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Learning about the use of tools in vocational education

Classroom observations of student teacher-interaction

Hamid Asghari , Nina Kilbrink , Stig-Börje Asplund
Karlstad University
Contact: hamid.asghari@kau.se

Abstract

The article is about the various ways tools can be used in the interactions between teacher and students during workshop sessions in vocational education. Through video observations in classrooms, we investigate how tools are used as objects of learning in four technical vocational programs. The theoretical foundation of the study is the variation theory of learning. In the video-recorded lessons, situations where tools have been foregrounded in the interaction between students and teachers have been categorised in relation to the research question: In what different ways is the use of tools foregrounded as an object of learning in vocational workshop teaching? The result points to four categories about 1) finding any object to solve a task, 2) contributing to the understanding of using a specific tool for a specific task, 3) understanding the complexity of using tools to solve a task and 4) creating and recreating a tool to complete a task. The conclusion is that there are different kinds of learning content and abilities related to tools which can be understood in the enacted vocational workshop teaching. Our study shows that tools are dynamic, created, and shaped in various contexts, and the tools are often spontaneously used as an object of learning, in different teaching situations and in interactions between teachers and students. In the workshop, the vocational students get different opportunities to learn to use tools in different ways in here-and-now situations based on the requirements of the vocational work.

Keywords: Vocational teaching, Vocational learning, Tools, Vocational education, Learning Content, Variation theory of learning

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Introduction

In school workshops, many things can happen here and now and the vocational teachers find themselves in their teaching, and in meeting with students, in situations that require spontaneous strategies for dealing with these here-and-now situations (Asplund et al., 2022; Kilbrink et al., 2021). When students and teachers work with handling and solving practical tasks in a vocational education setting, tools often play a crucial role in the interaction. For example, tools can be used to carry out planned tasks, but a great deal of attention could also be directed towards how the use of tools is foregrounded as a learning content to solve unexpected problems that arise in here-and-now situations in the vocational teaching. Vocational teaching and learning often take place in the interaction between vocational teachers, vocational students, and their environment (Kilbrink et al., 2021), and in this study, we focus on *how the tools can be used* in the interaction between vocational teachers and vocational students in vocational learning. Although many researchers have emphasised that tools are central in vocational training (Asplund et al., 2022; Berner, 2009; Edwards, 2011; Lindberg, 2003), research based on observations of how the use of tools enacts in various ways in vocational education remains sparse. Different ways of using of tools will be understood in relation to vocational learning, something that has been overlooked in previous research.

In addition, tools are a central part of vocational education but we know little about how teaching and learning about *the use of tools* are done in actual teaching situations in vocational education. In this study, we therefore try to respond to this lack of research and focus on analysing teaching and learning situations where the use of tools is foregrounded as an object of learning, hence the learning content, in the enacted vocational workshop teaching. This will be done to see if and how the tools are used in different ways in the interaction between teacher and student. Thus, the purpose of this study is to contribute with knowledge about use of tools in the interaction between teacher and student in vocational education settings. To achieve the aim, we base the study on the research question: In what different ways is the use of tools foregrounded as an object of learning in vocational workshop teaching to solve unexpected problems that arise in the here-and-now situations?

The importance of the tool in vocational learning

The concept of 'tool' is complex and multidimensional. In general, a tool is an instrument or apparatus used to perform specific tasks (Dron, 2022). In Richardson och Stokoe's (2014) study, a cash register is seen as a tool used as a resource to provide service to customers in a bar. We can also use the term 'tool' to describe various methods, materials, and strategies that facilitate learning and teaching. This can include everything from traditional physical aids, such as books, whiteboards, and laboratory equipment, to digital resources and interactive platforms (Koretsky et al., 2018). In Goodwin's (2013) study, stand-alone semiotically charged objects are identified as tools, such as maps that help people organise everyday life. In parallel with the labour market change and technological development, new tools are created for new work areas (Edwards, 2011). Importantly, tools do not necessarily have to be physical artifacts. They can also be symbolic, such as language, rituals, or cultural norms (Vygotsky, 1978).

We live in a time of extensive technological change (Gutiérrez et al., 2017). This technological

development has implications for vocational learning and necessitates a flexible vocational education system that can meet companies' demands for competent professionals (Tran, 2013). An example of technological advancement can be found in industrial companies, where CNC machines (computer-controlled turning and milling machines) have replaced manual workshop machines (Berners, 2009). In this context, we argue that a CNC machine can be considered a tool, but within a CNC machine, there are several tools that work together to process a workpiece. Tools such as calculators, drawing programs, vices, pliers, screwdrivers are also used in CNC machining training, and the interaction of these tools is critical to production. Berner (2009) notes that with technology development, the type of professional work has also been developed and tools are given an important place in industrial production. Hiim (2013) confirms that tools are important components of vocational learning and also writes (Hiim 2017) that tools acquire meaning through actual work situations and challenges.

