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This is the accepted version of a paper published in *Scandinavian Journal of Educational Research*. This paper has been peer-reviewed but does not include the final publisher proof-corrections or journal pagination.

Citation for the original published paper (version of record):

Asplund, S-B., Kilbrink, N. (2018)

Learning How (and How Not) to Weld: Vocational Learning in Technical Vocational Education

*Scandinavian Journal of Educational Research*, 62(1): 1-16

<https://doi.org/10.1080/00313831.2016.1188147>

Access to the published version may require subscription.

N.B. When citing this work, cite the original published paper.

Permanent link to this version:

<http://urn.kb.se/resolve?urn=urn:nbn:se:kau:diva-43561>

# **Learning how (and how not) to Weld: Vocational Learning in Technical Vocational Education**

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**Abstract**

This article focuses on vocational learning in technical vocational education in upper secondary school, with a special focus on the object of learning to weld. A concrete teaching situation where the learning object to weld is the focus of the interaction between a vocational teacher and an upper secondary student was documented by a video camera and then analysed from two different perspectives: a conversation analytical and a variation theory perspective. The combination of the two perspectives allows studying learning that deals with issues regarding both form and content, which may increase our understanding of vocational learning in technical vocational education in upper secondary school.

Keywords: Vocational learning, vocational education, conversation analysis, variation theory, technical vocational education

A recurring question in educational settings is to understand the relation between teaching and learning and how to create efficient learning environments where students learn what they are supposed to learn (Emanuelsson & Sahlström, 2008; Marton & Tsui, 2004). The importance of studying learning in school practices is highlighted in different studies (Carlgren, 2009; Freebody, 2013; Sahlström, 2008), but there is a striking lack of such studies in vocational education (Berglund, 2009; Pahl, 2014). The previous research in the field of vocational education has mainly focused on historical or sociological issues. Less frequent is research on teaching, learning and learning content from both a teacher and a learner perspective (Berglund, 2009; Lindberg, 2003; Nylund, 2013; Young, 2006, 2008). In order to broaden the knowledge of learning processes in educational settings, the relation between teaching and learning in the classroom, with a focus on different learning content needs to be studied (Carlgren, 2009; Emanuelsson & Sahlström, 2008; Jones, Bunting, & de Vries, 2013; Marton, 2009).

This study aims to redress the lack of research in vocational education and to respond to the call for research on content by focusing on learning in a vocational educational setting. In the context of a technical vocational education programme, providing training for a career in plumbing, in a Swedish upper secondary school, the specific focus is on the learning processes involved when a vocational teacher and an upper secondary student engage in welding.

Learning includes both an aspect of how something is learned and an aspect of what is learned (Emanuelsson & Sahlström, 2008; Marton & Booth, 1997). In order to deepen the knowledge of learning processes in vocational education, both these aspects need to be taken into account. Therefore, we combine two perspectives in this study: conversation analysis (CA) and variation theory. CA can help us understand the aspect of how and variation theory can highlight the aspect of what is learned. A combination of those perspectives can deal with both form and content issues and through a close and detailed micro-analysis of a teaching sequence, we can show how the learning object to weld is made visible and oriented towards in a teaching situation. In short, the aim of the analysis is to deepen the knowledge of vocational learning by focusing on the specific object of learning, *to weld*, which is a central skill in technical vocational programs (compare Kilbrink & Bjurulf, 2013). CA research on learning to weld has been done before (cf Filliettaz, 2011) and there are also CA studies dealing with learning processes among plumbers, and plumbing is the occupation that the student in this study is preparing for (cf Sakai, Korenaga, Mizukawa & Igarashi, 2014). The learning processes in these studies, however, take place at companies and workplaces, rather than a school context, and they do not subject their material to the same close and detailed micro-analysis in combination with variation theory analysis (VTA) that is reported in this article.

## **Theory and method**

An important basis for our research and the analysis presented in the article is the new concept of learning developed in the last two decades, namely the view on learning as changes in participation (Lave 1993; Rogoff, 2003; Sahlström, 2011, 2012a; Sfard & Lavie, 2005). Learning – and teaching – is in this perspective a social phenomenon that is constructed, maintained and changed in interaction between people, and between people and various material artefacts.

In the wake of the changing concept of learning, it has also, in particular in the conversation analysis research tradition, been applied in a growing number of empirical studies that show how learning and teaching are done in interaction between people (Cekaite, 2007; Hellermann, 2008; Melander, 2009; Melander & Sahlström, 2009a, 2009b; Nishizaka, 2006; Sahlström, 2012b;

Tanner, 2014), and the approach is also discussed by several Nordic educational researchers in some articles in a previously published issue of the *Scandinavian Journal of Educational Research* (Volume 53, Issue 2, 2009). Common to these CA studies is that they, through a detailed micro-analysis and a participant oriented perspective, have managed to capture how participants in interaction orient themselves towards knowledge, learning and understanding. In other words, these studies show how learning is something that is done in the interaction between people and between people and the artefacts in the immediate surrounding context, here and now.

