

Teachers' learning in a learning study

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Abstract The point of departure in this study is the question: do teachers who develop theoretical knowledge of the variation theory change the way(s) they offer their pupils the object of learning due to the theoretical framework. The aim of the study is to describe this development, i.e. to find if and how teachers developed theoretical knowledge when planning instruction, and in what way(s) this has an impact on the pupils' learning outcome when using contrasts in the instruction. The theoretical framework is strongly content related, and by analysing the learning object's critical aspects the teachers are guided to focus on the content in this particular way. The question "what does it take to develop knowledge about the object of learning?" has to be answered by the teachers before choice of teaching method is made. The research method used is Learning Study, a fusion between lesson study and design experiment. The teachers (6) have carried out nine research lessons in three Learning Study cycles (containing three lessons each). The pupils belong to three different classes and are between 9 and 11 years old. The result shows how the teachers gradually use the variation theory when planning instruction and how the learning outcomes shown by the pupils improve. The developed theoretical insight seems to affect the teachers' ways of seeing the object of learning, such as subtle changes of how to organize the critical features of the learning object, are discerned. In every learning study cycle contrasts are used in one lesson, and in the analysis of the effect of the contrasts, the two remaining lessons are used as control groups. The results show the impact of contrasts in the pupils' learning outcomes. The need to complement a lesson study with a theoretical perspective on learning is that the teachers are then given the opportunity to make use of the theory when planning instruction individually, not only in a lesson study. There again, the Learning Study model seems to be a powerful model with which to develop teachers' understanding of the theoretical framework.

Keywords Variation theory · Learning study · Teacher learning

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Introduction

In a study of teachers' lesson plans, interesting differences were found concerning what possibilities teachers were given to plan education in different countries. Shen et al. (2007) show that teachers in the USA have approximately 30 min at their disposal to plan and teach six to seven lessons per day, while teachers in China only teach one or two lessons per day and therefore have much more time for planning and cooperation with other teachers. Chen et al. consider this as one of the reasons why teachers in the USA have not developed extensive or in-depth lesson plans about the subject matter. As a contrast to these results, a study from Hong Kong (Lee 2008) shows that teachers have a heavier workload, which makes it more difficult to find time to work with lesson studies. It can therefore be assumed that the time for lesson plans in Hong Kong deviates from the results in Chen et al.'s study. In the plans, the learning objects are defined and delimited, and descriptions of what is required in order to understand the phenomenon (i. e. the critical aspects) and in which way variation of the critical aspects will be used in the learning situation are presented.

In one of our previous studies (Gustavsson 2008), the results showed that the teachers' ways of experiencing learning studies could be linked to three categories:

- a. The teachers directed their awareness first of all to different methods without connection to the lesson content.
- b. The teachers directed their awareness first of all toward the content and how to handle the object of learning.
- c. The teachers discussed how to handle the object of learning in terms of the variation theory. (Gustavsson 2008, p. 160)

The results also showed that the teachers did not commonly reflect upon the content in terms of different ways of understanding; it was more or less considered as manifest and predetermined. On the other hand, methods were discussed much more frequently, often with no relation to the chosen learning object. The results made us question if this was related only to this group of teachers, who were working at different schools with no contact with each other in their daily work. By that, their discussions might not have been as reflective as they should have been if the teachers worked together with the same group of pupils. Instead, this study is based on a learning study made by teachers working in a team at one school to find out if their ways of experiencing is the same or differs from Gustavsson's findings.

Theoretical assumptions

The study described in this paper takes its departure in variation theory (Marton and Booth 1997; Marton 2000; Runesson 1999; Holmqvist et al. 2008). This means learning is analyzed on the basis of the concepts *discernment*, *simultaneity* and *variation* (Holmqvist and Mattisson 2008). In variation theory, all three components are required in order to make learning possible. Learning is defined as a new way to experience the environment, which means the learner has to discern new aspects of the phenomenon that will be learned (Marton et al. 1977; Marton 2004). These aspects are discerned simultaneously with other aspects, and the experiences vary depending on how the individual combines the discerned aspects into a whole. In order to discern these aspects, a variation must be offered, i.e. a number of different aspects that can be experienced

