

Vocational didactics based on industrial teachers' stories

A study on vocational teaching and vocational learning in Swedish vocational upper secondary schools

Hamid Asghari 

Department of Educational Studies, Karlstad University, Sweden

Contact: hamid.asghari@kau.se

Abstract

Based on industrial teachers' narrated experiences of teaching and meeting students at Swedish vocational high schools, this study will provide a definition of the concept of vocational didactics. The study is based on two central pillars: 1) the concept of vocational didactics and 2) narrative research. The concept of vocational didactics is elaborated on the basis of previous research, and stories are further described as the theoretical and methodological starting points. The results show that ten themes about vocational didactics (vocational teaching and vocational learning) emerge from the industrial teachers' stories. The common denominator in the themes is the concept of *occupation*, which is related to employability as an industrial worker. The vocational didactics and its constituent themes, which are context-bound and change as a result of technological development and societal changes, are processed and discussed in relation to the workshop environment (master-apprentice tradition) and school environment. The conclusion is that vocational didactics comprises teaching and learning professional skills and enabling students to become professional practitioners in a profession and a labour market that change continuously in step with technological development and social change.

Keywords: Vocational didactics, vocational teaching, vocational learning, narrative research, Industrial technology program, vocational upper secondary education

Introduction

During the last decade, a growing number of studies in vocational didactics have been carried out. For example, various aspects of vocational teachers' work such as assessment, professional identity, and the relationship between vocational subjects and university preparation subjects have been addressed (Fejes et al., 2017). Vocational didactics has also been described as vocationally oriented teaching and learning (Asghari, 2014; Hiim, 2020; Lindberg & Wärvik, 2017; Pahl, 2014). The vocational didactics research field is broad and spans from decision-making at policy level to teaching practice in the classroom, and includes both upper secondary vocational education and vocational education within municipal adult education and the polytechnics (Muhrman, 2020). The concept of vocational didactics has been discussed in terms of work-based teaching and learning (Gessler & Howe, 2015), and with a focus on content-related aspects to promote knowledge and research in the field of vocational education (Herrera & Gessler, 2018). Vocational didactics has also been studied in relation to digital learning resources and pedagogical tools that can contribute to student motivation and tailor vocational education for the individual student (Haaland & Nilsen, 2023). Studies on vocational didactics have moreover been done with a focus on the development of relevant vocational knowledge and competence, democracy, and student participation in vocational education (Hansen, 2017). Due to an increased interest in research that affects working life in Sweden since the end of the 1970s and the development of international research on vocational teaching and vocational learning in the early 1980s (Muhrman, 2020), there is a need for further development of vocational didactics (Pahl, 2014). In the context of societal changes and technological development, research on vocational education and vocational learning must be continuously updated, which is why this particular study is needed. In addition, there is a need to study, on the basis of narrative research, what the vocational teachers themselves say about vocational didactics, which this article aims to do.

The study is based on three industrial teachers' stories and focuses on *the content of the narrated teaching and learning*. Within the social science research tradition, story research is one of many ways to understand a phenomenon where the main interest is directed towards the content of the stories and the life that the stories are about (Goodson, 2012). The teachers' stories relate the experiences they have of their daily work as teachers (Pérez Prieto, 2007). I have therefore chosen to use industrial teachers' stories as a way to understand what vocational teaching and vocational learning can be for them. Thus, the study will define, develop, and discuss the concept of vocational didactics through industrial teachers' narrated experiences of their teaching and their students' learning. The research question to be answered in the study is: What vocational didactics themes, with particular focus on the content of narrated teaching and learning, emerge from the industrial teachers' descriptions?

For this study, I have chosen a thematic analysis of the stories. This is because thematic analysis is based on a holistic approach where the research material is encoded into different aspects of the problem that the research wants to address, without the stories being broken up into shorter statements (Lieblich et al., 1998; Riessman, 2008). This means that the thematic analysis retains stories more or less in their entirety, and the researcher actively and carefully identifies, organises, and describes patterns based on the explicit details of what the industrial teachers say about their teaching and their students' learning (cf. Lieblich et al., 1998). The study

is based on two central pillars: 1) the concepts of vocational didactics and 2) narrative research as theoretical and methodological starting point. In the coming sections, I will elaborate on the concept of didactics and further describe the theoretical and methodological basis of the study. In the Results section, I present the industrial teachers' stories about their teaching of, and meeting with, the students, and discuss prominent themes in relation to previous research. Furthermore, I discuss the results of the study in relation to research on teaching and learning in the Discussion section. Finally, the Conclusion summarises what vocational didactics means in relation to a labour market that is continuously changing.