Another important starting-point of this study is that learning always is about learning something and that teaching is conducted to create opportunities for learning (Marton & Tsui, 2004). This is based on variation theory, which emphasises that learning always is about an *object of learning* and that the learning of the object of learning is facilitated through variation of *critical aspects*. The critical aspects are the aspects you need to know in order to know the object of learning, and those aspects can adopt different values. This requires studying how the learning content is varied and what critical aspects of the object of learning are possible to discern in the learning situation in addition to studying the interaction.

Until a few years ago, the conversation analytic learning studies have mainly focused on how learning is done, while the interest in what is taught – i.e., issues of content – have been less prominent. Research based on an integrated approach to content and form, which is what we advocate in this article, has also been established in a Nordic context in recent years by Sahlström and Melander (Melander & Sahlström, 2009a, 2009b, Melander, 2009; 2012a, 2012b; Sahlström, 2012a, 2012b) among others. From a CA perspective, they show how learning is something that is established in interaction and how issues of content can be integrated in the analysis of interaction.

Research studies combining CA with other theoretical perspectives in order to clarify the content being taught and towards which participants orient in interaction have been done before, although to a small extent. Asplund and Pérez Prieto (2013), for instance, combine CA with a social geographic perspective and manage to show how a group of working class boys construct place and identity in literature discussions, and in an article from 2008, Emanuelsson and Sahlström show how the combination of CA and variation theory can promote a deeper understanding of what is learned, and how it is done in interaction. Our research should be seen as a contribution and an attempt to build further on this research.

### ***Conversation analysis***

The ethnographic research tradition which emphasizes the researcher's presence in the studied environment form the methodological basis for our study (Delamont & Atkinson, 2008; Dunne, Pryor & Yates, 2005), and through our use of video recorded material along with the conversation analysis perspective as an analytical tool the micro ethnographic variant plays a significant role (Sahlström, 2008).

Conversation analysis (henceforth CA) as a research discipline centres on how people express meaning and understanding in interaction with each other and various artifacts in the surrounding social and cultural context (Drew & Heritage, 2006; Schegloff, 2007; Goodwin, 2000). In the participants' pursuit of a shared understanding on which their interaction is built, both verbal and non-verbal communicative resources are being used (Goodwin, 2000, 2003, 2006), and CA researchers try to study how this work is set into play and what communicative resources, participants use in the interaction. To this end, CA adopts a radical participant

perspective; attention is not only paid to the producer of an action, but also to how participants show their interpretation and understanding of other people's actions, and what new actions this generates (Goodwin, 2000; Hutchby & Wooffitt, 1998; Schegloff, 1996, 2006).

This perspective means that our analysis of the student's and the teacher's interaction aims to understand how each contribution in the interaction builds on previous contributions, and how it also shapes what follows, and how this inter-subjectivity is the line in the interaction that both teacher and student, through the use of both verbal and non-verbal communicative resources, construct and relate to (Heritage, 1984; Schegloff, 1991). In our analysis we will do this not only by presenting detailed transcriptions of what is said, but also by showing how the teacher and the student use other semiotic resources, such as bodies, gazes and physical objects in the interaction.

### ***Critical aspects and patterns of variation – analytical tools based on variation theory***

In variation theory, learning involves discerning aspects of an object of learning in a new way. The aspects that are central for understanding an object of learning are the *critical aspects*. In order to discern certain critical aspects, variation is needed. The object of learning can be divided into what the teacher planned for (the intended object of learning), what was possible to learn in the actual learning situation (the enacted object of learning) and what the students actually learned (the lived object of learning) (Marton & Tsui, 2004). In this study, the focus is only on what happens in the actual learning situation and therefore solely on the enacted object of learning. A similar study has been made by Bjurulf (2008) in relation to technology education, but not in relation to CA. Variation theory has also been used in relation to vocational education (von Schantz Lundgren et al., 2013) in a Learning study, but not with our detailed focus on the interaction in the learning situation, which the combination with CA contributes to.

The enacted object of learning is jointly constituted by the teacher and the learner in the learning situation (Tsui, 2004) and what is possible to learn depends on which critical aspects are varying and which are invariant (Runesson & Mok, 2004). The variation must be possible to discern simultaneously by the learner in order to learn the critical aspects and the variation can be experienced in different patterns of variation – *contrast, generalization, separation and fusion* (Marton, Runesson & Tsui, 2004). These patterns are used as analytical tools in this study, and can be described as follows: Contrast involves comparing critical aspects to something they are not, for example, a triangle is not a square, or the need to know how not to do something to know how to do it; generalization is about experiencing different appearances of the critical aspects, e.g., there may be different kinds of triangles or different ways of solving a problem; separation is when one of the many critical aspects of objects of learning is separated from other aspects and varied while other aspects are invariant. Finally, fusion is about varying several critical aspects simultaneously. Marton, Runesson and Tsui argue that it is more efficient for learning to separate the aspects first and then to fuse them together.