(Marton and Booth 1997; Marton and Morris 2002). For example, if we e.g. consider the taste of an apple on the basis of all those tastes other apples have, we can decide if the apple is sweet or sour (discernment). This experience link can be linked to another aspect—the colour of the apple—and we learn gradually that a certain colour or an apple's appearance can be linked to a special taste (simultaneity). But it is not possible to develop this knowledge until we have experienced a variation of apples; it cannot be developed if we have experienced only one type of apple (variation). By that, we separate the focused object from other objects, uses fusion to find similarities between different objects and by that develop an ability to generalize. In this study contrasts are used, in one lesson in each learning study cycle, as a tool for instruction to make it possible to offer the pupils to experience the learning object in such a way.

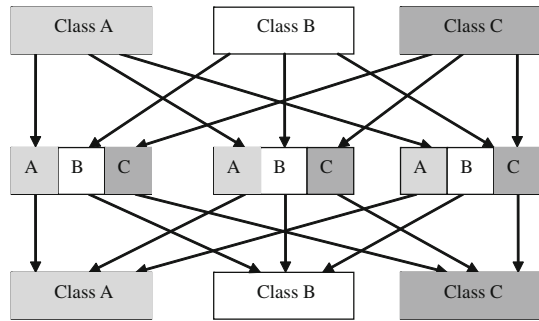
Variation is applied also in Shen's et al.'s (2007) study. In the description of how a lesson is planned, the intention to find a pattern of variation in the examples used during the lesson is highlighted. This is in accordance with the assumptions on which variation theory rests. Both the lesson plans Chen et al. describe and the theoretical assumptions of variation theory emphasize variation of the organization of features within the learning object, as opposed to variation of method (Holmqvist et al. 2008).

Implementation

The aim of the study is to describe this change of perspective during three focused learning studies of how teachers develop theoretical knowledge. Special attention is paid to the importance of focusing on content when planning instruction, and in what way(s) this has an impact on the pupils' learning outcome. The method used in the studies presented is learning study (Marton and Tsui 2004; Holmqvist et al. 2006, 2008). A learning study consists of a number of stages, and starts with the choice of a learning object to be handled in a teaching situation. A lesson is planned jointly by the teachers and researcher, and is implemented by one of the teachers in one group of pupils. The pupils take one pre-test before the lesson and a post-test after the lesson. The results are analyzed along with video-recorded lessons. The knowledge about the pupils' developed learning during this first phase provides the basis for the development of a new lesson in a new group of pupils. One learning study was implemented per semester (Learning Study A, B and C), for a total of three semesters, which means that three different learning objects were focused upon. In this study, three micro-cycles form a macro-learning study cycle (Learning Study A includes lessons A1, A2 and A3). The participants in the study were six teachers, their pupils and researchers. The teachers were included in a team at a school for pupils aged 10–12 years. The numbers of participating pupils in the first learning study were 54 (23 boys and 31 girls) in school year 5. During study two 64 pupils were included (29 boys and 35 girls) in school year 4. In study three 48 pupils participated (26 boys and 22 girls) in school year 4. In all learning studies the pupils were divided into three new groups as shown in Fig. 1.

The subject studied was English as second language. The design of the learning study has followed the model developed by Marton (2003), Lo et al. (2005) and Holmqvist (2006). This means the teachers chose which learning object to focus, based on their knowledge about the pupil's previous understanding as well as a letter each pupil had to write to the researcher. The analysis of the letters was made in cooperation with the teachers. Before each lesson, two to four tape-recorded meetings to plan the lesson and find

Fig. 1 Pupil-groups in the research lessons (Holmqvist et al. 2006)



the critical aspects were held. After the lessons, which all were video-recorded and transcribed verbatim, an analysis was made and compared with the results of the tests taken by the pupils (pre-test, post-test and delayed post-test). Finally, all the three learning study cycles (including three lessons each) were analysed and compared with each other, as well as the teacher's meetings.

In the first learning study cycle, the teachers only got a brief introduction on the variation theory together with some articles to read (Marton and Booth 1997). The researcher played an important role to introduce the concepts of the variation theory during the meetings with the teachers, on a general level, but the design of the instruction and the work-sheets or group-work was made by the teachers. The tests were made in collaboration between the teachers and the researcher. Before the second learning study cycle, the teachers participated in a lecture given by professor Ference Marton on learning study, and he also participated on meetings twice during the research period, as he was a member of the research team lead by Holmqvist (The Pedagogy of Learning).

