, we must discern its structure (Marton & Booth, 1997). In Figure 6.1, two geometric shapes can be seen, but they are not actually there; they are made up in the viewer’s mind and are connected to his or her previous knowledge.

To discern something familiar to something you know already has been studied, especially by the Gestalt psychologists (Wertheimer, 1959). Criticism of the Gestalt psychologists’ theories was founded in how meaningless figures become understandable by an illusion made up by the interpreters because of their previous knowledge but failed to explain a wholeness experienced in the nonsense figures. The study of learning and education might have something in common with understanding how nonsense figures are supposed to create a new wholeness for the one who experiences them. Gestalt psychologists’ theories do not provide many answers about how learning develops in areas where the learner had few or no insights before.

In order for us to discern something, we have to focus on some aspects while not paying attention to others. To make it possible to focus on some aspects, they must be varied against an invariant background; that is, variation is necessary for discerning, and discerning is necessary for experiencing. The contrasts between what varies and what does not make a pattern of contrasts, which makes it possible to discern. Thorndike (1914: 14) wrote: “... man is originally attentive (1) to sudden change and sharp contrasts ...”, and Bransford and Schwartz (1999: 77) found that: “Data strongly supported the assumption that contrasting cases better prepared students for future learning.” The contrasted aspects that can be focused on simultaneously make a pattern of the whole, which changes if the different aspects change. Bransford et al. (1989: 481–482) say: “a single stimulus has no meaning except in the context of

Figure 6.1 Geometric Shapes Suggested by Pre-existing Knowledge.
alternatives.” If you describe a girl as short for her age, you have contrasted in your mind examples of other girls of the same age but different heights. Otherwise, you probably would not mention anything about her height.

Another example of the difference between people’s numerous ways of experiencing depends on what aspects are being discerned and focused on simultaneously. Neuman (1987) gives an example of how the number nine refers to four different aspects at the same time: the quantity (nine items), the sequence (the ninth in a series), part–whole relationships \(9 = 7 + 2\), and the different unities that nine is composed of (nine 1s). These four aspects of nine are critical for a full understanding of the phenomenon. Thus, to experience the number nine fully means to be able to discern all four aspects and to be aware of all of them at the same time (Carlgren & Marton, 2002).

Schwartz and Bransford (1998: 504) found that “analyzing the contrasting cases provided students with the differentiated knowledge structures necessary to understand a subsequent explanation at a deep level.” They also found that telling students about features was not as effective as helping them to discover them by using contrasted cases to guide their discovery of critical aspects (called significant features by them) and that deep understanding requires differential knowledge of empirical phenomena or theories as well as an understanding of their significance. When a learner has gained the ability to discern aspects of a phenomenon and can be simultaneously and focally aware of more aspects than before, this leads to a deeper understanding of phenomena through differentiation or enrichment, or the fusion of both.

To teach someone to experience in a new way requires building a structure of relevance and the architecture of variation. A structure of relevance means an awareness of a purpose, its demands, and information about where they will lead. To sum up, in a learning situation, there must be a structure of relevance and a variation to make it possible to discern critical aspects. The teacher must find the critical aspects of a phenomenon and the aspects of variation must be evoked. This variation can be presented by contrasted cases.

The alternatives needed to constitute a dimension of variation of the phenomenon’s characteristics. Bransford and Schwartz (1999: 71) call this field of alternatives: “... a single stimulus is defined in the context of a ‘field’ of alternatives”, and a field of alternatives can be “‘lived experience’. ... These experiences can function as ‘contrasting cases’... that help people notice features of their own culture that previously were unnoticed” (p. 85). One of the difficulties of teaching students subject matter that is familiar to the teacher includes the perception of how the students’ understandings of the object of learning can differ from the teacher’s views.

How do we know what dimensions of variation to look for? How do we identify the critical features? According to Marton et al. (2004), the critical features have to be found empirically, and they must be found for every specific object of learning. In this work, we assume that the teachers are playing an important role because “it seems highly probable that people need help thinking about their experiences and organizing them into some coherent view of the world” (Bransford & Schwartz, 1999: 85).

The teacher must enable students to focus on critical aspects of the object of learning. Some aspects must be presented as basic, and others concentrated on through variation. The basis is the knowledge shared by both the teacher and the students. To create a space of learning means to open up a dimension of variation that offers students new ways of discerning critical aspects (Marton et al., 2004). This dimension covers phenomena, but parts of a phenomenon can be separated into new dimensions as a kind of differentiation or enrichment, where the learner gets a deeper understanding. “Previous research on perceptual learning, for example, has shown that, if people
discern distinctions within a domain, these distinctions can facilitate subsequent learning” (Schwartz & Bransford, 1998: 499).

The question is: What kind of variation gives students the most possibilities to learn? Schwartz and Bransford found that:

In domains in which students have less prior experience, less complex contrasting cases may be more appropriate lest students get lost in the little contrasts. . . . The contrasts between the tools are less ‘cluttered’ compared to the contrasting cases of these studies. This makes it so students with limited algebra knowledge can still locate the important contrasts.

(1998: 507)

Variation theory offers an opportunity to conduct microanalyses of the enacted object of learning (i.e., what happens in the lesson). The results of these microanalyses can be used to change very subtle details in the educational situation, which can result in different learning outcomes for students. This will be described later in this chapter, when results from two studies are presented.