The importance of tools in vocational education is widely recognised by researchers such as Asghari (2024), Köpsén (2014), Asplund et al. (2022), Berner (2009), and Hiim (2013, 2017). Tools, from a vocational didactic perspective, are essential for teaching and learning, including hand tools like hammers and screwdrivers, and machinery like CNC machines (Asghari, 2024). Köpsén (2014) highlights that vocational education includes both practical and theoretical content, with tools playing a crucial role. Asplund et al. (2022) focus on the learning processes when teachers and students handle tools and machines, showing that teaching often occurs in response to problems students encounter. This teaching is often individual, leading to varied learning opportunities among students.

In our study, we assume that tools are socially constructed and context-dependent. To delve deeper into tool usage, we must also define what tools can be, which we did in the section above. We focus on their function and usage. Through close classroom observations (video recordings), we have identified tools by analysing how they are used, the role they play, and the impact they have on activities. We concentrate on the use of tools, and in this context, we refer to Fitch (2010), who writes that the use of tools expands an individual's ability to perform practical tasks effectively. The use of tools is considered a central component of vocational education (Berner, 2008, 2009; Bjurulf, 2008, 2012), where tools are utilised in various ways and forms. Based on the reasoning presented by Fitch (2010), Berner (2008, 2009), and Bjurulf (2008, 2012), we believe that tools can be defined as means used to perform specific tasks. This may include methods, strategies, or resources that help people achieve their goals. For example, a calculator can be considered a tool for solving mathematical problems. Other examples of tools include smartphones and mobile phones, which are used in learning situations (cf. Asplund & Kontio, 2020). Mobile phones are used for calls but can also be used as work-related tools and help the user to perform certain tasks (Edwards, 2011). Furthermore, tools can also be understood as physical objects used in everyday life to perform various activities, such as a screwdriver used to tighten or loosen screws.

In subjects like science and chemistry, modelling makes concepts more concrete and helps students understand the subject (e.g., Gilbert, 2004; Justi, 2009). Similarly, in vocational education, using tools can be compared to modelling. Modelling in vocational education visualises how tools or combinations of tools function, aiding students in solving upcoming production problems and understanding the production process. This approach is particularly

valuable because the teachers who teach students in the school environment are the ones who have knowledge of the production process and the prevailing production problems that exist in working life (Gustafsson & Thång, 2017). It is important that what vocational students learn can also be used in new unknown contexts where the technology has developed or the solution to future unforeseen problems has not been established yet (Kilbrink et al., 2021).

Previous research indicates that the definition and use of tools vary widely. Tools can be seen as instruments for specific tasks (Dron, 2022), practical resources in service contexts (Stokoe, 2014), or as encompassing both physical and digital resources that facilitate learning (Koretsky et al., 2018). Tools can also be understood as symbolic elements, such as maps, or as language and cultural norms (Edwards, 2011). Within vocational education, the importance and meaning of tools in vocational learning and work situations are highlighted (Berner, 2009; Hiim, 2013, 2017), as well as the importance of tools in production (Köpsén, 2014). Unlike previous research presented in this section, which focused on describing tools, this study will focus on *the use of tools* when they come to the foreground as an object of learning to solve unexpected problems that arise in here-and-now situations.

Learning in vocational education

Learning is a central concept within educational science. It encompasses contextual cognitive, social, and emotional dimensions, as well as how people acquire knowledge and the factors that motivate human learning (Hattie, 2008). Previous studies show that learning in a company workshop differs from learning in a school environment (Berner, 1989; Gustafsson & Thång, 2017; Lindberg, 2003). Students in industrial workshops gain more experience in problem-solving than those in schools (Berner, 1989). In schools, students often lack production problem-solving experience. However, vocational learning in schools is based on both the curriculum and the need for skilled staff in working life, aiming to solve real-world problems (Gustafsson & Thång, 2017). Asplund et al. (2022) and Kilbrink et al. (2021) also highlight that the vocational learning at schools often is done in interaction between teachers, students and different artifacts. Furthermore, they state that learning always concern a learning content.

To make it easier for vocational students to adopt new ways of using tools, they need opportunities to interpret and experience this use (cf. Wieman, 2007). This approach fosters curiosity and motivation, crucial for learning (Chen et al., 2020). Teachers should link teaching to students' realities, making it recognisable and giving them some control over their learning (Jidesjö et al., 2009). Abdulrasool and Mishra (2010) discuss the importance of using the right tools in the right way(s) for the right task in technical education to maintain motivation. They highlight that understanding CAD/CAM (the tools for drawing technology, for programming, and for production) and tools in CNC technology enhances students' knowledge and motivation. Linking teaching to real production problems and relevant tools creates effective learning conditions (Jidesjö et al., 2009; Abdulrasool & Mishra, 2010).

Furthermore, modelling as visualising in vocational education can be compared to Mayer and Moreno (2003), who point out that teachers can help students in their learning through a combination of words and images. In vocational education, where physical artefacts such as tools are integral to teaching, vocational teachers can enhance students' learning and problem-solving

abilities by demonstrating and explaining the use of these tools to address various workshop challenges. This approach aids students in developing skills necessary for future production work in companies (cf. Asplund et al., 2022; Kilbrink et al., 2021).