Results

Learning study A

The first study was carried out in school year 5. The learning object was possessive pronouns. The teachers met in order to plan the study on 4 occasions, and the critical aspects was identified Holmqvist et al. (2008):

The focus of the analysis in the first part of the learning study is, as already explained, to demonstrate how the targeted knowledge is constructed, identify the teacher's goal(s), and ascertain what the pupils have learned. It is also designed to illustrate the relationship between what pupils *demonstrate* that they have learned, and what they were *given the opportunity* to learn. In order to demonstrate the difference between the pupils' knowledge before and after the lesson they were asked to complete a test without prior warning: no previous instruction had been given on the subject. The learning object in this study was dependent possessive pronouns (Taylor 1996). After a four-week interval, the pupils were asked to fill in a post-test, which was identical to the original one, though the sentence order was changed and all names replaced by new ones. The pupils were asked to translate the following Swedish sentences into English (figure 2).

Translate into English, please.

1. Tycker du om din syster [Do you like your sister]?
2. Jag tycker om min cykel [I like my bicycle].
3. Deras skola är blå [Their school is blue].
4. Hans T-shirt är ny [His T-shirt is new].
5. Hennes katter är svarta [Her cats are black].

Figure 2. Pre-test, post-test and delayed post-test (p 90)

The teachers reflected upon what was important to offer the pupils in order for them to discern about the learning object, strongly based upon the structure the pupils had already learned about the learning object. Secondly, the teachers emphasized a wish not to complicate the learning situation or to confuse the pupils. As a result of such assumptions, the teachers chose not to discuss independent possessive pronouns (e.g. mine and yours) during the lesson. The first lesson (A1) was implemented very systematically; each personal pronoun was linked to a possessive pronoun in a table (in–my, you–your and so on). When the pupils mentioned an independent possessive pronoun, the teacher chose to redirect the question and guide the pupils' focus to the dependent possessives (e.g. my and your).

The teachers' opinion about the systematic way of teaching was strengthened because the post-test showed improved ability (Table 1). Despite this, in the following meeting the teachers discussed the lack of opportunity for the pupils' own experiences to govern the lesson to a higher degree, since the first group of pupils proposed independent possessive pronouns without getting them discussed during the first lesson. The second lesson (A2) was therefore based entirely on the pupils' pre-understanding. The teacher wrote the words the pupils gave as proposals for possessive pronouns ("words that show that someone owns something"). Then he grouped the words for them, and the difference between dependent and independent possessive pronouns was clarified. The post-test (Table 1) showed that the pupils in A2 had not developed their knowledge as much as the pupils in A1.

The results confirmed the teachers' view that to simplify the instruction and introduce the pupils bit-by-bit, systematically and one aspect at a time would be more successful for the pupils' learning. The instruction in the third lesson (A3) was re-directed to the systematic schedule of personal pronouns and possessive pronouns. The difference between the first (A1) and the third (A3) lesson is that the pupils in A3 were introduced to a systematic structure of both dependent and independent pronouns. In A1, the systematic structure of dependent pronouns was presented, and in A2 the pupils made their own structures of both dependent and independent pronouns (experimental group using contrast). The results showed that A1 was most successful in the short run, i.e. in the post-test directly after the lesson. In the delayed post-test four weeks after the research lesson, the result was contrary to the result of the post-test immediately after the lesson.

Table 1 Results of learning study on possessive pronouns (average scores)

	A 1 (<i>n</i> = 19)	A 2 (<i>n</i> = 17)	A 3 (<i>n</i> = 18)
Pre-test (1)	2.16	2.08	2.23
Post-test (2)	4.02	3.47	3.79
Diff. 1 & 2	+1.86	+1.39	+1.56
Delayed post-test (3)	2.97	2.94	2.82
Diff. 2 & 3	−1.05	−0.50	−1.15
Diff. 1 & 3	+0.81	+0.86	+0.59

The result showed how the pupils in group A2, who had not been introduced to the systematic structure (the tables with personal and possessive pronouns), had developed most knowledge in a long-term perspective. It seems that during the lesson the pupils had been opened up for other learning possibilities than had the pupils in lessons one and three.