The concept of vocational didactics

Vocational didactics is described as the interaction between vocational teachers' pedagogical knowledge, their vocational knowledge, their teaching knowledge, and their knowledge of children's/young people's learning (cf. Gessler & Herrera, 2015; Herrera & Gessler, 2018; Pahl, 2014). Within vocational didactics, teaching in vocational subjects is integrated with regard to the goals and missions of the education and the school. Vocational subjects have not had their own subject didactic foundation as study preparation subjects (such as for example English, biology, physics), and they have not historically had the same status as academic subjects (Muhrman, 2020; Nylund, 2013).

Vocational didactics is aimed at the goal of vocational education, which is to create the conditions for students to have sufficient knowledge to perform a professional job and to use the resources available both in school and in working life (Hiim, 2015). Vocational didactics is about how a profession can be perceived as meaningful, how vocational students can improve their vocational knowledge and competence, and how vocational knowledge can be further developed through systematic education and research processes (cf. Hiim, 2013; Lindberg & Wärvik, 2017). Critical analysis and use of professional functions, which are the basis for vocational learning, are included in vocational didactics. This means that both the curriculum and the facilitation of the learning process are based on central tasks and functions in the current profession (Andersson & Köpsén, 2014; Wärvik & Lindberg, 2018). Vocational didactics thus tries to discover a useful framework for vocational education and explain the action of vocational teachers in relation to the curriculum (Gessler & Herrera, 2015). Vocational teachers' lesson planning based on the interpretation of the curriculum, and their imparting of knowledge in the classroom environment, become central (Herrera & Gessler, 2018). Vocational teachers are also given the task of updating their knowledge and reflecting on it (Lindberg & Wärvik, 2017). The core of vocational teachers' professional teaching work is about finding methods for teaching, and didactics serves as a framework to help the teacher to reflect on their vocational teaching and to identify tasks that help the vocational students in their knowledge development (Fejes et al., 2017; Hiim, 2015). Vocational teachers' careful teaching planning is considered central in the vocational didactic field (Hiim & Hippe, 2001; Klope & Gåfväls, 2022).

Vocational didactics is described as practical-theoretical planning, implementation, evaluation of vocationally specified education, teaching and learning in school and working life (Hiim, 2013, 2015; Hiim & Hippe, 2001) and it is defined as a process that takes place in an interaction between practical teaching work, reflection and theory development within the profession

(Henning Loeb et al., 2019; Kontio & Lundmark, 2021; Paul, 2017). Vocational didactics focuses on teaching and learning a profession (Asghari, 2014; Hiim, 2020; Lindberg & Wärvik, 2017; Pahl, 2014), and can be seen as a process that takes place in an interaction between practical teaching work, reflection on teaching and theory development, and concept explanation over teaching (Andersson & Köpsén, 2014; Tyson, 2016). The interaction also includes the knowledge content and goals of the profession, students' conditions for learning, frame factors, and evaluation of both teaching and learning (Hiim, 2013, 2015). Evaluation of the teaching process and students' learning takes place based on the standard set by the school authority.

I have a constructionist perspective on vocational didactics and see the *profession in itself* and also *the process of professional development*, which is continuously changing, as constructions. Profession as a *product* can be seen as the *result of a process* that can also be perceived in different ways by different actors who are involved in the profession. Understanding profession in terms of products and processes means that we can see vocational didactics from a broader perspective, that is, vocational teaching and vocational learning do not take place in a vacuum. Generally speaking, the teaching profession changes in relation to social change and technological development, and more specifically, industrial teachers and industrial students also bring their thoughts and ideas to each lesson. The ideas are shared and developed and teaching and learning take place in a process through these meetings. In this way, no teaching experience and no learning experience is the same because the individuals are different and different ideas are shared and combined in different contexts. This means that teaching and learning can be seen as always in progress based on the participants' emerging ideas in different contexts. I also understand vocational didactics as the doctrine of teaching professional skills, or in other words the art, technology, and science of teaching a profession.

Stories as theoretical and methodological starting points

The methodological starting point in the article is based on *narrative research*. I have collected the research material in this study over the fifteen years that I have been a researcher in vocational education, with a deeper focus on the upper secondary Industrial technology program in Sweden. During these years, I have narratively interviewed (in-depth interviewed) seventeen industrial teachers for various research projects and in the analysis of the stories during those years, it emerged what vocational teaching and vocational learning meant for these teachers. As the material is very rich, a challenge for me has been to select a few stories for an article with a limited word count. Based on the constructionist perspective on stories (Goodson, 2012; Mishler, 1999; Pérez Prieto, 2007), I chose three stories from three industrial teachers (a welding teacher, a CNC¹ teacher, and a lathe teacher). For the selection, I have used a critical eye to identify the parts of the story (descriptions) where the themes of vocational didactics (teaching and learning) emerged in a clear way so I did not have to overinterpret the stories in relation to the themes. In addition, all of the prominent themes from the three industrial teachers' narratives have been prominent in the other fourteen industrial teachers' narratives that are not reported in the article. Besides this, in order to reduce the repetition of the same prominent theme in different stories, I chose different parts of the stories where different themes