The variation theory analysis (henceforth, VTA) is applied to the study of film sequences where a student learns the critical aspects of how to weld and how those aspects are varied in different patterns of variation. The VTA is interwoven in the detailed CA transcripts, where the critical aspects of the object of learning are highlighted in the learning situation interaction showing which patterns of variation are present. In the analysis, the critical aspects are in bold type and the patterns of variation in italics.

### **Description of data**

The data analysed in this study consist of three excerpts from a 42-minute-long video recorded interaction when a 17-year-old vocational student in a mid-Sweden upper secondary school is welding for the first time in school. Welding is an important part of his vocational program, and in the examples analysed below, it is the backhand welding that he performs together with his teacher.

The student's interaction with his vocational teacher in the school's workshop<sup>1</sup> has been recorded by a researcher and the analysis of the interaction that takes place is presented in this article with a transcript that reflects certain aspects of the interaction (see appendix).

The basis of our analysis is thus one video recording. This very limited empirical material means that we cannot draw any general conclusions about learning welding at school, and this is not our intention. In this article we explore the situated meaning of learning how to weld through the micro-level analysis of a student-teacher interaction. The analysis integrates multimodality within a CA framework whose fundamental principle is that the analysis should be grounded in the participants' orientations to the actions here and now, and not in categories that are pre-defined and imposed on the data by the analyst (Schegloff, 1996). This approach can reveal the complexity of knowing and learning how to weld as interactional accomplishments, thereby empirically substantiating the understanding of learning how to weld as it emerges through participation in situated activities. This interactional process is described in the result section below. The description also includes the VTA used to identify the critical aspects that emerge in the orientation of the interaction and the patterns of variation used to highlight these critical aspects in the teaching situation.

## Results

The first situation where the learning of back hand welding in a vocational school is the focus of the interaction that we have chosen to take a closer look at begins with a situation where the teacher (T) sits down in front of the goods to be welded while the student (S), Robin (fictive name), stands diagonally to the left and in front of him. After they have taken these positions, a minute follows during which the teacher is welding and Robin is watching. As soon as the teacher has finished the welding process, he takes off his goggles and starts explaining to Robin how he should proceed:

### *Example 1: Ninety degrees*

1. T: If this is ( . ) if this is the welding nozzle ((Bends the top of the welding wire in a
2. 45 degree angle.))
3. S: Yea:h.
4. T: Then you have about the same. ( . ) First you should have ninety degrees like this.

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<sup>1</sup> Both the teacher and the student gave their written consent to participating in the research project.



Picture A

5. S: ( )
6. T: And then like thi:s ((Flips his hand and the welding wire 45 degrees down to his right.)) So it cuts ( . ) that is you must blow hole with that flame though. ((Points with the welding wire to the welding handle.))
7. S: ( )
8. T: ( )
9. S: Yeah.
10. T: Ninety degrees from the starting point and then you flip it down like thi:s.
11. S: ( )
12. T: You could say it's personal, you got to find it on your own.
13. S: But you hold it like thi:s ((Takes the welding wire that the teacher holds in his hand and moves it to the starting point in ninety degrees, upon which he moves the teacher's hand down to the right to a 45 degree angle.)) as long as it doesn:'t ( . )
14. S: ( )
15. T: get too hot then?
16. S: ( )
17. T: No but ( . ) Yes, you can warm it like that yes but when I weld I do it like this.



Picture B

18. S: One should start with ninety degrees and then ( )?
19. T: Yes, it doesn't matter.
20. S: Yes.
21. T: The important thing is ( . ) the important thing is that when you meld like this ( . )
22. S: that you keep ( . ) ninety degrees like this ( . ) and then you flip it down like thi:s.



Picture C

23. S: Yeah, okey. ((Nods))

24. T: That is, not like this.



Picture D

25. S: N:[o.

26. T: [Because (.) then it becomes too hot over here.

27. S: Y[e:s.

28. T: [And if you do like this (.) it becomes too hot over here.

29. S: ((Gets up from his stooped position. Moves backwards with his torso.)) A:h right.

30. T: And it's (.) do you see how the plate spreads the heat quite equally?

31. S: Yes ( ) ((points to the plate)) here.

32. T: Yes, I have more cautery over here, than I have here.

33. S: Yes.

34. T: But it shows on the plate. ((Gets up.))

In the example above there is work in process in which the teacher and the student together and socially are constructing a teaching situation where the teacher positions himself as the more knowledgeable other while the student takes the role of being the less skilled of the two. This is a relationship already established when the teacher (before line 1) takes the position as the expert, sits down and shows the student how the welding should be done.

When the teacher then takes the role of the expert and shows the student how to weld, his welding becomes a model of how the welding process should proceed, and there are several critical aspects of the learning object to weld present simultaneously. The variation pattern that is made visible in this situation is *fusion* and the student gets to see the teacher as a role model who demonstrates the actions that the student himself is expected to do. The interaction that follows shows that the teacher and student roles are also constantly constructed in the interaction, and that both teacher and student, in different ways and with different techniques, highlight various

critical aspects of the object of learning separately (*separation*) in the learning situation that follows, which they themselves are creating.