The Methodological Framework: Learning Study

The approach used in the study discussed in this chapter is called the learning study method. It is a fusion of two methodological approaches: lesson study (Lewis, 2002; Lewis & Tsuchida, 1998; Stiegler & Hiebert, 1999) and design experiments (Brown, 1992; Cobb et al., 2003; Kelly & Lesh, 2000). Like a design experiment, a learning study seeks to understand the ecology of learning (Cobb et al., 2003). A learning study is an iterative process, designed in a cycle like the lesson study cycle. However, lesson study cycles do not grow necessarily from, or aim to develop, a scientific theory, which both design experiments and learning studies claim to do. A design experiment is also an iterative process, but it differs from the learning study in that the latter focuses on the classroom and the collaboration between teachers and researchers trying to study how a limited object of learning is learned. A design experiment can be used in several other settings, including the classroom, and can have other focuses than learning objects.

Another significant difference is the focus of the research project. In a design experiment, the researcher often owns this question, but, in a learning study, the teachers decide what the focus of the study will be. A shared goal of all three approaches is to improve the initial educational setting by revision based upon the analyses of the data that show the students’ development. The most obvious differences between a design experiment and a lesson study are the focus on a theoretical framework and the tests in the design experiment, whereas the point of departure of a lesson study cycle is not necessarily a theory or the results of tests. A lesson study makes explicit certain methods for teaching; the students’ learning process is important to the extent that it informs the teacher what aspects of the instruction are guiding learning through variation.

Examples of the stages of a learning study cycle (and the ones used in this chapter) are given below:

1 Critical aspects of the learning object are analyzed by studying the students’ previously developed knowledge (readiness) through pretests (the lived object of learning, i.e. what the students have learned) combined with subject matter research from the literature.
The lesson plan is developed from the perspective of variation theory. In this study, the first lesson was implemented with student group 1. The students were divided into three groups of equally mixed abilities. They were randomized by the teachers. The groups included students from three classes, divided into groups as shown in Figure 6.2.

The enacted object of learning in English Research Lesson One is analyzed, taking into consideration the outcome of the post-test and the analysis of the first lesson. A revised lesson plan is created, in which it is attempted to understand better the students’ readiness and to point out which kind of complexity in the varied critical aspects of the learning object may address the students’ learning needs. The revised lesson is implemented with student group 2. The revised lesson is analyzed, taking into consideration the outcome of the post-test and contrasting the results with the outcome of English Research Lesson One.

The lesson plan is revised a second time. Again, attempts are made to understand better the students’ readiness and to point out which kind of complexity in the varied critical aspects of the learning object may address the students’ learning needs. The third variation of the lesson is implemented with student group 3. This lesson is analyzed, taking into account the outcome of the post-test and all prior analyses of the lesson.

A post-test is conducted.

The entire learning study cycle and its conclusions are documented.

Variation Theory in Practice

We have chosen two learning study cycles to describe the use of variation theory. In the first one, the subject was learning English as the second language; the second one was in literacy, with Swedish as the first language. Learning studies in mathematics and science and subjects related to those fields have been reported already (Lo & Pong, 2002; Marton & Morris, 2002). Most of the articles about learning studies describe learning situations at schools in Asia (Hong Kong), which may differ from school situations in Europe.

Figure 6.2 Selection Process Used to Make Up the Groups of Students who Participated in the Learning Study Cycles.
The first step in a learning study cycle is to choose an object of learning in cooperation with the teachers that focuses on a teacher-identified problem. In this study, the teachers chose the present tense—*am, are, is*—of the verb *to be*. The learning study described here is the second learning study cycle in a series of three such cycles carried out with the same group of teachers. The teachers had been introduced already to the theoretical framework used in the study (variation theory). All of the teachers (N = 5) participated in designing the learning study cycle and in planning the lessons. Three of them were chosen to teach one lesson each. For research purposes, the students (N = 61) were divided into three groups. The groups were constructed to be heterogeneous; that is, each group contained students with different levels of knowledge—high, middle, and low—who reflected normal classroom circumstances as much as possible.

**Analyzing Critical Aspects of the Learning Object**

Analysis of the critical aspects of the learning object takes as its point of departure the three central concepts of the theory: discernment, simultaneity, and variation. To begin, the teachers focused upon what the students had discerned already about how to use the verb *to be* in the present tense—*am, are, is*. To collect more precise data, the group decided to use different sources. These sources were: (a) written letters (which the students wrote as an answer to a letter to them from Holmqvist), (b) the teachers’ experiences from previous teaching, (c) research findings, and (d) a scanning test whose design was based upon the results of the data from sources (a), (b), and (c).

To determine each student’s ability, the teachers and researchers constructed a scanning test (see below), which gave the students the opportunity to show how they thought the Swedish word *är* (*am, are, or is*) should be translated into English. The students had not been told by the teacher which English words to use when they took the test. The test consisted of 11 items:

1. I _________ eleven years old.
2. My dog _________ at home.
3. My parents _________ at work.
4. Mary _________ my sister.
5. She _________ seven years old.
6. How old _________ you?
7. Sam _________ my friend.
8. He _________ ten years old.
9. Sam and Mary _________ at school.
10. Sam and I _________ best friends.
11. We _________ British.