emerged, as clearly as possible, from the descriptions. In the selection, I also stayed close to the stories and chose the parts that contained explicit phrases such as *I talk to the students about, I tell the students that, I have conversations with the students about, I teach about*, and so on, and have tried to distance myself from descriptions that contained opinions and thoughts, expressed in phrases such as *I think that, I think this way, it is my opinion that*. This is because in the latter case I do not know if the teachers had conversations about their perceptions and opinions with the students, but when they talk about their conversation with the students, this suggests to me that they shared their perceptions of what is important for learning with the students. I interviewed the industrial teachers two or three times during those years. The number of interviews depends on what knowledge gaps I found after each preliminary analysis of each story (cf. Mishler, 1999). I conducted all the interviews at the industrial teachers' schools (their workplaces), recorded the interviews with a Dictaphone, and transcribed them immediately after the interview. Based on the constructionist perspective on narratives, I brought together each teacher's transcribed material from the first, second, and third interviews (of those who had been interviewed a third time). In the next step, I constructed the stories chronologically and created a constructed narrative of their stories (cf. Ochs & Capps, 2001; Zeller, 1995) to be able to analyse the stories with a focus on the research questions.

The theoretical starting point is about the understanding of *what* the industrial teachers tell. I position myself within a research tradition where the stories of industrial teachers are regarded as socially constructed products (cf. Mishler, 1999; Pérez Prieto, 2006). Based on the constructionist perspective on stories, I see stories as social acts through which the teachers are involved in a creative process of narrative reflection. The narrative reflection is not only about remembering their lives in narrative, but also about trying to understand their lives as narrators and creating contexts of different stages of their lives into a meaningful whole (Freeman, 2023). The story thus becomes a meaning-making and identity-creating process, through which industrial teachers try to understand both themselves and their surroundings, within the framework of the interview conversation that I, as the interviewer and the researcher, initiate. Based on Goodson (2012), Mishler (1999), and Pérez Prieto (2007), this means that the industrial teachers create meaning about themselves and their world in the narrative. Already in the interview situation, they highlighted what they considered relevant to me as an interviewer and/or what they thought I wanted to hear. While the industrial teachers talked about their teaching, they created a sense of their own self (cf. Bamberg, 2006), and constructed different kinds of identities, what Mishler (1999, p. 19) calls "identity performances". Identity performances can be seen in the industrial teachers' narratives as them wanting to show me as an interviewer who they were and how they should be perceived. When they told me about their teaching and meeting the students, they looked back on their lives and the times they met and taught their students. In the narration, they reflect on their experiences and actions (Freeman, 2023; Meretoja & Freeman, 2023) and in interaction with me they constructed their stories based on the interview situation they were in. Consequently, they gave form and meaning to their experiences of the lived life, but I was with them, both as a conversation partner and as an audience, when they talked about, and reflected on, their experiences. What the industrial teachers told and how and why they told what they told were shaped by their experiences, but also by my participation and the questions I asked.

Analysis of the industrial teachers' stories

In my thematic analysis, I started from Lieblich (1993; 1998) and tried to compile, describe, and make comprehensible the various didactic elements taken into account by the industrial teachers in order to clarify what the teachers say that they do when they teach. Based on Riessman (2008), I also tried to highlight what is characteristic in the stories of several industrial teachers. By studying what the industrial teachers told me, I was able to identify different themes in their stories. Based on Riessman (2008), a theme can be discovered by comparing either different stories with each other, or by comparing different parts of the same story, where repetitive descriptions take place. I worked on my thematic analysis by reading a number of different industrial teachers' stories in several rounds and coding the descriptions that had been repeated many times, in one industrial teacher's stories or in several teachers' stories about what they perceived their teaching and students' learning to be about. The prominent themes will be presented in the following sections.

Ethical approach

The collected material in this article consisted of narrative interviews with seventeen vocational teachers within various research projects. All those research projects have, before implementation, either been reviewed by ethics advisors at my university or approved by the Swedish Ethical Review Authority where there was no ethical objection to the implementation of the project. In the research process, I have relied on the guidance of Swedish Research Council (2017). I informed the vocational teachers about the research project through an information letter. In the information letter, I also wrote that their participation in the research project was voluntary and they had the right to stop their participation in the project whenever they wanted without explaining to me why they dropped out. The interviews with the vocational teachers were conducted in Swedish and translated into English. I have both told the vocational teachers and written in the information letter that the interview material will be used in scientific publications and/or research conferences and teaching. Before interviewing, I collected consent from the vocational teachers through a consent form.