The example above thus begins with the teacher who in line 1 “transforms” the welding wire that he is holding in his hand to a welding nozzle by saying “this is the welding nozzle” while bending the upper part of the welding wire in a 45 degree angle, and simultaneously using different kinds of semiotic resources (talk, embodied actions and artefact) in order to demonstrate the process of the transformation of the welding wire.

In lines 4, 6-8 and 10 the teacher then turns straight to Robin and explains to him that he should first find a position where the welding nozzle is in a ninety degree angle (Picture A) before flipping it down sideways to an angle approaching 45 degrees. That the starting position is to be in a ninety degree angle is something the teacher says in line 10, but the other angle - i.e. the one that Robin will “find” after the starting position when he should lower the welding nozzle – is not made explicit except by the teacher’s movement and positioning of the imagined welding nozzle (i.e. the welding wire). Robin follows the teacher with his gaze and he also affirms his teacher’s instructions on some occasions (lines 3 and 9).

By using another artefact than the welding nozzle itself, the teacher shows the angle without the presence of all other critical aspects of welding. Thereby, all other aspects of welding are kept constant, and the only varying critical aspect of welding is the **angle**. Hence, in the teaching situation the variation pattern *separation* is used. Furthermore, *generalization* is used when the teacher shows the angle both with the welding nozzle, but also with another artefact – the welding wire – that he bends like a welding nozzle. The starting position (90 degrees) and the movement to 45 degrees are the values for the critical aspect ratio in this teaching sequence.

In line 11, Robin asks, what we interpret as a question, depending on the rising intonation and on the following teacher response. This indicates that Robin is seeking answer to how to do this, and tries to sort this out. The teacher answers that this is something that is “personal” and something you have to “find it on your own” (line 12). This indicates that Robin is presumably asking for the position he should take after angling down the welding nozzle from the starting position at 90 degrees. Here, the **movement** from the starting point could be interpreted as a critical aspect that can take different values (it is possible to do in different ways, but not any way and is therefore still a critical aspect). It can also be interpreted that the movement can be made in any way since the teacher says that it is something the student has to find out for himself. In the second interpretation, the movement is not seen as a critical aspect. In this teaching sequence, this is not made clear by any pattern of variation.

As soon as Robin receives this response, he repeats the movement that the teacher has shown him in previous turns (lines 13-16). When repeating the teacher’s movement, Robin asks the teacher if he should hold (at this moment Robin is holding the welding wire in a ninety degree angle) “as long as it doesn’t ( . ) get too hot then?” (lines 15-16). With his question Robin now leaves the epistemic authority (Heritage & Raymond, 2005) to the teacher, whose confirmation he is seeking, or a reaction, and he thus makes the claim to demonstrate an understanding of something he did not understand earlier.

Another result of Robin’s question is that the interaction between him and the teacher not only concerns the angle of the welding nozzle in the actual welding moment, but also heat. Hence, the student Robin introduces heat as a new topic. In this situation, it is also the student who highlights a new critical aspect of the object of learning – namely the **heat** – by using the variation pattern *separation*.

The teacher confirms Robin’s question in line 17 by answering “No, but ( . ) Yes” but then he completes the turn by showing once again how he does it when he welds (“but when I weld I do it like this”), thus orienting himself once again towards **the angle** (which he shows with the imagined welding nozzle) as a critical aspect (Picture B). The teacher, however, will reintroduce **the heat** as the critical aspect that the student introduces later on in the example, something that we will return to.

In line 18, Robin once again makes a new claim to understand something when he asks if he should start at ninety degrees “and then” which the teacher follows up by confirming Robin’s displayed understanding (“Yes”) at the same time as he says that it doesn’t matter (line 19) . Exactly what it is that does not matter is not made explicit in the interaction, but in lines 21-22 the teacher makes it clear to the student, using several different semiotic resources (speech, body, and artifact), that it is important to “hold ( . ) ninety degrees like this: ( . ) and then you flip it down like this:” (Picture C).

The question-answer sequence that takes place between lines 11 and 23 is thus an example of how the teacher and the student roles are constructed in interaction, partly by Robin who assigns the epistemic authority to the teacher by asking him questions, thus constructing the teacher as the more knowledgeable from whom information is to be sought and himself as the one seeking new knowledge and understanding. Both the teacher and student also contribute here to highlighting critical aspects of the object of learning in the interaction.

In line 24 then, something interesting happens. Until now, the teacher and Robin in unison have focused on how something (i.e. welding) should be done in order to be done in a proper manner, but in line 24 he says and demonstrates how something should *not* be done when he says: “That is, not like this”, while he pulls the imagined welding nozzle against his own body (Picture D) by using *contrast* as pattern of variation.