Teaching and learning in teacher-student-tool interaction

A central aspect of this study is the teaching sessions, where tools are used in various contexts and teaching situations, as well as in the interaction between vocational teachers and students. In vocational education, the term *learning practice* is used to refer to a social practice focused on learning (Lindberg, 2003). According to Lindberg, learning in vocational education, which takes place in the school workshop, is context-dependent and occurs through the interaction between vocational teachers and students. Teacher-student interactions are important for students' learning, as they provide opportunities to ask questions, receive feedback, and develop skills (cf. Hofkens et al., 2023). Consequently, we argue that when vocational teachers and students interact with each other and with various tools, a learning environment is created where discussions, negotiations, practical exercises, and the use of both physical and digital tools are central. Tools can range from traditional textbooks and laboratory equipment to digital resources such as apps and online platforms, which concretise abstract concepts and enable practical application for students (Ong & Quek, 2023).

In these interactions, teachers adapt various tools based on the teaching situation and the individual needs and prior knowledge of the students, making learning more effective and engaging (Miao et al., 2022). Therefore, we believe that the teaching sessions our study focuses on adapt learning to the needs that arise in vocational education to solve practical tasks and develop students' problem-solving abilities. Based on Hofkens et al. (2023), we believe that the interaction between vocational teachers, vocational students, and tools creates conditions for students to participate in practical exercises, group work, and projects that help them apply their vocational knowledge in real-world situations.

Classroom observations as research method

In our study, video observations were used as our primary method (Knoblauch & Schnettler, 2012; Tverbakk, 2021). According to Tverbakk (2021), video observations can provide more precise and accurate representations of what occurs in learning environments compared to direct observation. Video observations can reveal important details about individuals' actions and complex interactions, both verbal and non-verbal. Moreover, through observations, the researcher can obtain direct insights into behaviours and interactions that are not always captured through interviews or surveys (Creswell, 2007). In our case, we used this research method to gain a better understanding of the interaction between teachers, students, and tools in the school's workshop. Although video observations can provide detailed and objective data, the researcher's interpretation of these data can be subjective. It is important to be aware of and manage this subjectivity in the analysis (Walker & Boyer, 2018). The researcher's expectations can also shape what is observed and documented. Additionally, it can be difficult to understand why a certain behaviour occurs without complementing it with other methods such as interviews (Creswell, 2007). In our study, we had no expectations other than to see what actually happens

when teachers, students, and tools interact with each other in the school's workshop (Asplund et al., 2022; Kilbrink et al., 2021). In video-recorded studies of interaction, the focus is directed towards the concrete and observable actions in the video-recorded material, rather than the subjective perceptions of individual actors. This means that in our analytical work, we have approached the video data from an emic perspective (Knoblauch & Schnettler, 2012), where we have conducted interpretive video analysis to identify objective patterns of particulars of the situated performances of participants' social interaction.

Variation theory of learning as theoretical starting point

In the Variation theory of learning, a specific focus is placed on the learning content of teaching and learning which is referred to as the *object of learning*. The object of learning can be divided into a direct and an indirect object of learning, where the direct object of learning refers to the content and the indirect object of learning to the ability related to the object of learning and what the students are supposed to do with the learning content (e.g., understand, use, construct, perform) (e.g., Lo, 2012; Marton et al., 2004). Several studies show how there can be a difference between what the teacher planned for (intended object of learning), what was possible to learn during the learning situation (the enacted object of learning), and what the students actually learned (the lived object of learning) (Marton, 2015; Marton et al., 2004). In this study, we focus on situations where tools are used as the enacted object of learning and how the tools are made relevant as the learning content in the interaction between teacher and student(s) in an actual teaching/learning situation.

Context and data

We conducted this study at a vocational upper secondary school in a large Swedish city. The study focuses on four technical vocational programs: the Heating, Water, Sanitation and Property Management Programme, the Building and Construction Programme, the Electricity and Energy Programme, and the Handicraft Programme with a focus on hair and makeup stylist. These four programs were selected for this research because we were looking for vocational technical programs. The vocational technical programs available at the school and willing to participate in our research were those programs. We have video-recorded vocational education in the technical vocational programs listed above for a total of 33 hours, including 14 hours for the Heating, Water, Sanitation and Property Management Programme, seven hours for the Building and Construction Programme, seven hours for the Electrical and Energy Programme, and five hours for the Handicraft Programme.

In the Heating, Water, Sanitation and Property Management Programme, the Building and Construction Programme, and the Electricity and Energy Programme, parts of vocational subjects are carried out in the school workshops, and in the case of the Handicraft Programme, vocational subjects are carried out in the school makeup room. Our data material (video recordings) has been collected in those workshops and in that makeup room. The research material is a part of a larger project, focusing on vocational learning in interaction between teachers and students in technical vocational workshops (Asplund et al., 2022; Kilbrink et al., 2021). The number of

students varied between 10 and 25 during the lessons that were video-recorded. In a total of 33 hours of video-recordings, tools have been used periodically more than 200 times in the interaction between teachers and students in teaching. This quantification of the number of times that tools are used during vocational lessons shows the importance of tools in vocational education, specifically in the interaction between vocational teachers and vocational students.