In this first learning study cycle (A), it was methods that dominated in the discussions with the teachers, in line with category (a) of Gustavsson's work (Gustavsson 2008). The content was not questioned; the teachers had chosen to accept the systematic structure with which they were already familiar. The focus was not one the pupils' own preunderstanding. What was discussed regarding content was the need for delimitation, but not in terms of what is required in order to understand the learning object. Instead, the teachers had an attitude that learning will happen if the instruction is sequential and can be carried out systematically according to a kind of predetermined schedule. The teachers did not discuss what would be critical for the pupils' learning. Their ambition to link the personal pronoun of the subject together with the correct form of the dependent possessive pronoun was clear (e.g. I—mine, you—your etc.). During lessons A2 and A3 a contrast was introduced between dependent and independent pronouns, but the analysis of the results made the teachers return to the more systematic structure of method that characterized lesson A1. The result in the long-term perspective showed how the pupils in lesson A2, who did not receive the structured system, nevertheless seem to have developed a deeper ability and actually seem to retain more knowledge about the learning object in a long-term perspective. This result meant a breakthrough in the discussions among the teachers, and their previous assumption about how the learning object would be learned systematically began to be questioned. It is not possible to claim that the teachers would be classified into category a according to Gustavsson (2008), since they actually had an idea about how the learning object was defined; in one way or another, knowledge about the content of the subject decided choice of method, which means they actually focused on content before method. On the other hand, they did not discuss the content on the basis of its critical aspects.

Learning study B

The second learning object was “to be” in present tense (am, are, is). In the general planning of the second (B) learning study cycle, the teachers returned to the result of the first study (A) and established how important it is to take into consideration the pupils' pre-understanding of the learning object. At the same time it is important to consider the characterizing features of the learning object. A pre-test was given the pupils, which showed their abilities:

The results of the scanning test were analyzed in categories that indicate 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 the ability 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:

- 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, it 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. (Holmqvist et al. 2008, pp 118–119)

The discussion shifted direction from focussing on method to how to make it possible for the pupils to be made aware of the differences among the various critical aspects through introducing them simultaneously instead of in sequence. The pupils' pre-understanding and the critical aspects were defined in a detailed way (Holmqvist et al. 2008). This resulted in that both—I/am, he/she/it is, you/we/they are—were introduced simultaneously. In this study (B), the teachers had clearly shifted their attention to content; they discussed the learning object on a much more detailed level, as well as what the critical features could mean for the pupils.

The most interesting result is how the teachers' discussions about the learning object led them to revise the work sheet used in all three lessons. The work sheet was changed in line with how the teachers' understanding of the learning object had developed. The work sheet's design in the first lesson (B1) is shown in Fig. 1. The pupils were given the opportunity to experience the learning object (*am/are/is*) at the beginning of the lesson, when the teacher had a dialog with the pupils to find all three words of *to be* in present tense. After the pupils had identified the words, the teacher contrasted singular and plural form. Finally, the pupils worked in groups when they discussed the work sheet (Fig. 1). The worksheet was prepared to make it possible for the pupils to experience the difference between the learning objects' critical aspects such as; *my sister is/my brother is* but *my sister and brother are* and *mother is/father is* but *my parents are*.

After lesson B1, the teachers thought the task was too simple, as the pupils had already found the words in the dialogue in the beginning of the lesson. They only had to identify the words in present tense (*am/are/is*) in a text. They did not need to understand the meaning of the entire text or to look for contexts in order to understand what should be in present tense, and thereby they missed the connection between the word and what decides which form of *to be* is used. Before lesson two (B2), the teachers decided to start with the text in the work sheet. This was done to make the pupils search for the words in the text before the teacher had started the dialogue. However, this was not very successful; the short-term results were lower than the results in lesson one (B1). In the meeting where the instruction for B2 was planned, the teachers considered that the pupils still failed to find what decides which form of the infinitive verb to use. The pupils failed to see the

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 fish. They are orange. We are British.