The next step was to compare the test results with how the target words are used in the students’ mother tongue. This analysis showed the differences that the students have not experienced in their mother tongue. There is only one word in Swedish—*är*—for *am, are, and is*. In other words, there is no variation in the Swedish language to indicate singular from plural or between first, second, and third person; the Swedish word *är* serves all these purposes. Therefore, in Swedish, students have not needed to focus on
three different words (am, are, and is) and have to decide which is the right word to use. Thus, it has not been possible for them to develop this simultaneity when using their mother tongue because only one word is used in Swedish to express the three English words, as shown in Table 6.1.

The comparison in Table 6.1 shows that the information given by the present tense of to be in English (am, are, is) is more differentiated than the information that can be obtained from the Swedish word är. If the word am is used, it refers to the personal pronoun I; when the word is is used, it refers to he, she, or it. When the Swedish word är is used, it is not possible to get precise information. Therefore, the teachers studied first which knowledge the students might have because of their mother tongue by analyzing similarities and differences between Swedish and English. The skill that Swedish students have to master is when to use the word am, when to use the word is, and when to use the word are as a translation for the all-purpose Swedish word är.

The results of the scanning test were analyzed in categories that indicated the qualitative differences in discernment shown by the students (N = 61):

- No right answers: 10 students.
- Är is replaced by an incorrect word almost like the Swedish “er”: 2 students.
- Discern one correct word, are: 23 students.
- Discern one correct word, is: 8 students.
- Discern at least two English words correctly: 18 students.

The last category is divided into subcategories depending on how well students are able to discern which of two or three English words to use instead of the Swedish word är (n = 18). At this level, it is possible to see which kind of simultaneity the students use, and if they are aware of the variation in a way that makes it possible for them to pick the correct word. The pattern of variation is shown by how the student is able to choose the correct form of to be in relation to different representations of personal pronouns or substantives (e.g., Billy is; Mary is; but Billy and Mary are). The students were judged on their knowledge of two different words (is/are or am/are); knowledge of all three words (am, are, and is); and knowledge of the difference between singular and plural (Billy and Mary are, my parents are).

From the analysis of the data collected, the critical aspects found at the beginning of the learning study cycle were the abilities to:

<table>
<thead>
<tr>
<th>Personal pronouns</th>
<th>Verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>English</td>
</tr>
<tr>
<td>I</td>
<td>jag</td>
</tr>
<tr>
<td>you</td>
<td>du</td>
</tr>
<tr>
<td>he</td>
<td>han</td>
</tr>
<tr>
<td>she</td>
<td>hon</td>
</tr>
<tr>
<td>it</td>
<td>den, det</td>
</tr>
<tr>
<td>we</td>
<td>vi</td>
</tr>
<tr>
<td>you</td>
<td>ni</td>
</tr>
<tr>
<td>they</td>
<td>de</td>
</tr>
</tbody>
</table>

Table 6.1 Comparison of the English and Swedish Forms of the Present Tense of the Verb To Be

118 Mona Holmqvist, Laila Gustavsson, and Anna Wernberg
• Discern the three different words to use: am, are, and is.
• Connect the correct form of the verb to the personal pronouns (I am, you are, he is, she is, we are, . . .).
• Know who or what is can be connected to: my mother (she) is, my cousin (he) is, my dog (it) is, the flower (it) is.
• Discern the difference between one or more (singular or plural) persons or objects when using are (Sam is and Mary is but Sam and Mary are, the flower is but the flowers are).
• Discern that the pronoun you can be both singular and plural.

The next step in the learning study cycle was to plan the first of the three research lessons. Although one of the teachers taught it, all of the members of the group participated in its design.

English Research Lesson One

The teacher started with a conversation whose purpose was to enable the students to distinguish between the three different words am, are, and is. Then, she focused on the plural form, contrasting it to the singular form. Next, she gave the students a sheet with some English text on it. They were supposed to search for the word är in English, working first in small groups and following that with a class discussion. The text was set up so that the students would have to make several distinctions, especially the difference between singular and plural. The text also was constructed so that it made apparent the patterns of variation. Previously, it had been found necessary for students to be able to recognize these aspects: (a) the three different words to use—am, are, and is, (b) the connection between the correct form of the verb and the personal pronouns, (c) to know who or what is can be connected to, (d) the difference between one or more (singular or plural) persons or objects when using are, and (e) that the pronoun you can be both singular and plural. The following sentences illustrate these aspects:

My name is Bill. I am ten years old, and I live in England. I have a sister and a brother. My sister is six years old, and my brother is four years old. My sister and brother are sick today. My mother is at work, and my father is at home with my sister and brother today. Both my parents are 35 years old. We have got a dog. The dog’s name is Tam. My sister has got two fishes. They are orange. We are British. [Italics by the authors]

Finally, the teacher and the students talked about the text and why the words am, are, and is change. After the lesson, the students took a post-test. The design of the post-test was almost the same as the pretest, except for a difference in the order in which the sentences were presented, as well as the names of the characters. The results showed improvements overall, especially in the singular form (he is, she is), but fewer in the plural form.

Analysis of the lesson showed that the teacher opened a space of learning that offered the students the opportunity to discern the three different words am, are, and is. However, the connections between the personal pronouns and the present forms of to be had not been presented simultaneously. Thus, the differences were still unclear to the students.