The students in the programmes study theoretical subjects such as Mathematics, Swedish, and English, but also vocational subjects that are linked to the profession. Students also have the opportunity to choose courses that make them qualified for university studies (Skolverket, 2011). Part of the students' vocational education is moreover workplace-based. In this study, however, we focus on the vocation-specific education that is carried out in school.

The workshop of the Heating, Water, Sanitation and Property Management Programme consists of various work booths where students practice pulling pipes and working with bathroom adaptations, including installation of toilets, sinks, boilers, and water heaters. The workshop of the Building and Construction Programme consists of a hall where students work individually or in pairs and walls and bends sheet metal to water gutters. The workshop of the Electricity and Energy Programme consists of a room where students work in groups and pull cables, work with electrical installation and prepare a kitchen, install electrical boxes, main control panel, transformers, lamps, electrical outlets, and switches based on electrical schedule. The vocational teachers in these programs move around and help students who have questions about their practical work. The craft room of the Handicraft Programme consists of a stylist room with included workstations. The students work in pairs in each workstation and apply make up on each other in turn. The vocational teacher goes from workstation to workstation to help students who have questions about their practical work. The vocational teachers in the programs introduce the students to the tasks before the students enter the workshops and the craft room and start the work.

We adhered to the ethical principles outlined by the Swedish Research Council (2017) in our study. All teachers and students in the participating classes were informed about the purpose and implementation of the study and provided their written consent to participate. We ensured the anonymity and confidentiality of the participants by anonymising the images and transcriptions.

Analysis of film sequences

Analysis of video-recorded lessons from the aforementioned four technical vocational programs forms the basis of this study. In the video-recorded lessons, situations where tools have been foregrounded in the interaction between students and teachers have been categorised in order to find out the different ways in which the use of tools is made relevant as an object of learning in vocational workshop teaching. Additionally, we focus on what the students are supposed to do with, or how they are supposed to use (the indirect object of learning) the tools when categorising the data. Hence, the indirect object varies and will serve as the basis for categorisation. Furthermore, even if the direct objects of learning in this study always are tools, the interpretation of what a tool can be can vary. Moreover, In the section 'The importance of the tool in vocational learning', we have defined what a tool can be. Based on this definition, we

will, with an open mind and broad interpretation, analyse how something becomes a tool in the interaction between teachers in teaching situations.

As a first step in our analysis of the data (video recordings), we identified and separated those sequences where *the use of tools was foregrounded as an object of learning* in the interactions between vocational teachers and students during vocational workshop teaching in here-and-now situation. An object of learning consists of an indirect aspect (ability) as well as a direct aspect (the learning content) (compare Marton & Pang, 2006; Marton & Tsui, 2004).

As a second step in the analysis, we have searched for categories (cf. Davidson and diGregorio, 2011) in relation to differences within the indirect object of learning when a tool is foregrounded as an object of learning in the interaction. Hence what the students are supposed to do with, or how they are supposed to use (the indirect object of learning) the tools is analysed and divided into categories. Consequently, the categories concern different abilities, like use, choose and understand. From the empirical data, we identified four different categories:

The first category that we identified from this interaction is:

1. Finding *any object to solve a task* in here-and-now situations that is illustrated by two different ways of using tools:
   1.1. *Finding an object that can be turned into a tool to solve a task* and
   1.2. *Finding any tool to solve a task*.

The second category that we identified from the interaction between teacher, student, and tool is:

2. Contributing to the *understanding of using a specific tool for a specific task* in here-and-now situations that is illustrated by two different ways of using tools:
   2.1. Contributing to the understanding of *using the right tool* and
   2.2. Contributing to the understanding of how to *use the tool correctly*.

The third category that we identified from the interaction between teacher, student, and tool is:

3. Understanding the *complexity of using tools to solve a task* in here-and-now situations that is illustrated by two different ways of the use of tools:
   3.1. The *complexity of the use of tools* and
   3.2. The *complexity of assembling different parts as a tool*.

Finally, the fourth category that we identified from the interaction between teacher, student, and tool is:

4. *Creating and recreating a tool to complete a task* in here-and-now situations that is illustrated by two different ways of the use of tools:
   4.1. *Creating a tool to be able to perform a specific task* and
   4.2. *Recreating a tool to be able to perform a specific task*.

In the following section, we will present the different categories in more detail and provide examples from the empirical material to illustrate how the tools are used in each category.