Results

In this section, I answer the research question, which deals with the vocational didactic themes, with a special focus on the narrated teaching and learning content, emerging from the industrial teachers' descriptions. The themes that emerge from their stories regarding what is included in their teaching and students' learning are: *production knowledge* (the concrete knowledge that an industrial worker needs to manufacture an industrial product), *professional language*, *professional assessment* (assessing whether a product meets the requirements for approval in order to be able to pass it on to customers), *professional identity*, *professional status*, *professional pride*, *professional culture*, *professional ethics*, *professional morality* and *professional safety* (knowing enough to feel safe and secure with a professional practice so that it does not cause material damage or personal injury).

Welding teacher's story

A story in which the themes of *professional identity*, *professional status*, *professional pride* and *professional culture* appear is a welding teacher's story about his teaching. The teacher says:

I tell my [welding] students that thanks to this profession you will be able to afford a good life. You become a welder, it is a very important profession that gives you both a good income and respect among people for what you do, because this [welding] profession is always needed. [...] then I heard that the plumbing students said to the welding students; it's us you have to call when the water pipe bursts at your house, and then the welding students say; we will weld together the car parts that you will buy, but for them to become welders, they have to learn a lot. So, I try to teach them that we have an unwritten culture with us, how to behave with a customer or in a work team, in the workplace, so when you enter the coffee room, you don't go and take the first best chair because it's somebody's chair, and if you want your coffee place then you fix your chair and your coffee place and then you wash your mug after you. [...] Not everything is in our textbooks, but they [welding students] have to understand that if they want to have employment, then it is important to return the tools to the same place after use, so that no one else is looking for them, they have to clean up after themselves, they have to take care of the tools and the machines they use because they cost money, they have to come to work on time because it's about respect for the workplace, respect for the work team, that's how it is with us, and I'm talking about that all the time so that at some point it will stick in here [in the brain].

One of the themes that emerges from the description above is *professional identity*. Professional identity is described as a kind of perception of who you are in your profession. A professional does not only have one professional identity, but several professional identities that are context-bound and change over time, for example in interaction with other people and the environment, or in relation to professional skills, or in relation to technological development and societal changes (Asghari, 2014, 2018). Professional identities can also change in relation to previous professional experiences (Vähäsantanen & Eteläpelto, 2009). A welding teacher, for example, can identify herself/himself as a welder and as a teacher at the same time (cf. Asghari, 2014; Robson et al., 2004). *Professional identity* appears in the story above when the welding teacher says to his students: "you are welders". In other words, the industrial students are reminded of the professional identity that they will create for themselves through the vocational education. Related to the professional identity, which is constructed in the students through the vocational education, is also a good economy and an orderly life. *Professional identity* also appears when the plumbing students identify themselves as welders who weld together parts for cars.

The themes of *professional status* and *professional pride* also appear in the teacher's description. Professional status focuses on the external characteristics of the profession. Salary, education, influence, and power are often highlighted as important characteristics for professional status (Berntsson, 2007). Professional pride, on the other hand, can be related to the meaningfulness of the profession, and the professional workers' satisfaction with carrying out their professional practice. Both concepts can be understood in relation to the concept of professional identity, and the professional roles practitioners take in their professional practice.

For example, working as a welder at a world-renowned company, with computerised and high-tech welding machines, can give a higher status than working in a workshop with run-down premises and old welding machines. Welders at the world-renowned company can, through their work, identify themselves as employees of a world-renowned company, and therefore assume the professional status of working as welders at the world-renowned company. However, both the welder at the world-renowned company and the welder at the run-down workshop can see the meaning of their profession and be satisfied with their professional skills, for instance the ability to weld difficult and complicated details with a perfect result, and they can thus feel professional pride as welders. In the story, the theme of *professional status* appears when the teacher says that the profession is respected among people, and the theme of *professional pride* appears when he says that the profession of welding is always needed (in society).

A theme that also emerges from the welding teacher's story is the theme of *professional culture*. Professional culture is described as professional norms and the values that professionals learn through work in business and that characterise the professional group (Höghielm, 2001). Professional culture is thus about frames of reference, norms, and attitudes that are expressed in the professional community. In the story, the theme of *professional culture* appears when the teacher talks about the unwritten cultural code of behaviour that exists among welders in the workshop. This professional culture includes, among other things, how a newly employed welder should behave in the coffee room at his workplace. The *professional culture* that the teacher relates to employability also includes handling tools and machines, keeping the workshop clean, and showing respect for working hours, the work team, and the workplace.