The differences between singular and plural were contrasted to each other, but not simultaneously in the first part of the lesson. The singular form was introduced first,
then the plural form. When the students had to find the three English words that replace the single Swedish word är in an English text, the difference between those three words was discernible immediately. However, it did not seem to affect the learning outcome because the task appeared to be simple for the students.

The analysis suggested that the students found the three English words in the first part of the lesson. Because of this, they looked at the text as a part of a whole, identifying the words that they had been introduced to previously in the lesson. One result of the analysis was to ask how to make it even clearer how to tell the difference between singular and plural.

**English Research Lesson Two**

The second lesson was planned to start at a more complex level than English Research Lesson One. The teacher used the same text as in Lesson One, but, this time, the students were not told which words to seek. This made the task more difficult for them. The theoretical principles, which suggest that the ability to discern different critical aspects simultaneously depends on the use of variation, were followed. By forcing the students to use the content of the text to discern the target words, they had the opportunity to see some patterns that indicate when the different words are used. The variations used in the text—my sister is, my brother is, but my sister and brother are—were assumed to make the pattern discernible.

The teacher started the lesson by asking the students to be detectives and search for the English equivalents of är words in the text. From the beginning, they were forced to think of the text as a whole unit, not knowing which words to look for. They had to understand the content of the text in order to find the words. After this part of the lesson, the teacher discussed the text and the words that the students had found. The next part of the lesson was similar to the first part of the first lesson, where the teacher had a conversation with the class. The conversation focused on sentences containing the words am, are, and is. The students had the possibility to discern both the singular and the plural forms simultaneously, and the teacher used an empty table on which she wrote in separate columns the sentences that the students gave her as examples that included am, are, or is, as shown in Table 6.2. The headings between parentheses were written after the sentences had been placed in the correct field by the teacher. The students and the teacher made the headings together, as a conclusion of the lesson.

The teacher made this table to help the students see patterns of how the different words are used. At the outset, when the teacher wrote the students’ sentences on the table, it was impossible to distinguish when am, are, and is are used because the headings between parentheses were not written on the table at the beginning.

**Table 6.2 Examples of Students’ Sentences Containing Am, Are, and Is in English Research Lesson Two**

<table>
<thead>
<tr>
<th>Subject and verb</th>
<th>Student sentence example</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am.</td>
<td>I am a teacher.</td>
</tr>
<tr>
<td>You are.</td>
<td>You are a boy.</td>
</tr>
<tr>
<td>He/She/It is.</td>
<td>My name is Anna.</td>
</tr>
<tr>
<td>We are.</td>
<td>Sarah and I are friends.</td>
</tr>
<tr>
<td>You are.</td>
<td>You are students.</td>
</tr>
<tr>
<td>They are.</td>
<td>Your cousins are from England.</td>
</tr>
</tbody>
</table>
The teacher discussed the structure of the table after the students had stated their sentences; as noted above, the headings were written on the table at the end of this discussion. Although the students were able to discern the structure of the table spontaneously, which included the simultaneous presentation of the singular and plural forms, they had to think in steps in order to try to understand the pattern. For example, the teacher showed how the word *they* can be replaced with my sister and her friend or my parents and the word *she* with my sister or my grandmother. These were forms of “translations.” Finally, the teacher focused on the word *you*, used in both the singular and the plural.

Like the first group of students, this group also took a post-test. Although two rather significant changes in the pattern of variation were made in the second lesson, the results were about the same as in the first lesson. The results still showed little improvement in the students’ knowledge of the plural form. They also showed difficulties with the plural form when the plural is made by adding the letter *s*. The students were asked to connect *am, are,* and *is* to different persons or objects; the answers to questions in the test that were connected to examples in the lesson showed an improvement. But the students were not offered “Mary and Sam are” and “parents are” simultaneously with “they are.” Instead, they “translated” “Sam and Mary” or “parents” into *they*, which decreased the variation and may be linked to the small improvement in the results of this test. The analysis also suggested that the text to students did not show explicitly the words that determine the correct form of the present tense of *to be* to use. By forcing the students to find the correct words by understanding the content of the story, it was assumed that they would discern the pattern. This should show a connection between the personal pronouns or the substantive and which form of the verb *to be* to use. However, the data do not support this conjecture.

**English Research Lesson Three**

The teacher began by asking the students to find sentences with the English equivalent (*am, are, is*) of the Swedish word *är* in them. The sentences were written in a table, as in English Research Lesson Two; however, the plural forms were not divided. In the table, the singular forms were divided into subgroups (*am, are, is*), but the plural form was left as one group (because *are* is always used when there is more than one person or object).