Fig. 2 Work sheet lesson one and two

connection between the infinitive verb and the pronoun. The results also showed that the pupils had not yet understood the difference between singular and plural forms.

Before the third lesson in this cycle (B3), a change was made in the work sheet's design. The sentences were made as fill-in-the-gap tasks as shown in Fig. 2.

As the words are missing, the pupils were forced to discuss and justify their choice of word (am/are/is) to each other. That offered them a possibility to discern what decides the choice of verb. Another change was to exclude unnecessary information. Instead of dividing up all plural forms (we are, they are, you are) the teacher decided to emphasize the pupils to use *are* always if more than one person or item is involved. The results show that B3 was the most successful in a short-term perspective. However, in a long-term perspective the results were not as good as one might expect. The teachers' focus was definitely set on the content differently from the systematic structure that they previously preferred. Instead, the focus was on the organization of the content, and thus they might have discerned subtle changes and critical features of the learning object that are decisive for the pupils' ability to learn. It seems as the instruction used in lesson two, where the pupils were offered to discern singular in contrast to plural, and did not know the words am/are/is in advance, developed a more sustainable knowledge. They had to contrast these words with all other words to gain knowledge about which words mean to be in present form. Table 2

Learning study C

In the third learning study (C) the learning object was "to have". The critical aspects were found in a much more detailed way (Holmqvist and Mattisson 2009). This was also seen in the way the test was constructed:

The test, as in the previous screening process, included 15 sentences of varying degrees of difficulty:

- A. Knowledge that there are two English equivalents of the Swedish word "har."
- B. Knowledge of how to use the two different words ("have"/"has") with different personal pronouns.

Table 2 Results of learning study on the infinite verb *to be* (average scores)

	B 1	B 2	B 3
Pre-test (1)	5.5	7.8	8.6
Post-test (2)	11.1	12.4	16.5
Diff. 1 & 2	+5.6	+3.4	+7.9
Delayed post-test (3)	8.1	11.2	12.1
Diff. 2 & 3	-3.0	-1.2	-4.4
Diff. 1 & 3	+2.6	+3.4	+3.5

- C. Knowledge of how to use “have” and “has” when words other than personal pronouns are identified in the sentences, including the difference between singular and plural.

The test included different degrees of difficulty, as presented below (from Holmqvist et al. 2007):

1. *I **have** a bike.*
2. *You **have** blue eyes.*

In these sentences, the personal pronouns are singular, while the nouns are plural, which could confuse pupils who do not understand the meaning of the sentence.

3. ***Have** you got a dog?*

The change of word order in sentence 3 can be more problematic since the sentence includes both “you” and “a dog (it).”

4. ***Has** he blue jeans?*

In sentence 4, both “he” and “jeans” could refer to “has.” It cannot thus be determined if the pupil made a mistake in agreement or not.

5. *My father **has** a green car.*

“Has” could apply to both “my father” and “green car.” Sentence 6 was so constructed to ensure that the pupil knows which word determines the use of “have” or “has.” The pupil must know that “[m]y father” should be followed by “has,” but “two children” by “have.”

6. *My father **has** two children.*
7. *She **has** breakfast at eight.*
8. *The dog is nine years old, and it **has** a big nose.*

Sentence 8 is less difficult than 9 since it includes “it.”

9. *The flower **has** beautiful colours.*
10. *We **have** one house.*
11. *Sarah and I **have** dinner at five.*

Here it is possible to connect “Sarah” with “has,” which could be confusing as the relationship between “I” and “have” is not usually a problem for the pupils. If the latter do not know the rules governing singular and plural forms, it is difficult to pick the right word. Sentence 15 was included to ascertain if the pupils had a clear picture of the difference between the forms.

12. *There are 67 pupils in your class. All of **you** *have* got pencils.*
13. ***They** *have* two cars.*
14. ***They** *have* an umbrella.*

In sentences 13 and 14, “they” is plural while “an umbrella” is singular. A pupil must know what to look at in the sentence in order to pick the correct word.