CNC teacher's story

One of the stories where the themes of *production knowledge*, *professional ethics* and *professional safety* appear is a CNC teacher's story about his teaching. The teacher says:

To get a job as a CNC operator, they have to read a lot during these three years, blueprint reading, workshop math, cutting technology, CAM² expansion, the machine itself, how it works. [...] They also study a lot of workshop math which is included in the subject Computer controlled production in the CNC education to be able to program angles, phases, catheter and hypotenuse, but I'm the one who teaches workshop math. Otherwise, we have a maths teacher who teaches general maths that all high school students take, but then it becomes different. I always have 80 - 90 % attendance in my class while the math teacher does everything to make them think math is fun, but they ask me what are we going to do with quadratic equations? They don't know how to use quadratic equations as a CNC operator. [...] Then we also talk a lot about teamwork and that in the team includes heterosexuals, homosexuals, immigrants, all kinds of people, so they must learn to respect all people and be able to work with everyone who is part of the team. [...] Among my students there are many who really believe in equality, but there are also some who think otherwise, and then we discuss what a Swedish company looks like, that we have female managers in Swedish companies, we have talented CNC operators who are girls, and they do a great job, no worse than the guys anyway. We talk about that a lot. [...] They are also afraid of making mistakes, but that is also something that comes with experience when they work for a few years as CNC

operators. Now they all say; have I done it right? Will the machine crash? But I say to them; don't be afraid of the machine, but you must respect it. You have to know so much so that you can feel safe so that when you press the start button no person or machine will be harmed.

The theme of *professional safety* emerges from the CNC teacher's story. By safety is meant freedom from fear, anxiety, danger, doubt that leads to a state or feeling of security and calm (Beasy et al., 2023; Collins et al., 2023). Professional safety can be about the development and maintenance of a suitable position and place in the profession, that there is protection against skills dilution, and it is also related to the employee's opportunity for status and income-related career development (Swuste et al., 2010). Professional safety can also include the principles that prevent work-related bodily injuries and protect and promote the health of workers (Gyekye, 2010; Harms-Ringdahl, 2001). Professional safety aims to improve working conditions and the environment (Harms-Ringdahl, 2001). From the CNC teacher's story, it appears that professional safety is linked to *production knowledge*, that is, that the students should learn so much that they will not be afraid of their professional practice but instead feel safe with what they do, so that their action does not lead to material damage or personal injury.

Another theme that emerges from the CNC teacher's story is *professional ethics*. Ethics is described as respect for human dignity and justice, and contains values and norms for how each individual, based on human rights, should be treated as a person and how a person should treat other people. According to Lindqvist (1977), ethics deals with overall questions about right and wrong, evil and good, and questions about what characterises a good person, a good life, and the good society. In that context, professional ethics for teachers can be about creating the conditions for students to receive support in school and complete their studies, regardless of family background, gender, and class (Öhman, 2022). The theme of *professional ethics* that emerges from the CNC teacher's story is about respect for the value of all people and that the students should learn to cooperate with all the people who are part of the team. Professional ethics also appears when the teacher talks about teaching their students about equality in Swedish society, where female managers work in Swedish companies and girls are skilled CNC operators.

A theme that also emerges from the CNC teacher's story is *production knowledge*, which for that teacher is about knowledge of blueprint reading, workshop math, cutting technology, and CAM expansion. I will discuss the topic of production knowledge in relation to literature in the next section, Lathe teacher's story.

Lathe teacher's story

One of the stories where the themes of *production knowledge*, *professional language*, *professional morality*, *professional ethics* and *professional assessment* appear is a lathe teacher's story about his teaching. The teacher says:

A few years ago, we had a teacher who was a very good lathe operator in his home country, but he was new to Sweden. He didn't know what threading taps or crosscut saws or hacksaws was called in Swedish, so, he was a teacher for first grade, and then he had always told them; pick it up, move it here, put it back here. So, when the students came to me in the second

grade, they had learned how to lathe, read blueprints, but they didn't know the names of the things, and how do you even get a job as a lather when you don't know the names of tools and machine parts. So, they also said, this and that. They have names. Threading taps, threading dies, tailstock in a lathe, and then I started teaching them the names of those things in the second grade. [...] When they manufacture this [metal] piece that we say it's within the tolerances now when it's hot, it can go above or below the tolerance when it's cold, so depending on whether it's a hole or a surface, or if it is 1312³ or 1914⁴ or aluminium. So, they also have to make an assessment, what will happen to the tolerances on the piece when I send it to the customer, and the piece has then become cold. It is very important! Think, if it is going to sit in an airplane, if it is two thousandths of a millimetres below the tolerance, then something can go wrong in the plane and it crashes, it's about people's life and death, but also, if I talk time and time again about it, it's hard to teach them this. They have to work for a few years to get the right feeling.