The muzzle of the nozzle, however, has the same position as before (the value of the position of the nozzle is invariant), i.e. it is directed at the goods to be welded, but by angling the upper part of the imaginary nozzle against his own body, the teacher shows a welding position where the angle between the welding nozzle and the weld on the goods to be welded deviates sideways towards the intended welding position that is in line with the welding and the ninety-degree starting position that the teacher talked about initially in the example (Picture A). The teacher’s use of the positioning adverb “alltså”, here translated into “that is”, implies that he draws a conclusion based on what they have previously spoken of (Karlsson, 2006, p. 51), which in this case is the different angles used in welding.

Consequently, a new pattern of variation is introduced for the **angle** as critical aspect. The teacher *contrasts* the critical aspect to a value of the critical aspect which is incorrect. Furthermore, it becomes clear that he is highlighting the **angle** of ninety degrees **sideways**, as the critical aspect. The value of the angle as a critical aspect is contrasted to other values sideways. In contrast to before, this shows that the critical aspect is not the vertical angle (how the teacher holds the welding nozzle straight up and then moves it down to a position that the student has to find himself, line 4, 6-8 and 10). This also explains why the teacher answers Robin’s question that it does not matter if you start straight up (line 19), which could have been interpreted as a critical aspect in line 4. Hence, the starting position of ninety degrees highlighted in line 4 can be interpreted in two ways: Either as the height of the arm/welding nozzle or as the angle sideways in relation to the weld. Moreover, in the beginning of this excerpt the teacher does not contrast this critical aspect of welding (angle) sideways in relation to the weld, which invites the interpretation that the starting position ninety degrees straight up is the critical aspect that is varied in the movement to another vertical angle of about 45 degrees.

In line 26, the teacher follows up this action by saying that then it gets “too hot over here”. Then (line 28), the teacher shows another way of holding the welding nozzle. This time the lower position of the nozzle is kept in the same position, but the upper part of the welding nozzle is moved away from the body by the teacher. This is made so that the lower part of the nozzle is directed towards the teacher’s body while the teacher says: “And if you do like this ( . ) then it gets to hot here”.

Hence, in lines 24, 26 and 28, the teacher chooses to show how not to weld by showing undesired positions. Moreover, he tells Robin that such positions lead to a welding where the heat is distributed in an undesirable way. In this sequence, the critical aspect **heat** becomes a

consequence of another critical aspect (the **angle**). Those aspects were first highlighted one by one through *separation*, and thereafter they were highlighted as interacting by *fusion*.

Robin responds to the teacher's demonstration of the alternative, undesirable angles by getting up from his stooped position and in line 29 he says, "A:h right". Robin's altered bodily positioning leads to a situation where he moves his body, and his focus, from the welding that takes place in front of him, and together with his short "A:h right" indicates that he has gone through a change in his present state of knowledge and awareness.<sup>2</sup> It thus appears as if Robin, through his interaction with the teacher, finally has come to a point where he claims to have understood the teacher's instructions; at least that is what he signals to the teacher.

In line 30 the teacher makes Robin aware of the possibility to see how the heat is spread on the plate when he asks Robin if he can see how the plate "distributes the heat quite equally". With the question, the teacher shows that he wants to know if Robin has understood, and when Robin then responds in an affirmative way, and then also clarifies his understanding by pointing to the plate and saying "here" (line 31), the teacher has received an answer to his question and he then confirms Robin's understanding.

In line 32, another artefact is highlighted in the interaction. This artefact is the plate, where the result of the weld can be seen. On the plate, yet another critical aspect appears, the **cautery**. This is highlighted by the teacher (line 32) and the **cautery** is pointed out as a consequence of the **heat**. Again, the critical aspects were first *separated* and then *fused*. In line 32, the teacher uses *contrasting* as the pattern of variation, when showing different results of the weld, depending on how the cautery was made: "I have more cautery over here, than I have here". Robin shows that he understands this (line 33) and the example concludes with the teacher briefly noting that "it shows on the plate". Finally, the teacher and Robin have reached a point where a better balance of knowledge has been reached, compared to the start of the example. Normally, the interaction is terminated in these kinds of teaching sequences, or, a participant introduces a new subject (Tanner, 2014). This is also what happens in this example.

In the example analysed here, we can see how Robin and his teacher are working to construct a common understanding of how to weld, but to achieve this shared understanding, they must, and they also do so, make clear to each other what they understand and what they do not understand. The central difficulty, or challenge, oriented towards in the example, which they are trying to agree on how to deal with, is how the welding nozzle should be handled during the actual act of welding and how the welding nozzle should be angled to get the heat distributed equally in the right way.

In the next example, Robin has been welding on his own for a short time in front of the teacher and after a while Robin is encouraged by his teacher to "get some rest":

### *Example 2: Very good*

1. T: It- it is very good it is ((lifts the plate where Robin has been welding and looks at
2. it)).
3. S: Yes?
4. T: Eh: (.) What can you say. (.) ((Takes out a knife and moves it towards
5. the welding mart at the plate.)) You should have a li:ttle bit more like it is over here.
6. S: Oke:y. Well, how do I do to get it like that?
7. T: Slow down a little. ((Moves the knife back and forward over the plate.))
8. S: Okey. ((Looks up at the teacher.))