15. *Sam and Tom *have* got a cat.*

As already mentioned, in this sentence the pupils could be confused by “Sam has” and “Tom has” but “Sam and Tom have” if they are not familiar with the difference between singular and plural forms and their implications. If they do not understand the meaning of the sentence, they could also be confused by “a cat.” (p 42-43)

In the first lesson (C1), the contrast was used with am/are/is in order to clarify similarities and differences between these learning objects. A text was used approximately in the same way as in the previous study (Fig. 3). The task was to find all “to have” words and to explain why they differed in different places in the text. To make the pupils notice one critical aspect, they are invited to notice that two words could be hidden behind she’s and he’s– s/he is or has. The critical aspect is to simultaneously notice the possible words is and has, together with the meaning of the sentence as such, to understand which word is the intended. Without noticing this critical aspect, the pupils might understand ‘s consistently as is. Figure 4


The same group of pupils that participated in learning study B participated in this study. In contrast to the first study (A), the teachers considered the weak development of the pupils in group 1 (C1) in the short term (Table 3) as an indication that a change was required. In the previous study (B), the division of the different forms of plural was removed, and was found to affect the pupils’ learning positively. Therefore, the conclusion was made that information about am/are/is is unnecessary for developing knowledge about “to have”, and this contrast was cancelled. Contrasts were instead made between the differences between singular and plural forms, since the knowledge in this area was not developed in the previous lesson as one could wish. The differences between C1, C2 and

- My name ____ Bill.
- I ____ ten years old, and I live in England.
- My sister ____ six years old, and my brother ____ four years old.
- My sister and brother ____ sick today.
- My mother ____ at work and my father ____ at home with my sister and brother today.
- Both my parents ____35 years old.
- We have got a dog. The dog’s name ____ Tam.
- My sister has got two fish. They ____ orange.
- Their names ____ Sim and Sam.
- We ____ British.

Fig. 3 Work sheet lesson three

Hello!

I have a friend called Sarah.



This is Sarah. She’s rather short, and she’s got long brown hair. She lives in Toddington – in a house not far from mine. She’s got a cat.

I’ve a sister and a little brother. We have a big dog. He’s an Old English Sheepdog. He’s got big brown eyes. My sister has a rabbit. It’s got blue eyes. Do you have any pets?

Bye from
David

Fig. 4 Work sheet learning study three

Table 3 Results of learning study on the verb *to have* (average scores)

	C 1	C 2	C 3
Pre-test (1)	15.7	13.1	14.4
Post-test (2)	18.1	18.4	19.5
Diff. 1 & 2	+2.4	+5.3	+5
Delayed post-test (3)	19.1	15.5	16.8
Diff. 2 & 3	+1.2	-2.9	-2.7
Diff. 1 & 3	+3.4	+ 2.4	+2.4

C3 were the teacher's ways of using contrasts and variation during the entire lesson. In lesson C1, the contrast between *am/are/is* and *have/has* was used during the entire lesson. The difference between lesson C2 and C3 is small and mostly concerns the order of the parts of the lessons—lesson C2 starts with a dialogue while lesson C3 starts with a discussion about the text the pupils got.

The results show that learning in a long-term perspective was highest in C1, where the contrast between *am/are/is* and *have/has* was introduced. In the discussions with the teachers, this success has been explained as the pupils' having developed a special ability to see rather subtle differences between critical features that seem to be crucial for developing knowledge about the learning object beyond but in line with the learning situation. This has also been described in other studies, a phenomenon referred to as generative learning (Holmqvist et al. 2007). This is a kind of transfer, which Marton (2006) has discussed as a function not only of sameness but also of differences.

Hypothesis testing

According to the findings above, a twofold hypothesis was generated. First, the experimental treatment (including contrasts; A2, B2 and C1) was expected to lead to greater long term gain than the alternative treatments, according to Marton's (2006) findings. For simplicity of exposition, the two control treatments were collapsed into one group and compared to the experimental group by t-tests for independent groups. Second, a particular pattern of changes was expected. The experimental group, although undergoing greater long-term change, would probably not show evidence of their long-term gains on the first post-test occasion. The use of complex contrasts in the learning situation could possibly put them at a disadvantage in the short perspective, their advantage coming to the fore only by the delayed post test. This profile of changes over time was tested by a repeated measures analysis of variance, using trend contrasts to capture the patterns. Trend contrasts (Rosenthal & Rosnow, 1985) over three measurement occasions can be either linear or quadratic. The present hypotheses encompassed both. The trend contrasts were expected to interact with group membership, such that the linear contrast (from pre-test to delayed post test) would rise more markedly for the experimental group. Further, the quadratic trend contrast could be expected to show a more pronounced inverted-U pattern for the control group, with an early rise followed by a decline.