Knowledge is described as something that comes in different forms, theoretical, practical, and tacit. Theoretical knowledge can be defined as theory about something that is only about understanding, or theory for something that is more action-oriented (Gustavsson, 2000). According to Gustavsson (2004), practical knowledge lies in the professional skills and appears in action. It is knowledge that humans use to produce for instance a craft, give expression to an art, or develop an object. According to Polanyi (1966), tacit knowledge cannot be given an explicit formulation but it can be transmitted via practical training or accessed through personal experience. Tacit knowledge can also be repressed or silenced knowledge. According to Gustavsson (2000), tacit knowledge is the unwritten and partly indescribable practical knowledge that is common, among other things, in handicrafts. Gustavsson (2000) further explains that when you carry tacit knowledge, it is difficult to report the details of the knowledge, although you can talk about the whole. The theme of *production knowledge* that becomes visible in the lathe teacher's story concerns knowledge about the changed tolerances of products due to cold and heat. This knowledge that lathe operators must take into account in their production appears to be tacit, because it is related to professional experience, and lathe operators will learn over time about tolerance changes that occur depending on the type of metal, the size of the part, and the function of the product.

Another theme that emerges is *professional language*. Professional language arises in groups that share a profession or an interest where communication is facilitated by common terms. Through the professional language, the common knowledge base can be made visible and the activities and operations described. Professionals can use the professional language to put into words the work they carry out (Colnerud & Granström, 2015; Laurén, 1993). The lathe teacher's story shows the importance of *professional language* and having knowledge of the names of the tools and machine parts that are part of the profession. In the description, it becomes visible how the lathe teacher's teaching and the industrial students' learning (vocational didactics) can be affected when there is a lack of knowledge about the professional terms, and when the industrial students cannot put into words the work they carry out.

The theme of *professional assessment* also emerges from the description. The concept of assessment is described as a process that includes the collection, interpretation, and production

of data and leads to a determined decision (Lundahl, 2011; Nyström, 2004). Assessment is context-bound and can have different meanings. Assessment can, for example, create opportunities for feedback to students (Wyszynska Johansson, 2018; Öhman, 2018). Assessment can also serve as a way to motivate students in their learning (Lindberg, 2002; Lundahl, 2006). Assessment can make students' reasoning about the subject visible to teachers and enable different identity creations for students (Asghari, 2014; Asghari & Kilbrink, 2018). Evaluation in relation to professional skills is discussed by Gåfväls (2016), where the floristic work and flower arranging with colour, shape, and composition are constantly evaluated by students and teachers. Assessment in relation to Vocational Bildung is treated by Tyson (2023). Tyson relates the context-bound Vocational Bildung to the professional practitioner's development process, to value-based professional practice, and to ethics. In line with Gåfväls' and Tyson's studies, the *professional assessment* that emerges from the lathe teacher's story is about the student's *production knowledge* of product quality, which should lead to the decision whether the product meets the requirements for approval so that it can be sent on to customers. This *production knowledge*, which should lead to the student's *professional assessment*, appears to be related to his professional experiences.

Both *professional morality* and *professional ethics* emerge from the lathe teacher's story. Unlike ethics, which was discussed in the previous section about the CNC teacher's story, morality deals with the practical, concrete, and actual actions of humans. Morality is expressed for instance in the form of speech where one expresses what one considers to be right or wrong in a certain matter (Gustafsson, 1988; Heberlein, 2014). *Professional morality* is shown in the lathe teacher's story in the form of the repeated conversation with the students about the *assessment* of the quality of a product before it is sent to customers (an expression of what is considered right or wrong), and the *professional ethics* emerges when the lathe teacher says that a product that has not been manufactured within approved tolerances should not be sent to the customer because it may pose a danger to human life (an action related to respect for human dignity).

Discussion

The study shows that vocational didactics is more than teaching the *production knowledge* that an industrial student must learn in order to handle a workpiece and produce a product. Speaking of production knowledge, the concept of knowledge can be understood as theoretical, practical (Gustavsson, 2000), and tacit (Polanyi, 1966). For example, the knowledge of programming a CNC multi-operational machine, which must turn a workpiece into a finished product with a tolerance of a few thousandths of millimetres, can be seen as theoretical knowledge. In that case, incorrect programming can lead to the machine crashing or the product not being manufactured within the tolerance. The practical knowledge includes professional skills that make it possible for an industrial worker to produce a product (Gustavsson, 2000). The tacit knowledge is the experience-based unwritten and partly indescribable practical knowledge (Gustavsson, 2000; Polanyi, 1966) that a skilled industrial worker uses to produce a product. The industrial worker can, with her/his professional skills, combine and use theoretical, practical, and tacit industrial knowledge to carry out an industrial work and produce a product (cf. Asghari, 2018, 2021). The more capable the industrial worker is of using her/his theoretical, practical, and tacit industrial

knowledge in combination, the more skilled he or she becomes. This implies that professional skills develop in relation to professional experiences. Included in these professional skills is practical wisdom and judgment, which also includes moral and ethical principles. An example of practical wisdom and judgment can be found in a lathe operator who will produce a product that is going to be used in a passenger airplane. The lathe operator can in that case ask herself/himself how the lathe should be implemented. In that context, there is a kind of judgment of the lathe operator who, based on her/his professional experiences, carry out a work task as correctly as possible. Such professional judgment (cf. Tyson's (2023) value-based professional practice) also has ethical aspects since the lathe operator's wrong judgment can lead to danger to human life.