Results

We present four categories where the use of tools is *foregrounded as an object of learning*, are utilised in the interaction between students and teachers in eight distinct ways when problems arise in here-and-now situations. We have identified four of these ways in the Heating, Water, Sanitation and Property Management Programme, two in the Building and Construction Programme, one in the Electricity and Energy Programme, and one in the Handicraft Programme. In each category, we have described what can be seen as direct or indirect object of learning.

Finding any object to solve a task in here-and-now situations

In this category, the *indirect* object of learning concerns *finding* something (a tool, an object) which can help the student solve a problem or complete a task. *The tool or the object which is used to solve the problem or complete the task* then becomes the *direct* object of learning.

Finding an object that can be turned into a tool to solve a task

In a teaching opportunity in the Heating, Water, Sanitation and Property Management Programme, the teacher uses an object that has been turned into a tool, just to solve a task in a here-and-now situation. In the example, the student will thread a pipe externally. The teacher and the student are standing by an electric threading machine. The teacher in picture 1 picks up the metal pipe from the threading machine that is next to the die head. They strike the locking device with the pipe and say to the student: "so you pull you actually use a hammer, but it can go with one, a piece of pipe".

Picture 1. A pipe is turned into a tool

The example demonstrates that objects that were not originally created as tools can in some situations become tools. It shows that a pipe is turned into a tool (a hammer) to solve a problem in the here-and-now situation, so that the teaching can continue.

Finding any tool to solve a task

In a teaching opportunity in the Electricity and Energy Programme, the teacher and the students use any tool, just to solve a task in a here-and-now situation. In the example, three students work

with an electrical circuit based on a wiring diagram. The teacher comes to the students who have not been able to make the electrical circuit work (picture 2) and tells them: "you must not have loose cables". One of the students takes a screwdriver from a toolbox and tries to pull out a blue box with the loose cable inserted into it, but he does not succeed. The teacher takes the screwdriver from the student and says: "We'll see if these releases here, he doesn't".

Picture 2. Using a screwdriver

The teacher who fails to get the blue box out with the help of the screwdriver, asks the student for something with a thinner edge. The student takes another screwdriver from the toolbox and shows it to the teacher (picture 3) and says: "one of these?" and the teacher says: "yes one of those, because then you get in properly". Now the student tries to pull out the blue box, but he still cannot get it out with the help of the new screwdriver.

Picture 3. Using another screwdriver

The teacher who had previously said "you must not have loose cables" now says: "unfold away [the cable] then, on it, because it is only a zero" and continues: "just put it [the cable] there, then you will manage it".

In this example, two tools (two screwdrivers) were used randomly and could not help the students to get the box out. It also seemed as though it was not part of the planning for this teaching session how the blue box would be pulled out in the event of a problem. In other words, conditions are not created for the students to experience how the problem with the loose cable could be solved. Although a randomly chosen tool could not help the teacher and students to pull out the blue box in this particular example, the example shows that any tool can be used as an attempt to complete a task in here-and-now situations.

Contributing to the understanding of using a specific tool for a specific task in here-and-now situations

Through the interaction between teacher and student(s) in here-and-now situations, the *ability to understand* (indirect object of learning) how to *use the right tools* (direct object of learning), and to *understand how* (indirect object of learning) *these tools can be used correctly* (direct object of learning), becomes visible. These aspects of learning are demonstrated in the examples below.

Contributing to the understanding of using the right tool

In a teaching opportunity in the Building and Construction Programme, a certain tool is used as a way to contribute with understanding that this tool is the right tool for a specific task, that is, it is not possible to use just any tool to solve a problem. In the example, the teacher goes to a student who puts plaster on a wall. The student already has a trowel and a plasterer's hawk in his hands, and with the help of the trowel, he evens out the plaster on the wall. The teacher says that the first stage of the masonry is complete, and that the student can take care of the last part of the masonry. The teacher also says that the student must take another trowel, a tongue trowel, to access narrow wall corners because "it [the tongue trowel] is shaped in a good way". Later, the teacher goes to another part of the workshop and picks up a tongue trowel and a wood float. He comes back to the student, shows him what a tongue trowel and a wood float are, says that it is easier to work with the tongue trowel, takes the plasterer's hawk from the student, and puts plaster on it. Later, the teacher climbs the ladder and shows the student how the work should be done (picture 4).

Picture 4. Using the right tool

In this example, the teacher teaches the student that the correct tool for plastering, in the here-and-now situation, is the tongue trowel. The teacher also tries, by using the tongue trowel, wood float, and plasterer's hawk himself, to show the student how the correct tool, that is, the tongue trowel, can be used in combination with wood float and plasterer's hawk.

Contributing to the understanding of how to use the tool correctly

The following example is from a teaching opportunity at the Heating, Water, Sanitation and Property Management Programme. The teacher and the student go to a workbench, where there is a pipe that must be threaded externally. The teacher tells the student to place the pipe in the U-shaped vise and to spray oil on the pipe for threading. The student does as the teacher says, but the student also says that he does not know how the hand-threading tool works. The teacher takes the hand-threading tool from the student and puts it on the tube to start the threading. The teacher also says to the student: ”you have to pull in the right direction”. When the student says that the right direction is down, the teacher nods. The teacher in picture 5 pulls the hand-threading tool down and starts threading.