After this introduction, the teacher started a conversation that contrasted singular and plural forms simultaneously. She talked about “a girl *is* and a boy *is*, but a girl and a boy *are*.” She also focused on the plural form shown by the letter *s* at the end of a substantive. Finally, she had the students concentrate on the words that determine that *am, are,* or *is* is the correct English usage, using the same text as in the previous lessons. However, the text was changed to make the students focus on the words that make these determinations by deleting all occurrences of *am, are,* and *is*. This differed from the previous lessons, in which the students only had to identify already discerned words in a written text (as in the first lesson). By understanding the text’s content, they could find the words without reflecting on why the different forms appeared as they did. In English Research Lesson Three, they had to make a choice about which form to pick. In other words, they had to think about the words that determine the correct form. In fact, by deleting the word, the sought-after simultaneity was reached, although the students were forced to find some clues in order to decide which word to use. They got the insights that they could not focus only on the words *am, are,* and *is* and that more information was needed. This information can be gleaned from how the students had to think of the word that determines the use of *am, are,* or *is*. By focusing on two different
kinds of words simultaneously, the students were able to see a pattern in how to use am, are, and is. This is the worksheet used in English Research Lesson Three:

1. My name _______ Bill.
2. I _______ ten years old, and I live in England.
3. My sister _______ six years old, and my brother _______ four years old.
4. My sister and brother _______ sick today.
5. My mother _______ at work, and my father _______ at home with my sister and brother today.
6. Both my parents _______ 35 years old.
7. We have got a dog. The dog’s name _______ Tam.
8. My sister has got two fishes. They _______ orange.
9. Their names _______ Sim and Sam.
10. We _______ British.

Finally, the teacher and the class discussed the worksheet and why the words used were appropriate or inappropriate. Some of the results of English Research Lesson Three are worth mentioning. The students were told always to use are when talking about more than one person or object. This seemed to produce an improvement in the test results for the use of the plural form (with one exception). The teacher also asked the students to discern the plural form ending in s, as indicated by the following dialogue:

Teacher: How do we know it is many say, three friends? How can you see it? It is not just one friend; it is more friends.

Student: Friends.

Teacher: Friends, yes. What in “friends” says it is more than one?

Student: The letter s.

In the singular form, the need to divide them into subgroups was met. This was reflected in improved test scores. But by connecting are so strongly to the plural usage, the singular form of “you are” was difficult to discern. This appeared to account for a decreased score. The teacher tried to explain this, but it seems as if the focus on the “more than one” concept had been easier for the students to understand. This can be illustrated by analyzing the following excerpt of the Teacher from English Research Lesson Three:

Now, look at this. Here it says: “You are a teacher,” but here it is: “You are boys.” In the last phrase, you can see it is more than one boy. It is shown by are and s. But the first sentence says: “You are a teacher.” When it is more than one word, it is you are, and you should choose are. Du [Swedish for you in the singular form in English] is the same as ni [Swedish for you in the plural form in English] in English. (See Table 6.1 for the singular and plural forms of personal pronouns in English and Swedish.)

The test scores also showed a decrease in comprehension of the plural form for the phrase “Sam and I are” because the students believed strongly that am must always follow the personal pronoun I, as was emphasized in the lesson:

Teacher: In Swedish, we always use the same word, but, in English, we use am, are, or is. Now, we are going to find out when to use the first, the second, or the
third word in English. Look at the first sentence: “I am a student.” Which word is deciding the word am? Which word decides? What do you say, Sonny?

Student: I.  
Teacher: It is I; after I, it is am. What do I mean?
Student: Jag [I in Swedish].

In spite of the errors, the development of the students’ knowledge was greater in English Research Lesson Three than in the other two research lessons, as evidenced by the test scores, which are shown on Table 6.3.

Results of the Learning Study Cycle in English as the Second Language

Analysis of the enacted (what happened in the lesson) and lived (what the students learned) objects of learning made it possible to design changes in the educational situation that affected learning. Although the changes were subtle, they resulted in important differences in the students’ learning outcomes. This learning study cycle is an example of how the use of a theory, combined with an iterative design, makes it possible to develop lessons that are associated with increased learning outcomes.

Table 6.4 shows the differences in what the students were offered in the three learning situations. The dimensions of variation and invariance differ. In English Research Lesson Three, the students had the possibility of discerning two dimensions of variation that were not offered to the students who participated in the first two lessons.

What conclusions can be drawn from this study? Can we assume that a worksheet with missing words to fill in is preferable to other kinds of worksheets? Such an assumption would be very misleading and is not the intention of variation theory. In fact, it would result in a loss of focus on the theoretical level and represent a step down to a methodological level, which we argued against initially. On the theoretical level, the focus is on what it takes to learn the learning object; based on this, the teacher chooses which method to use. If the focus had been on a methodological level, we might have

<table>
<thead>
<tr>
<th>Subject and verb</th>
<th>Student Group 1</th>
<th>Student Group 2</th>
<th>Student Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre (%)</td>
<td>Post (%)</td>
<td>Diff</td>
</tr>
<tr>
<td>I am.</td>
<td>15</td>
<td>45</td>
<td>+30</td>
</tr>
<tr>
<td>You are.</td>
<td>28</td>
<td>50</td>
<td>+22</td>
</tr>
<tr>
<td>She is.</td>
<td>35</td>
<td>75</td>
<td>+40</td>
</tr>
<tr>
<td>Mary is.</td>
<td>45</td>
<td>65</td>
<td>+20</td>
</tr>
<tr>
<td>He is.</td>
<td>38</td>
<td>55</td>
<td>+17</td>
</tr>
<tr>
<td>Sam is.</td>
<td>35</td>
<td>90</td>
<td>+55</td>
</tr>
<tr>
<td>My dog is.</td>
<td>25</td>
<td>40</td>
<td>+15</td>
</tr>
<tr>
<td>We are.</td>
<td>15</td>
<td>35</td>
<td>+20</td>
</tr>
<tr>
<td>Sam and Mary are.</td>
<td>15</td>
<td>40</td>
<td>+25</td>
</tr>
<tr>
<td>My parents are.</td>
<td>10</td>
<td>32</td>
<td>+22</td>
</tr>
<tr>
<td>Sam and I are.</td>
<td>15</td>
<td>28</td>
<td>+13</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>50</td>
<td>+25</td>
</tr>
</tbody>
</table>
concluded that it is better to use worksheets with blanks to fill in. However, the theory is a tool to examine a learning object, to find the most appropriate way to present it, and not the means to find one single best method. This view is being developed still. A second learning study cycle in another subject is described next as a contrast.