However, I lean towards the research that indicates that professional theoretical knowledge, professional practical knowledge, and tacit professional knowledge are indivisible (Asghari, 2018; Klope & Gåfvels, 2022; Korp, 2011; Lindberg, 2009). An example of this is the ISO metric screw thread with a M4⁵ threading tap, in a CNC multi-operational machine. In order for a CNC operator to be able to carry out such threading in a workpiece, *production knowledge* is needed, but also the knowledge of (the feeling of) when a M4 threading tap can go off, even if the speed and feed are correctly calculated in the CNC machine, and the coolant is switched on. This feeling as a type of tacit knowledge is experiential, and it cannot be described to novices. The novices have to thread with the M4 threading tap in the CNC multi-operational machine for a number of years themselves to access this feeling (this silent knowledge). These forms of knowledge are indivisible when it comes to production, and in combination with each other they make it possible for the workpiece to be threaded. With that said, I contend that *production knowledge*, that is, the concrete knowledge that an industrial worker needs in order to manufacture an industrial product as it emerges from the stories of the three industrial teachers in this study, involves knowledge of production and production machines, blueprint reading, CAM expansion, workshop mathematics, cutting technology, the tolerances of the product and its change due to cold and heat, and knowledge of assessing the quality of the product before it is sent to the customer.

As part of vocational didactics, the themes of *production knowledge*, *professional language*, *professional assessment*, *professional identity*, *professional status*, *professional pride*, *professional culture*, *professional ethics*, *professional morality* and *professional safety* emerge from the industrial teachers' narrated experiences of their teaching and meeting with students. A common denominator in these themes is the concept of *profession*. This common denominator emerges from the CNC teacher's description when he says: "I always have 80 - 90 % attendance in my class while the math teacher does everything to make them think math is fun, but they ask me what are we going to do with quadratic equations? They don't know how to use quadratic equations as a CNC operator". I believe that in the vocational school there must be some significant difference between the teaching and learning of general mathematics (subject didactics) and the teaching and learning of workshop mathematics (vocational didactics) (cf. Asghari, 2014). For me, the difference is in the concept of *profession* itself, and the connection of the subject to the profession, which is included in CNC education, in terms of both teaching and learning. A CNC student studying general mathematics will not work as a mathematician after completing vocational education and probably finds it difficult to see the connection between quadratic equations and the specific objectives of the CNC profession (if the mathematics

teacher does not clarify this connection), but the CNC student will hopefully work as a CNC operator after completing vocational education, and for this reason the connection between workshop mathematics and the CNC profession is probably more obvious to the student. However, it is one of the goals of vocational education that the vocational students should receive a basic vocational qualification which indicates that they have sufficient knowledge to perform professional tasks for a labour market which is continuously changing (Asghari, 2021; Wärvik & Lindberg, 2018). This means that the CNC teacher's teaching is adapted to, and the CNC student's learning is based on, future employment as a CNC-operator. In other words, it is precisely the concept of *profession* that is related to employability as a professional practitioner. Employability is contextual and changes in step with technological development and societal change (Harvey, 2001; McQuaid & Lindsay, 2005). An individual is employable if she/he has the skills and experience required to gain employment in the labour market (Harvey, 2001). In addition to competence and experience, flexibility, development ability, and different types of personal characteristics may be what is required for employability (McQuaid & Lindsay, 2005). Being employable is also defined in different ways by the industrial teachers. The welding teacher relates students' employability to both *production knowledge* and the unwritten *professional culture*. For the CNC teacher, employability (to get a job as a CNC operator) is about both *production knowledge* and knowledge of *professional ethics* (respect for the value of all people). As a practical-theoretical process, vocational didactics consists of theorising and reflecting on vocational language, and this is shown in the lathe teacher's story when he relates employability (getting a job as a lathe operator) to both *production knowledge* and knowledge of *professional language*.

One of the most important foundations of industrial education can be found in its professional tradition. Education in the industrial profession is directed towards working life, and it is affected by changes in working life, and society's approach to working life development. Industrial students do not know if the professional knowledge they learn in a school environment is sufficient to carry out industrial work in a working life that is continuously changing. However, the industrial teachers are aware of this continuous change, and they know whether an industrial student is capable of a certain professional practice or not. In other words, in vocational didactics, feelings and practical knowledge work together (cf. Berner, 2009). In the practical-theoretical process, the industrial education is based on a concept of industrial knowledge that has less distinction between practice and theory and between words and deeds.