Test scores were converted to proportions by dividing them by the maximum number of points attainable. Further, proportions were arcsine transformed (Kirk 1995) to conform to normality. Proportions quoted in text or illustrated in figures have been converted back by the inverse transformation. The t-tests were performed for each experiment separately, whereas the more power-demanding test of the trend contrasts was performed over all three

experiments jointly. The t-tests did not uncover a significant advantage for the experimental group in any of the experiments. In experiment 1, the experimental group (A2) showed a larger long-term gain, but the difference did not reach significance ($t [51] = 1.30; p < .2$). In experiment 2, there was no tendency towards a difference between the groups ($t [62] < 1$; N.S.). Finally, in study 3, long-term gain was again larger in the experimental group (C1), although not significantly so, ($t [46] < 1$; N.S.).

The test of the change profiles was designed as a $3 \times 2 \times 3$ repeated measures ANOVA, with two between subjects factors, experiment (three levels), treatment (two levels experimental versus control), and measurement occasions (three levels, pre-, post and delayed post). The effect of critical interest was the interaction between experimental group and measurement occasion. This interaction proved to be significant, $F (2, 318) = 5.78; p = 0.003$. Decomposing it into trend contrasts showed a reliable quadratic trend, $F (1, 159) = 11.43; p = 0.001$. The linear trend interaction was not reliable. The results give modest support to the hypothesis that learning trajectories over time are affected by the experimental treatment (using contrasts). However, larger numbers of participants would be needed to demonstrate reliable effects on long-term gain in performance. Figures 5, 6, 7

Fig. 5 Learning study A.
Experimental lesson A2

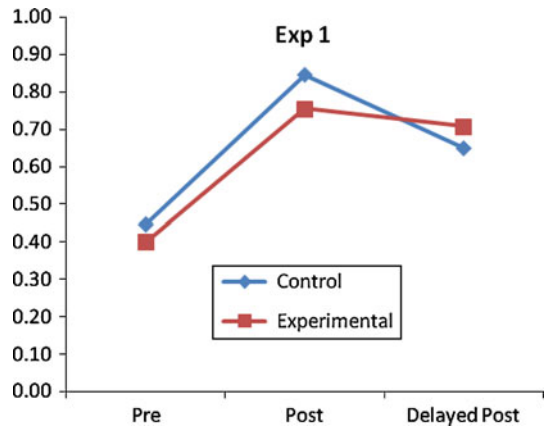


Fig. 6 Learning study B.
Experimental lesson B2

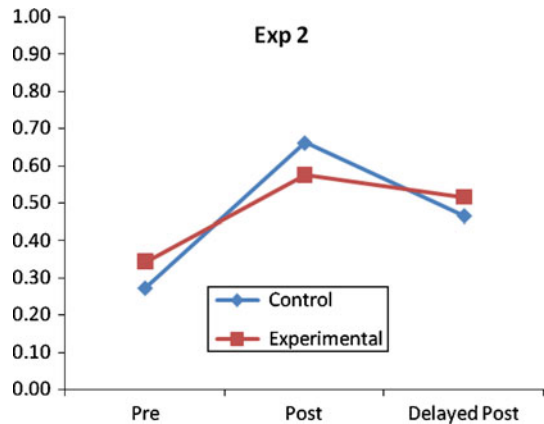
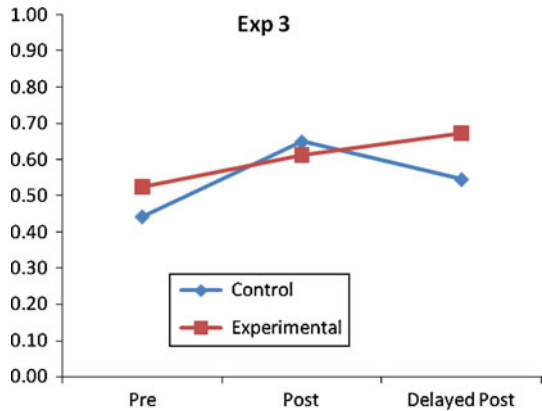