Learning Study Cycle in Literacy with Swedish as the First Language

This study was carried out in the same way as the first one, but with another group of teachers and students from three different schools. Because of this, the students had to be kept together in their classes instead of being mixed as in Figure 6.2. The teachers decided that the object of learning was for the students to recognize the four ways that the Swedish tj sounds (similar to the initial sound in child, but without the initial t sound); it can be spelled tj, k, kj, or ch. The students’ previous written texts suggested that they had limited mastery of the spelling of such words. The teachers constructed a test that also showed the students’ uncertainty about spelling words with the tj sound. Analysis of the results of this test showed that the critical aspect was to focus upon the second letter in order to decide the correct way to spell tj, k, kj, or ch. By focusing

<table>
<thead>
<tr>
<th>Discern am, are, is</th>
<th>Research Lesson One</th>
<th>Research Lesson Two</th>
<th>Research Lesson Three</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversation in which the students discern the different words one by one</td>
<td>The students find the different words in a text, followed by a conversation. All three words can be discerned simultaneously</td>
<td>The students create sentences in which the Swedish word är has to be mentioned. All three words can be discerned simultaneously</td>
<td></td>
</tr>
<tr>
<td>Discern the difference between singular and plural</td>
<td>Presentation of the singular form, followed by a presentation of the plural form. Sequenced design of the critical aspects—one by one instead of simultaneously</td>
<td>The students start with a text, in which the two forms are presented simultaneously</td>
<td>In a conversation led by the teacher, she uses examples in which the two forms are presented simultaneously</td>
</tr>
<tr>
<td>Discern the different forms of plural</td>
<td>Not discerned</td>
<td>Not discerned</td>
<td>More than one (by enumerating) and the plural s on the substantive were presented simultaneously to make the students discern the characteristics of plural in English – and by that understand the use of are in all plural forms</td>
</tr>
<tr>
<td>Discern what decides the form of the present tense of to be to use</td>
<td>Not discerned</td>
<td>Not discerned</td>
<td>By using a text in which the students have to fill in the correct form of to be in the present tense (am, are, is), the teacher makes the students focus on the words that determine the form to use</td>
</tr>
</tbody>
</table>

Table 6.4 The Enacted Object of Learning for the Three English Research Lessons
simultaneously on words that involve the $tj$ and $sj$ sounds, the students were asked to
discern the difference between these sounds. This also gave them the opportunity to
learn something about the spelling. Otherwise, they could spell words with $sj$ sounds
(similar to the initial sound in shop) and spelled $sj$, $stj$, $sk$, or $skj$ with $tj$, $k$, $kj$, or $ch$ or
vice versa, but they did not recognize the different sounds initially. The distinction in
sound between the two groups of words also gave them some clues to the spelling.

Swedish Research Lesson Four

The first lesson started with the teacher asking the students to work in groups and locate
as many words as they could containing the $tj$ sound, which required them to listen very
carefully in order to discern the difference between the $tj$ and $sj$ sounds. Afterwards, the
teacher wrote all the $tj$ words that the students had found in a jumble on the black-
board. The students had to find as many different kinds of spelling of the $tj$ sound
as they could. Then, the teacher asked if they could see some connections between the
words that are spelled the same way. In the next part of the lesson, the teacher used the
same kind of material as in the learning study cycle in English as the second language,
introducing a written text in which the students had to find the words that included the
$tj$ sound. The text was in the form of a letter, which the teacher distributed, that
involved variation by the use of different words, specifically words that contrasted the $tj$
and $sj$ sounds. Finally, the teacher put the letter on the blackboard, and, during a
discussion, the students marked the $tj$ sounds. They also connected them to the words
they had found by themselves at the beginning of the lesson in order to find a pattern
that would enable them to discern how to spell the words correctly. The scores on the
learning outcome did increase, compared to the pretest. The teachers and researchers
discussed whether it was advantageous or disadvantageous to the students’ learning
situation to focus upon the contrast between words that contained the $tj$ and $sj$ sounds;
they decided to decrease the variation by focusing only on words that contained the
$tj$ sound.