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<sup>2</sup> The change-of-state token "oh" is described by Heritage (1984, p. 299) as part of a structure that participants use to signal receipt of new and interesting information. There exist some Swedish equivalents of the English "oh", and in the excerpt Robin uses the Swedish expression "ja:ja", which we have translated to "A:h right".

9. T: Keep the flame ((Robin looks up at the teacher and nods his head.)) so that  
 10. it gets so hot that it can melt.
11. S: Yes.
12. T: But you have ( . ) It is the first time you back hand weld like this.
13. S: Yes:.
14. T: And you cannot just sit down and back hand weld and then nail it and it.  
 15. But this is ((Points to the plate.)) you are very far ahead to be the first  
 16. time.
17. S: Yes [and then
18. T: [And then you slow down ( . ) a little
- 19-26 [..]
27. T: No, but you can see that you have the potential to learn quite fast but what  
 28. you need to do now is ( . ) for this weld you are going to make ( . )“have a li:ttle ( . )  
 29. don’t rush.
30. S: It should be about this thick? ((Looks up at the teacher.))
31. T: Yes ((Nods)).
32. S: ((Looks down at the plate and nods.)) It doesn’t matter if it is  
 33. ugly ((Looks up at the teacher.)) on pipes or things like that, does it?  
 34. ((The teacher looks away. Silence. ”Thinking-face”.)
35. S: [As long as it is sealed?
36. T: [Yes it does. ( . ) It does. So. Let’s say that we would sent it in for  
 37. X-ray.
38. S: Yes.
39. T: Or something. You know, X-ray means that they look at the weld inside as [well.  
 40. S: [Yes:.
41. T: Then it - ((Takes out a knife and moves it towards the weld.)) then it must ( . )  
 42. it must be goods inside as well. But it cannot be like this ((Points with the edge of  
 43. the knife towards the weld mark.)).
44. S: N:o.
45. T: Because, when the water comes into the pipe, this will.
46. S: Yes:?
47. T: Then: push the water schheu ((Onomatopoetic.))
48. S: ((Nods.))
49. T: Thus, it cannot start turning ((Makes a turning movement with the knife  
 50. forward.)) Because then it will wear out the pipes. So, such things are not allowed.

The fact that the teacher is satisfied with what Robin has achieved is made clear in the interaction that follows. The result of the melding that Robin has done is “very good” (line 1) and the teacher says to him that he has come far in his development, considering the lack of welding experience (lines 15-16), and a bit later in the excerpt he says that Robin has the “potential” to learn “quite fast” (line 27).

The teacher not only praises Robin for his efforts, but also directs his focus on what Robin can improve. Already in line 5 the teacher makes Robin aware that there is a place on the plate where he could have welded differently. To show how this could have been done, he points to this area with his knife and says: “You should have a li:ttle bit more like it is over here”. The area “over here” is thus an area which embodies a more successful result.

However, the teacher never says exactly what he means with “a little bit more like it is over here”. Instead, he just points to the area “over here” with his knife. In line 5, the variation pattern *contrasting* is used to show what the critical aspect **cautery** should look like on one side, and what it should not look like, on the other side. However, it is not yet made clear what critical aspects the cautery is a consequence of, when it looks good and when it does not.

In the following (line 6), the student confirms the teacher’s request. At the same time, he also shows that he wants to acquire the knowledge necessary to weld in such a way that the result is more like “over here” when he asks what he should do to “get it like that”. Then, the teacher answers that he needs to “slow down a little” (line 7) and to keep the flame “so that it gets so hot that it can melt” (lines 9-10). Again, the **speed** of the movement and the **heat** are highlighted as critical aspects of welding. By telling Robin to slow down a little, the teacher highlights that the **speed** should be slower than it was. Hence, he *contrasts* what was done to how it should have been done differently (slower), thus increasing the heat so the plate would melt together with the welding wire. In the turns when the teacher is answering Robin’s question, Robin looks up at the teacher. Simultaneously, Robin confirms that he understands the teacher’s instruction by saying “okay” (line 8) and later also confirms the remark by nodding affirmatively (line 9).

Then the teacher praises Robin about his welding (line 15-16) and repeats that Robin just has to “slow down ( . ) a little” (line 18). At this point, the teacher seems to suggest an overall assessment where all the critical aspects are merged and the pattern of variation is *fusion*. However, the teacher points to a more ideal result to aim for, that is, *contrast* as a pattern of variation but without making the desired values of the critical aspects explicit in this teaching sequence. The teacher then makes a kind of summary of his feed-back when he says that Robin has some talents for learning fast, but what he needs to develop is to “have a little ( . ) don’t rush” (lines 28-29). Thus, the critical aspect **speed** has the incorrect value, which is highlighted in the interaction and also *contrasted* to how it should be instead, i.e. a little bit slower (“don’t rush”).