Picture 5. How to use the tool correctly

In the example, a hand-threading tool is the focus for the interaction between a teacher and a student and hand threading becomes a teaching subject, hence the object of learning. As can be seen from the example, the student has no knowledge of how to use the tool correctly. The teacher teaches the student how the student should work with the tool.

Understanding the complexity of using tools to solve a task in here-and-now situations

When it comes to using tools, it is also important to cope with the complexity of using them. Note that a tool can be complex in itself, but our focus in this category is on the *use of tools*, that in the empirical examples include the fundamental complexity of using a tool, but also the assembly of several different tools to create a new tool, and the use of the newly created tool to solve a task in here-and-now situations. Hence, the indirect object of learning is the *ability to understand the complexity of using a tool*, in relation to the direct object of learning to *use tools to solve a task*.

The complexity of the use of tools

This example is taken from a teaching opportunity in the Heating, Water, Sanitation and Property Management Programme, where the student has put a safety valve in a vice and tries to loosen it. The student takes out an adjustable spanner from his tool bag and the teacher shows with his hand in which direction the adjustable spanner should be turned to loosen the safety valve. The student puts the adjustable spanner on the safety valve to loosen it, but he turns the adjustable spanner in the wrong direction and instead tightens it. When the student turned the wrench in the wrong direction (picture 6), the force of this wrong turn caused the safety valve to move slightly and it no longer sat firmly in the vice.

Picture 6. Turning the adjustable spanner

The teacher says to the student that he is turning the adjustable spanner in the wrong direction. The student loosens the vice and moves the safety valve. The teacher tells the student that he needs a better grip and the student again clamps the safety valve in the vice. This time the student turns the adjustable spanner in the right direction and loosens the safety valve.

The example shows that although the tool (the adjustable spanner) is a correct and relevant tool for the actual work situation, the safety valve must be properly clamped in the vice and the adjustable spanner must also be turned in the right direction, so that it can be released on the safety valve.

The complexity of assembling different parts as a tool

This example is also taken from a teaching session at the Heating, Water, Sanitation and Property Management Programme where a student must thread a pipe externally. In the example, *a threading tool is created by assembling two different tools, one a head holder mounted on the electric threading machine, and the other a die head mounted on the head holder*. Three different tools are included in this example: a head holder, a small die head, and a more powerful die head.

The teacher and the student go to an electric threading machine. The student points to the die head that sits on a die head holder in the threading machine and says: "How did you get that up?" The teacher answers: "Then you lift it, like that". The teacher later lifts one of the three tools, *the smaller die head*, out of another tool, *the head holder* (picture 7), and places it under the electric threading machine.

Picture 7. Lifting a more powerful die head

The teacher now lifts the third tool that is a *more powerful die head* located under the electric threading machine. In the next step, he mounts the *more powerful die head* to the *head holder* (picture 8).

Picture 8. Mounting the die head

The threading tool cannot be created and the threading work cannot be carried out if any of the tools are missing, that is, two tools (the head holder and the more powerful die head) are needed and must be assembled for the student to be able to perform threading in the electric threading machine. The example shows that in modern plumbing technology, selecting suitable tools to carry out work tasks also sometimes requires a combination of different tools. The complexity shows in the way that a number of different phenomena must interact with each other and harmonise with each other in order for the use of tools to be successful.

Creating and recreating a tool to complete a task in here-and-now situations

In teaching sessions and in the interaction between teachers and students in here-and-now situations, tools must be used to solve a task, but the right tool is sometimes missing. In that case, the tool must be created or recreated for use. Accordingly, the indirect object of learning in this category concerns *the ability to create or recreate* related to the direct object of learning which concerns a *tool which can be used to complete a specific task*.

Creating a tool to be able to perform a specific task

In the Building and Construction Programme, a student will manufacture a building fixture at 90 degrees (a tool) to be able to set up the masonry. The teacher asks the student if he knows how a building fixture is made and the student says that he does not know. The teacher says to the student: "you use two rules so. You cut off one and then nail it in" (picture 9).

Picture 9. Creating a tool

The teacher further says that he wants to see if he can find a building fixture to show to the student. When the teacher finds a building fixture, he tells the student: "it's important for it to be 90 degrees" (picture 10). When the student asks if he should make a new one or take the one that the teacher has picked up, the teacher answers that he may make his own.

Picture 10. Creating a precise tool for the specific task

The example shows that during the teaching session the student sometimes has to create his own tool (a building interior) and use it in order to continue with his professional work.

Recreating a tool to be able to perform a specific task

The following example is taken from a teaching opportunity in the Handicraft Programme. In the stylist room, the teacher goes to a workstation where a student sits on a make-up chair and is being made up by another student. In the example, a brush is the focus of the interaction between teacher and student. The teacher looks for a few seconds at how the student is using make-up and takes the brush (as a tool) from the student. She orients herself towards the brush which can change shape and become a completely different type of brush and says to the student: "if you press the brush now it becomes, because it becomes quite bushy". The teacher later takes the brush from the student again, presses the brush with her fingers (picture 11) and says: "You can shape it by doing this" at the same time as she presses her thumb against the straw of the brush so that the brush changes shape and stops being bushy.