Fig. 7 Learning study C.
Experimental lesson C1



Discussion

Although the differences in results of the tests taken by the pupils are small, making it possible to talk only about tendencies, there are some interesting findings. The two most important results are, firstly, the teachers' increased ability to discern critical features of a learning object in relation to the pupils' ability to learn. And secondly, the teachers changed their way(s) of offering the pupils the object of learning, from a more general way to a much more specified content-related way. The teachers' focus changed during the three semesters when the studies were carried out, and the results show that the movement from a more general level to a detailed level can be described as an increased ability to analyze the critical features of the learning object. They have developed an ability to find the crucial differences in how they offer the pupils the critical aspects of the learning object and in what way(s) those changes determine the pupils' possibilities to learn. Especially the changing of a work sheet in the second Learning Study (B) shows how the teachers analyze the learning object in relation to the pupils' ability to discern the critical aspects. The change served to make the pupils simultaneously focus on the connections between personal pronoun and the form of the verb to be, instead of focusing on each part separately.

As the teacher become more able to clarify the specific parts of the object of learning, in a way that gives the pupils the opportunity to learn, the results seem to improve. Study A shows that the teachers initially have a clear taken for granted-idea about the content, and are convinced that the learning object will be learned following a defined structure. The problem is that they do not question this idea on the basis of the pupils' actual understanding or ability to understand. The perspective of those who have already learned (the teachers) colours the perspective of those who have not yet learned (the pupils). However, during Learning Study A the teachers' taken for granted perspective was questioned, and thereby they opened up for new possibilities to see learning in Learning Studies B and C. In Learning Study Cycles B and C the teachers do not use the taken for granted-perspective, instead they pay attention to all kinds of reasoning about the object of learning to find the critical aspects in the pupil group.

The results also show that teachers' focus is not necessarily mainly on the contrast between method and content, as found in Gustavsson's study (2008). The focus seems instead to be the grade of specification of the learning object and in what way the teachers move from a general to a more specified level. If the teacher can clarify these specific parts

in a way that gives the pupils the possibility to learn, the results seem to increase. However, as study A has shown, it is not necessarily the method teachers have in mind when the content is not discussed. Study A shows that the teachers have a clear idea about the content, and are convinced that the learning object will be learned following a defined structure. The problem is that they do not question this idea on the basis of the pupils' actual understanding or ability to understand. The picture of what has already been learnt colours the perception of what has not yet been learned.

One explanation for why the teachers have developed this attitude might be explained by the shortage of time. The teachers' shortage of time might make them gladly see fast results, but long-term results cannot be ascertained. The short-term responses from the pupils suggest a way to teach that gives an impression of being powerful. Not until the teachers are confronted with the pupils' results on short-term as well as long-term perspectives do they seem to reevaluate their practical knowledge, developed through the pupils' responses to their instruction. Even if the teachers use the theoretical concepts in their planning, they still have a tendency to handle one item at a time. As variation theory focuses on the differences or relations between phenomena, the teachers' practical knowledge confronts the assumptions made by variation theory. The tendencies in the results of the pupils' post-tests support the teachers' practical knowledge, but the results of the delayed post-test support the variation theory assumptions. In order to try to also understand the teachers' learning in a long-term view, in 2008 they were asked if they had used variation theory and learning study after the project was completed in 2004. One teacher replied:

Yes, I plan my instruction on the basis of the theory. On some occasions several of us teachers have been planning together.

It seems as though it is easier for teachers to use the theoretical perspective in their daily teaching than to implement new learning studies independently. The shortage of time, as mentioned earlier, is an issue commonly raised. One reason that confirms the need to complement a lesson study with a theoretical perspective on learning is the teachers' possibilities to use the theory when planning instruction individually, even if in the future they may have difficulty implementing new learning studies because of lack of time. On the other hand, the learning study model seems to be working as a good method when developing teachers' understanding of variation theory. Their knowledge and understanding of this theory has gradually developed in line with the results of analysing the pupils' learning. Consequently, this combination seems to be successful.

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