It turns out, however, in the next turn that Robin wants to talk more about what he has welded and that he is not absolutely clear about the response he has received from the teacher when he somewhat critically asks: “It should be about this thick?” in line 30. According to the teacher it should be that thick (line 31) but Robin goes further when he questions the aesthetics of the welding (in lines 32-33 and 35) that the teacher has previously highlighted as a good example of a successful welding: “It doesn’t matter if it is ugly on pipes or things like that, does it? [ ... ] As long as it is sealed?”. In the teaching situation jointly and socially constructed by the teacher and student before line 30, the thickness was not varied, but when the student now introduces thickness as a topic, it turns out that **the thickness** of the welding is a critical aspect, but it has already got the correct value and is therefore not discussed in relation to something else.

The teaching sequence is still about the outcome of the welding – what appears on the plate – and this is divided into several critical aspects. There are aspects that can assume values of right and wrong, while other aspects are not as obvious. **The thickness, the density and the flatness** of the welding are made relevant as critical aspects through the student’s questions, while there is some uncertainty about the **aesthetics** itself.

By addressing questions, Robin also in this excerpt positions himself as the less skilled of the two. Since the questions are directed at the teacher, the teacher is given the epistemic authority. However, the questions are now slightly more critical by nature since the student hesitates about the aesthetical aspect of the weld. Furthermore, for a short moment, the teacher is cornered by Robin’s question in lines 32-33. This is indicated by the silence of the teacher and that his eyes look away into the workshop. In this sequence (lines 36-37; 41-42 and 50), the teacher suddenly

changes his previous attitude to the result of the weld. Previously, he has praised the student for the weld, but now he says that it would not pass a detailed evaluation if it were to undergo an X-ray which means that “they look at the weld inside as well” (line 39). The teacher elaborates his reasoning during this interaction by saying that “it must be goods inside as well” (line 42). Then, he points with the tip of the knife over the welded metal and says: “But it cannot be like this” (line 42). At this point, again the teacher uses *contrast* as pattern of variation by highlighting how it should not be. Here, he shows that the welding edge must be even inside, so **evenness** appears as a critical aspect. Furthermore, the value of the critical aspect needs to be more even than it is on the plate, where Robin and the teacher inspect the result of Robin’s welding. Whether this is an **aesthetic** aspect that should take the form of not being ugly is not clarified in the interaction. From this point on, the teacher changes into giving a mini-lecture (lines 39, 41-43, 45, 47 and 49-50), in which he explains the consequences of incorrectly executed weld in a pipe for water, namely that the water will start spinning, which is something that will wear the pipes out. Finally, he says that such “things” are not allowed and Robin shows in the subsequent lines that he has understood this.

Again, we have a sequence where the teacher and the student jointly construct a teaching situation and where the teacher positions himself as more knowledgeable. Moreover, by asking questions and focusing on what the teacher is saying and doing the student acts as a student who wants to learn more about how to weld. The rather more “challenging” questions Robin puts in lines 30 and 32-33 also prepares for the mini-lecture that the teacher holds at the end of the example, where the teacher also for a brief moment steps out of the role of evaluating the weld into discussing the consequences of an incorrect welding in a wider perspective. At this point, how to weld is about more than “just” getting a correctly executed weld. It has also been given a context and a meaning in relation to the consequences of the result. This context and meaning is possible to highlight through the collaborative work on constructing common knowledge on how to weld. The interaction between the teacher and the student also reveals new critical aspects of the object of learning how to weld. Furthermore, through the communication it is made clear that some critical aspects are more or less acceptable. However, some of those values are not explicitly made clear in the teaching situation. The variation pattern *contrasting* is often used in relation to something that should be a bit different, but it is not fully expressed what this difference means in all situations.

## **Discussion**

Research on human sociality has shown that people – when they engage in coordinated activities – also need to engage in shared commitments (Enfield & Levinson, 2006; Clark, 2006). When people do something together, they must also act on and respond to the shared commitments that they are negotiating in the interaction. This is thus work done by the social proof procedure in which participants, turn by turn, display what they have understood, and what they have not understood in the previous participant’s utterance or action (Schegloff, 1996). In the examples analysed above, we can see how such work is done in vocational practice when the teacher and the student express their shared understanding of the critical aspects of welding that are highlighted in the interaction. The examples also highlight that speech, body and surrounding material mutually contextualise one another, providing public resources for the participants to organize relevant actions that, in concert with each other, contribute to the ongoing activity (Goodwin, 1996, 2000, 2003, 2006; Streeck, Goodwin & LeBaron, 2011).

When the teacher and Robin thus communicate their understanding and non-understanding, they do this by also making use of the surrounding material structure (welding wire, plate and knife) and it is this surrounding structure along with their speech and bodily positions and their body movements that are expressions of their understanding (cf. Melander & Sahlström, 2010). Together they construct a teaching situation where the teacher is positioned as the one who has the skills and knows more than the student and the student positions himself as the one who wants to learn more about how to weld through his questions and his continued focus on what the teacher says and does.