Swedish Research Lesson Five

Swedish Research Lesson Five began in the same way as Swedish Research Lesson Four,
with the teacher asking the students to work in groups to discover the different ways
that the $tj$ sound can be spelled. The students wrote their words in columns on the
board. This resulted in four columns, with a few words in each column. After some
discussion, some connections about how to spell the sound were found. The students
got the same written letter as in Swedish Research Lesson Four, except that every $tj$
sound was cut out of the text, like this: _uta; a line marked the place for the sound. The
students had to fill in how they thought the sound would be spelled. After a class
discussion, the lesson ended. After this lesson, there was a small increase in the scores on
the post-test, but it was not as high as in Swedish Research Lesson Four. The analysis
resulted in the assumption that the words presented on the board were too few, which
did not offer the students a real chance to discern a pattern in how the words could be
spelled. The teachers did not suggest contrasting words with the $sj$ sound again. Instead,
they suggested increasing the variation to stimulate the students to find more words
with the $tj$ sound. The number of words was decreased compared to Swedish Research
Lesson Four, and the worksheet was changed as well. To find out which of the changes
had an impact on the learning outcome, the teachers and researchers decided to keep the
worksheet constant (with blanks), but they increased variation by using more words.
Swedish Research Lesson Six

The teacher started this lesson by distributing a pack of cards. The cards, which were given to each group of students, contained pictures illustrating different words spelled with the \textit{tj} sound. The students were asked to sort the cards by the spelling of the \textit{tj} sound. Afterwards, they had to say the words, and the teacher wrote them in columns on the board, depending on the spelling of the \textit{tj} sound. Together, they discussed if connections could be seen between the words spelled the same way. The second part of this lesson was identical to the second part of Swedish Research Lesson Five, and the students got the same worksheet. The post-test showed an increase in the students’ ability to spell the sound; however, it was about as limited as in the previous research lesson.

Results of the Learning Study Cycle in Literacy with Swedish as the First Language

The analyses suggested that the task given by the teacher in Swedish Research Lesson Four, to find as many words containing the \textit{tj} sound as possible, explained the increased scores. The opportunity for learning was opened up in comparison to Swedish Research Lessons Five and Six, where the variation was limited. Furthermore, the students in Swedish Research Lesson Four had the opportunity to contrast the \textit{tj} sound with the \textit{sj} sound simultaneously by using the letter format. It was necessary for the students to search the entire text to see where they could find the \textit{tj} sound. In Lessons Five and Six, the places for the \textit{tj} sounds were left blank. The students only had to fill in the blanks, even if the teacher had told them to read the letter. They knew already which words they should look for, and there was no possibility of confusing the \textit{tj} words with the \textit{sj} words.

By this decreased variation, the students did not face a challenge while looking for the words. They did not have to listen to the words to try to differentiate the correct sound from the incorrect sound. The meaning of the text in the letter was redundant because the words were identified already and marked by the blanks. Even if the students did not know which form of spelling to use, the choice was limited, and they did not have to listen to the words as carefully as the students in Swedish Research Lesson Four, who were offered more variation. The results of the spelling tests for the \textit{tj} sound are shown in Table 6.5.

Table 6.5 The Percentages of Correct Answers in the Spelling Tests in Swedish Research Lessons Four, Five, and Six

<table>
<thead>
<tr>
<th>Tj sound spelled as</th>
<th>Research Lesson Four</th>
<th>Research Lesson Five</th>
<th>Research Lesson Six</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre (%)</td>
<td>Post* (%)</td>
<td>Post† (%)</td>
</tr>
<tr>
<td>k</td>
<td>64</td>
<td>80</td>
<td>86</td>
</tr>
<tr>
<td>tj</td>
<td>35</td>
<td>61</td>
<td>77</td>
</tr>
<tr>
<td>kj</td>
<td>5</td>
<td>29</td>
<td>71</td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>70</td>
<td>81</td>
</tr>
</tbody>
</table>

Note

* Post-test result immediately after the research lesson.
† Delayed post-test result four weeks after the research lesson.
Conclusions

The learning study cycle in English as the second language showed how a worksheet with blanks directed the students to examine the words in order to decide the correct form to use of the present tense of the verb *to be* (*am, are, or is*). A variation theory analysis suggested that the students’ focus on single words (instead of the words in the text as a whole) made it hard for them to discern the pattern of use of the three different words. To recognize the usages in a text did not offer them a real challenge, especially when they had been introduced to the words already by the teacher. In English Research Lesson Two, the content showed a new group of students which words represented the forms to use of the present tense of *to be*. The content itself seemed to draw less attention to the words that determine the correct form to use. Not until blanks were inserted in the text did the students have to search for clues in the text to guide them to find the right form.

The learning study cycle in literacy with Swedish as the first language also included worksheets. The learning object was quite different, and use of the worksheet affected the learning outcome differently. In contrast to the learning study cycle in English as the second language, the best results in the learning study cycle in literacy were obtained when the worksheet did not include blanks, but why? The challenge in this study was to find the target words that included *tj* sounds by listening to them in a text. When blanks were put in the worksheet, the students did not have to listen any more because they could see which words were needed by the visual representation of the blanks. In other words, they could afford to stop listening to the sounds and look only at the differences between the two groups of words.

Similarly, the students in the learning study cycle in English as the second language had to focus on the text as a whole in order to find the words *am, are,* and *is*. This suggests that the focus on why the different representations appeared as they did was not discerned. Could the teachers in the learning study in literacy with Swedish as the first language have changed how they used the blanks to make another pattern of variation for the students to discern? If they had used blanks in the words containing both *sj* sounds and *tj* sounds, they had to think more carefully about the spelling because the words *(skj)unta* (shoot) and *(tj)unta* (scream) would look the same in a text with blanks. However, the distinction between the words is in the initial sounds, expressed in different ways to spell them. This means that the variation could be opened up to include two different groups of words, between which the students had to distinguish. However, too much variation does complicate the learners’ ability to discern those aspects that are critical, and we think that the many different ways of spelling would have been too confusing. In the learning study cycle in literacy with Swedish as the first language, the learning object was to spell words that included the *tj* sound. If blanks had been used for this, variation theory suggests that the different ways to spell would be too many and complicate the students’ possibilities to focus on how to spell the *tj* sound. First, the variation between two groups of words, differentiated by the *tj* and *sj* sounds, has to be focused. Second, the different ways of spelling those words differentiates between the two groups. To find the patterns in both of them would demand the discernment of many aspects. Thus, the variation might be too large, making it hard to see what varies and what is constant, and the pattern would be hard to discern.