Picture 11. Shaping a tool

While the teacher presses the straw of the brush with her thumb, she says: "then you get a completely different type of brush".

The example shows that a tool can be recreated and change shape to become different in order to perform a job. The vocational teacher tries to help her students in their learning by telling and showing them how to use the brush when a problem arises in the here-and-now situation of teaching.

Discussion

The purpose of the study was to contribute knowledge about the use of tools, based on how they are foregrounded as an object of learning, in the interaction between teacher and student. Through the analysis of selected video sequences, we identified four categories and eight subcategories, based on the ability connected to the use of the tool – hence what the students were supposed to do with, or how they were supposed to use (the indirect object of learning) the tools. One category involves finding any object to solve a task in a here-and-now situation. Subcategories illustrate instances where objects that are not tools by definition (such as a pipe) but are used as tools, or tools that are adapted for tasks beyond their original intent. A second category involves understanding how to use a specific tool for a specific task in a here-and-now situation. Here, tool usage is linked to 'understanding the tool's function' and how the 'right' tool can be used 'in the right way' to solve problems. The third category, akin to the second, also emphasises 'understanding'. However, it focuses on 'understanding the complexity' of tool usage to solve tasks in here-and-now situation. One subcategory highlights the challenges a student may face in understanding a tool's function to solve a problem. Another subcategory demonstrates the complexity of simultaneously combining multiple tools, where their interaction can be leveraged to address a task. The fourth category concerns the creation and recreation of tools to accomplish a task. In certain scenarios, it may be necessary to create a new tool to solve a problem. Alternatively, existing tools may need to be recreated for tasks they were not originally designed for, to effectively address the issue at hand.

The study shows that tools, foregrounded as an object of learning, are not something that 'are' but something that 'are made' and are context-dependent. Therefore, the use of tools is not self-evident in the sense that a tool created for a certain type of work should only be used for that type of work. For example, a knife does not always have to be used to cut a cable. In a given situation, the knife can be used as a screwdriver to tighten or loosen a screw with its sharp edge, just to solve a problem. When problems arise, various tools are used to solve them. This creates opportunities for learning, which, according to Almarode et al. (2018) and Ambrose et al. (2010), occurs through a process that leads to changes in how people act. In the film sequences we selected, we could see the students' commitment and active participation, which form the basis of vocational learning (cf. Hiim, 2010), in solving the problems.

One of the important actors in a teaching situation, who has knowledge of the tools and the use of tools and can teach this knowledge, is the vocational teacher. According to Hiim (2017), vocational teachers are expected to have specific knowledge of vocational subjects and general knowledge of the entire learning process, including the ability to know where in the learning process a student is, and the ability teach a profession in school environments. In situations where problems may arise, teachers are expected to guide students in their problem-solving. However, the study shows that these situations can sometimes be new even for the teachers. An example is where a vocational teacher, who had previously told the students not to have loose cables, tests two different screwdrivers. When neither of the screwdrivers works to solve the problem, the teacher tells the students to fold away the cable as it is just a neutral wire.

Based on the results of the study, we can discuss vocational students' problem-solving in school environments, which has also been highlighted in previous research. For example, Berner

(1989) notes that vocational students who train in school environments may have less experience of solving upcoming problems than students who train in industrial workshop environments. Since in working life and in industrial workshop environments, the production is more comprehensive than in a school environment, it becomes natural for professionals in working life to experience production problems more often than students in a school environment. In this way, professionals in working life gain greater experiences of problem-solving than students in a school environment. Although production in a school environment is different and less complex compared to production in a workplace, the study shows that when problems arise, opportunities are created for students to learn various approaches to problem-solving, break down complexity, and learn to use tools correctly or combine different tools solve those problems in collaboration with their teachers.

The vocational teaching situation, that is, vocational students' and vocational teachers' actions in a here-and-now situation, allows the use of tools to take different forms and/or content and tools such as stand-alone semiotically charged objects can expand people's ability to perform their practical tasks effectively (Asplund et al., 2022; Fitch, 2010; Goodwin, 2013). Like Richardson & Stokoe's (2014) study where a cash register was seen as a tool used as a resource to provide service to customers in a bar, our study also shows that the use of tools is context-dependent and that tools can be combined with each other, be created (a building fixture), be recreated (a different type of brush), or things that are not intended as tools can be used as a tool (a pipe that can be used as a hammer). However, the tongue trowel and the hand-threading tool in the study can be viewed as teaching subjects, and they represent contents that are taught. The tongue trowel and the hand-threading tool are used both as tools to perform a task and also as teaching subjects where knowledge of the function and ability of the tongue trowel and the hand-threading tool to perform the work becomes central (cf. Nevile et al., 2014). The size of the screwdriver also becomes important when a problem is to be solved in a here-and-now situation. All these different forms and/or contents of the use of tools, as our study shows, expand the ability of vocational teachers and vocational students to perform a task and solve a problem in here-and-now situations. At the same time, teaching about tools and machines is carried out individually, which leads to situations where some students have the opportunity to learn specific things about tools and machines, and others do not, even during the same teaching session (Asplund et al., 2022). In addition, as this study shows regarding the learning of specific things about tools and machines, what students learn in relation to the four categories about the use of tools can be very different.