The teaching that takes place and the learning that is made possible in the examples presented are the results of the teacher's and the student's joint efforts. According to recent theories on learning, one has to participate to learn. However, according to Emanuelsson and Sahlström (2008) there is a constant risk in educational settings that the consistency of content is sacrificed to participation, and what is needed for learning content is a less responsive and dynamic interaction. Our analysis, however, indicates that it seems possible, at least in the face-to-face interaction between a teacher and a student, that a responsive and dynamic interaction can be a reality in a vocational classroom without sacrificing the consistency of content. Through the entire interaction the teacher and Robin are establishing a clear focus on how to weld, and this is done, partly through quite a tight teacher control of the content, but also through the open and dynamic dialogue that is constructed and maintained between the teacher and the student. It is also clear that the student himself is using this open dialogue in order to ask questions about issues of content to promote changes in participation, that is, to promote learning (Lave, 1993; Lave & Wenger 1991, Rogoff, 2003), and that the teacher responds to these questions, thus providing opportunities for learning processes to take place.

The teacher and the student interact and talk about the critical aspects of welding. This concerns how the different welding tools are related during the welding act. More specifically, the interaction concerns how to ensure the equal distribution of heat over the plate when welding. Hence, the critical aspects that are possible to discern in the teaching situation are for example the angle of the welding nozzle, heat and cautery. Furthermore, in the teaching situation there seems to be a hierarchical structure between the various critical aspects, since they affect each other in a certain order. The angle of the welding nozzle is the superior critical aspect throughout the example. The critical aspects are highlighted one by one in separation as the pattern of variation. However, when they are highlighted as a consequence of one another, the pattern of variation is changed to fusion. Sometimes, the teacher contrasts the critical aspects to something they are not (right speed – the student should “slow down”) or should not be (“And if you do like this ( . ) then it gets to hot here”), and sometimes the teacher also uses generalization as pattern of variation in order to show varying appearances of a critical aspect (showing the angle with different artefacts). When comparing the critical aspects to what they are not or should not be, more interaction is needed in order to reach understanding on what they actually should be (cf. Illum & Johansson, 2009).

The combination of CA and VTA enables a deeper understanding of the enacted object of learning and what is possible to learn in the actual learning situation (cf. Marton, Runesson & Tsui, 2004; Runesson & Mok, 2004) than what previous CA-studies related to work-based learning/learning as apprentices have offered (cf. Filliettaz, 2011; Mondada, 2014; Sakai, Korenaga, Mizukawa & Igarashi, 2014). Our analysis also shows that the critical aspects can be negotiated in the learning situation and focus can change depending on the questions asked by

the student. Hence the space of learning is a shared space (Tsui, 2004) and the interaction between the teacher and the learner influences the enacted object of learning. In this vocational learning situation, we can also see that the teacher continuously alternate between separation and fusion as pattern of variation by showing what to do as a role model (cf. Bjurulf, 2012) (fusion) and highlighting the critical aspect one by one (separation). For some of the critical aspects in the examples above (the angle, the movement and the thickness), the teacher does not use any pattern of variation, which could lead to a misunderstanding of the critical aspects. The thickness was not highlighted with any variation pattern because it already had the right value in example 2. If the student had not asked about the thickness, the thickness would not have emerged as a critical aspect in the teaching situation. Thus, an awareness of using variation patterns in teaching in relation to the critical aspects in vocational learning is of importance in order for learners to learn.

The close and detailed CA-analysis of the interaction between the teacher and the student together with the VTA of the object of learning have thus made it possible to identify and define aspects of the interaction that each perspective alone would not have yielded. This indicates that the combination of the two perspectives can support studies of learning in dealing with both form and content issues. Furthermore, the approach helps to increase our understanding of vocational learning in technical vocational education. Thus, the article makes an important contribution to previous studies in the field using either a CA approach (cf. Fillietaz, 2011) or a VTA approach (cf. von Schantz Lundgren et al., 2013; Bjurulf, 2008). In the long run, more close studies on interaction in relation to learning a specific content in vocational education could contribute to a deeper knowledge and understanding of teaching and learning in vocational education. We would also recommend this approach in studying the whole learning process, by extending it to teachers' experiences of vocational knowing from various workplaces and assignments, and the students' everyday and school experiences in order to broaden the analysis of situated interactions in the present. This would also enable a deeper understanding of the intended and lived objects of learning, without losing the deepened knowledge of the enacted object of learning that this study contributes.

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## Appendix: Transcript notations

[	Overlapping utterances
( )	An uncertain hearing of what the speaker said
(.)	A short untimed pause (less than one second)
(( ))	Scenic description and accounts
-	A halting, abrupt cutoff
—	Stressed syllable or word
:	A prolonged stretch

like this In the transcripts, we make use of illustrations to show how the teacher and the student use their bodies and the artefacts surrounding them as linguistic resources in the interaction. To show more precisely where in the conversation the illustrated act is performed, we present the transcripts, with the words being said at the time, using an external frame.