Vocational teaching and vocational learning originally come from a master-apprentice tradition where apprentices, for example during the 19th century, worked and lived with the master and learned the craft. Apprentices were never graded F to A for their professional skills. They worked in a workshop environment as novices and gradually over time became masters, and later masters of masters in their occupation. Those who decided who would be the novice, the master, and the master of masters were the people who were in need of the professional skills of the practitioners. Sweden's Parliament decided in 1970 that vocational education would be reformed and integrated into the upper secondary school for the academic year 1971/1972. This was a change of context from vocational teaching and vocational learning in the workshop environment to vocational teaching and vocational learning in the school environment. This change of context has brought further changes for vocational education. For example, from

a democratic perspective, in the master-apprentice tradition, students' influence over their learning was neglected (cf. Klafki, 1997). In the school environment, if we start from the National School Inspectorate (2023), students have the right to learn, to develop as far as possible, and to get the help they need. In the school environment, teaching and learning are also based on the laws, regulations, rules, and policies that are placed on education, which stipulate that the school must, for example, counteract discrimination, violations, and harassment. Another change involves the professional skills. An apprentice electrician, who eventually became the master of the masters in the workshop environment, was able to draw high-voltage wires at the beginning of the 20th century, but a student who gets a grade A in the course Electricity and traction in the school environment is still a novice, and after completing the vocational education, she/he cannot directly carry out work on a high-voltage line without a master's supervision.

The fact that different conditions are created for the student to learn an occupation in a school environment compared to an apprentice who learns an occupation in a workshop environment has already been discussed by Berner (1989). Berner, who compares vocational education in school environments with vocational training in workshop environments, writes that students who train in workshop environments may be more experienced in solving upcoming problems and carrying out their tasks than those who train in school environments, and who may lack such experience. According to Berner, however, students who train in school environments can on the other hand be better at explaining what they do, than those who train in workshop environments. In addition to what Berner (1989) writes, I suggest that in school environments, industrial teachers through their teaching create the conditions for their students to acquire the concrete knowledge they need to be able to manufacture an industrial product (*production knowledge*), to acquire the *professional language* so that they can, among other things, put into words the industrial work they perform, and to learn the *professional culture*, *professional ethics* and *professional morality* within their profession. In addition to this, the teaching of industrial teachers includes the creation of opportunities for the industrial students to construct *professional identities*, *professional status*, *professional pride* and to feel safe (*professional security*) in the work they carry out. The industrial teacher's teaching also includes *professional assessment* where the student learns to assess whether a product meets the requirements for approval in order to be able to pass it on to customers.

Conclusion

Based on the ten prominent themes, the study concludes that vocational didactics can be described as a contextualised vocational teaching and vocational learning. The context involves a range of professional skills and professional procedures required to train the student to become a professional who can be employed and perform qualified work tasks in a labour market that is continuously changing. The ten prominent themes are not constant since they change in step with technological development and social change. The themes also demonstrate that vocational didactics is not something that 'is' but something that is 'done'. This 'doing' takes place in the interaction between teachers, students, and their environment.

It is also important to take into account that the themes are not separated from each other but overlap, and one theme leads to other themes. For example, a welding student who

learns *welding knowledge* can, at the same time, learn a functional *professional language*, gain knowledge about the existing *culture* within the welding profession, gain *assessment* knowledge about the quality of the product, learn *professional ethics* and *morals*, and *feel safe* with the profession. Parallel to these aspects, the student's *identity* as a welder can also emerge. With the emergence of an identity as a welder, the student can find the profession meaningful and become *proud* of her/his profession. This also applies to the occupational category of welder. In a society, when a number of welders have managed to acquire a good life with good finances through their *professional skills*, this can lead to *identity prominence* as 'we welders' is recognised as a skilled professional group and also raise the *status* of the welding profession.

Endnotes

- 1 CNC stands for Computer Numerical Control and is a computer system used to control workshop machines or machines that are programmed numerically.
- 2 CAM stands for computer-aided manufacturing.
- 3 1312 is a designation for structural steel, a type of steel used in building construction. One of the most important properties of structural steel is its strength, toughness, weldability, as well as its ability to bend and be cut.
- 4 1914 is a designation for automatic steel. Automatic steel is a type of steel with very good machinability, meaning that high cutting speeds can be used with short chips, resulting in a good surface quality.
- 5 The M stands for Metric. For an M4 threading tap, the number indicates the outer diameter of the threads.

Note on contributor

Hamid Asghari is an Associate Professor at the Department of Educational Studies at Karlstad University in Sweden. He holds a PhD in Educational Work. His research interests focus on narrative studies, vocational education, newly arrived refugee youths in vocational education, (vocational) teachers' and (vocational) students' life stories. Asghari is active in teacher and vocational teacher education at Karlstad University.

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