Connecting teaching to real situations and making it recognisable can increase vocational students' curiosity, which is important for their learning (Abdulrasool & Mishra, 2010; Berger & Girardet, 2020; Skaalvik & Skaalvik, 2018). The teachers in our study also link the use of tools to real situations. They teach their students what a tool is, and how a tool can be used in the process. Tools make sense in relation to actual work situations and challenges (Hiim, 2017). For instance, a tongue trowel or a hand-threading tool (in second category) becomes relevant when students are faced with problem-solving. In here-and-now situations, and in the learning process, things that were not originally created as tools can, in some situations, be adopted as tools to solve a problem, allowing the teaching to continue. This can be related to the results in the first category, where the teacher finds a metal pipe and turns it into a hammer, or finds two

screwdrivers randomly to solve a task. This category can be related to previous research where mobile phones could be used in learning situations (Asplund & Kontio, 2020), but also as tools for carrying out a job and helping the user perform certain tasks (Edwards, 2011; Goodwin, 2013; Richardson & Stokoe, 2014).

During a teaching session, students sometimes have to create or recreate their own tools to assist them in their continued vocational work. This can be seen in the fourth category, where the teacher and students create a building fixture or reshape a brush. This category can be understood in relation to the kind of modulation that Gilbert (2004) and Justi (2009) discuss. Modelling involves creating models that are connected to the reality of the theoretical subject in question. Through modelling, teaching becomes more concrete for students, enabling them to reason about the content and gain a greater awareness of it (Gilbert, 2004). When the students in our examples (compare the third category) aim to solve a problem by constructing a building fixture in masonry or assembling three different tools for threading work, we assert, based on Gilbert (2004) and Justi (2009), that these acts of tool-making and assembly can be likened to modelling. In a similar manner to a model, these activities can enhance students' understanding of what tools can consist of, how they are built, and how they can be used.

In developed professional work, the handling of tools has also developed and in that process tools have gained an important place in industrial production (Berner, 2009). Our examples also show that developed professional work could require a combination of different tools as well as the handling of suitable tools to carry out tasks. Since we live in a time of various major technical changes (Gutiérrez et al., 2017; Tran, 2013), we can also assume that in step with technical development, we will probably see more developed tools that require a deeper understanding of use and are handled in more advanced ways. This also places demand on technical vocational education to prepare students for a future labour market with greater challenges in terms of tool use.

Conclusion

In our study, we identified four different categories regarding the various ways in which the use of tools is foregrounded as an object of learning in vocational workshop teaching when teachers and students interact in actual teaching situations. We selected film sequences where our focus was on the tool's function and usage. The categories sometimes overlap or interact and involve different types of complexity regarding what learning is made possible in vocational teaching when it comes to tools. This shows that there are different kinds of learning content and abilities related to the tools used in enacted vocational classroom teaching. Tools play a central role in vocational education, where the use of specific tools is crucial for completing specific tasks. Our study shows that tools are not just something that 'are,' but rather something that are 'done' in interaction, and hence are context-dependent. The use of tools as an object of learning occurs in various contexts and teaching situations, within the interactions between teachers and students. The vocational students learn to use tools in different ways in here-and-now situations based on the requirements of the vocational work.

A limitation of our study was that during the 33 hours of video-recordings, we could only identify a few teaching situations in the vocational programme workshops/stylist rooms where

unexpected problems arose, requiring solutions that brought tools to the foreground as objects of learning. This may be because the lessons were often conducted as planned. To gain more insight into the use of tools in situations where unexpected problems arise, more video recordings of vocational teaching in workshops/stylist rooms are needed, as well as further research focusing on tool usage, which we hope to continue in the future.

Note on contributors

Hamid Asghari, first author, is Associate Professor at the Department of Educational Studies at Karlstad University in Sweden. His research interests focus on vocational education, newly arrived students in vocational education, and (vocational) teachers' and (vocational) students' life stories.

Nina Kilbrink, second author, is Associate Professor at the Department of Educational Studies at Karlstad University in Sweden. Her research interests concern for example vocational education, professional learning, and technical education, with a specific focus on teaching and learning and the relationship between theory and practice.

Stig-Börje Asplund, third author, is Professor at the Department of Educational Studies at Karlstad University in Sweden. His research interests include classroom interaction, processes of identity construction, and literacy practices, with a special focus on vocational education and boys' and men's relationship to reading.

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