Using a theory about learning to examine learning and education gives teachers increasingly precise knowledge about what matters in a learning situation and how to choose which aspects to change and which to keep constant. The two studies discussed
in this chapter show small differences in the use of the method, which had important influences on the learning outcome. By using a theory in an iterative fashion, the teachers and researchers were able to try out different designs to see if one proved more powerful than the other. Analyses of the lived object of learning, shown in the students’ learning outcomes, enabled the teachers and researchers to revise the plans for how the intended object of learning should be enacted with a new group of students. Different patterns of critical aspects, shown by different dimensions of variation, caused different learning outcomes. The knowledge the teachers gained by using this model at school developed their understanding of what it takes to learn an object of learning, which, in turn, enlarges the students’ opportunities to learn. On the other hand, by documenting and analyzing the entire process in a learning study cycle (including the meetings with the teachers and the observations of how the teachers’ and students’ knowledge develops), the researchers were able to learn about the learning process. The questions that have to be asked in this kind of study are: What features of the learning task should be varied in order to support learning? Do these variations inform us about why, in the same learning environment, some students learn but others do not?

In this chapter, we showed how the use of variation theory can guide lesson design. In a learning study cycle, teachers can create a new lesson after the first and second research lessons. They have the opportunity to take into consideration the insights from the previous lessons to make an even more powerful way of creating knowledge with their students. Although each group of students participates in only one research lesson, the teachers have the opportunity to teach the same lesson three times to a new student group each time. This makes it possible for them to reflect upon three different designs and how each design affects the students’ learning outcomes. The theoretical insights about learning and education can, and should, be shared both by the researchers and the teachers in order to make better learning circumstances for the learner. In the third research lesson with the students in group 3 in the learning study cycle in English as the second language, we found that the learning outcome increased in nearly all of the items except two (these were “Sarah and I are” and that are follows “you” in both the singular and plural), which was surprising. By analyzing the video sequences from this research lesson, we found the critical aspects that misled the students. Those were the ways that the teacher stressed the fact that, after I, am is always used, and are is always used when there is more than one object.

The design of this study, in which learning study was used as a method, gave researchers, teachers, and students increased knowledge about the learning object. The combination of a design experiment and a lesson study enables a learning study to be used to teach the same lesson to several different student groups (by giving the research lesson once to each student group) and to incorporate the results of one research lesson into the next one (by analyses of the test results and the data collected from the lesson itself). This makes it possible to improve the instruction and to study if the suggested improvements had the expected effects. Because pre-, post-, and delayed post-tests were used, it was possible for us to take into account the students’ readiness for, and knowledge of, the learning object before, after, and four weeks after the research lessons. The very strong focus on how the students think, which is studied with the phenomenographic approach (Marton et al., 1977), makes the teachers concentrate more on the experiences that the students have than on those that they want them to have. This means that the instruction is modified more to take into account the students’ points of view than it might be otherwise. The teachers’ assumptions do not consider how the learning object is experienced by the students. When someone has performed a task already, it is like having read a detective novel already and then trying to forget who the
killer was in order to be able to read the novel again and experience the original feelings of excitement and curiosity. When you have experienced the critical aspects of phenomena previously, it is impossible to understand what the phenomena would look like if you were not aware of one or two of their critical aspects.

Teachers often have an idea of what it takes to learn, but this idea emerges from the “expert” point of view. Sometimes, it is hard to tell what it takes to learn when you know the subject matter already. When you do not know the subject matter, it may be impossible to know what it takes to learn it. This paradox has to be dealt with in combination with the already learned and the going-to-be-learned perspectives. If the teacher’s and the students’ views of the learning object do not coincide, learning will not take place. Similarly, if we, as researchers, want teachers to use theories about learning, we have to recognize and acknowledge their thoughts and beliefs in order to know what it takes to learn how to use a theory in educational practice. The learning study is both a model, which can be used in teachers’ in-service training, as well as a method used by researchers to capture the students’ ways of seeing phenomena. In a learning study, teachers are introduced to a scientific theory about learning. The possibility for learning study to be used both as in-service training for teachers and by researchers is another facet that shows how lesson study and design experiment are combined into the learning study method. The manner in which teachers have to work in a learning study cycle forces them to focus on the intended object of learning in a theory about learning. The theory helps inform them how to vary their instruction in order to increase learning. To date, the three-fold aim to improve learning for students, teachers, and researchers has been fulfilled in the 18 learning study cycles that have been carried out in this research project.

Acknowledgments
In Sweden, the Research Council has started to strengthen praxis-related research at schools by establishing a Committee for Educational Science. The project mentioned in this chapter, called the Pedagogy of Learning, is one such activity financed by the Swedish Research Council.

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