Introduction

Welding as Embodied Technical Knowledge

This body is not cooperating.

Apparently, I am incapable of working a vice grip. I am trying to clamp my coupons—two mild-steel plates tacked[1] together on the ends—to the metal table in my booth, but I can't hold the coupons, turn the little tension screw on the vice grip, and hold the vice-grip handles at the same time. To make matters worse, I can barely get my hand around the splayed-out handles. How does anyone do this without four arms? I press the coupons against the table with my belly to give myself a free hand, trying not to brand myself on a still-hot tacked end. For the umpteenth time, the coupons clang onto the cement floor. Trying to pick them up while wearing my welding gloves will be yet another round in this battle. Worse yet, it's summer in central Iowa, and the welding lab does not have air conditioning. I'm getting hotter as minutes slide by, and I become more and more certain that the men in the class are looking at me, thinking I'm pathetic, unable even to get started on practicing my horizontal weld because I can't get the goddamn coupons clamped to the table. This body, my body, does not know what it is supposed to do.

Learning to weld means learning through the body. It means feeling—feeling the most comfortable and stable way to hold the welding gun and feeling the most effective angle and speed. It means learning to breathe as you go. Learning to weld, like learning other skilled trades such as auto and truck mechanics, plumbing, and machining, requires physical as well as mental engagement. It means repeating your efforts and integrating them with abstract concepts until you have learned how to read a situation—a joint, position, metal, temperature, and so on. Haas and Witte (2001) wrote that the development of such embodied knowledge culminates in “the usually skillful and often internalized manipulation of an individual’s body and of tools that have become second nature, virtual extensions of the human body” (416). They went on to say that we gain embodied knowledge through “lived experience” until we have a “felt sense” for what works and what does not (417). In brief, embodied knowledge—the kind of knowing that is physical as well as mental—develops through and resides throughout the body as well as the mind.

This book, *Welding Technical Communication: Teaching and Learning Embodied Knowledge* (*WTC*), relates two narratives: one personal and one academic. In regard to the former, I relate the story of how my welding teachers helped me develop embodied knowledge of the technical skilled trade of welding. In this personal narrative, I describe some of my experience as a student at Des Moines Area Community College (DMACC)—a middle-aged woman learning to operate comfortably and effectively amid the tools and talk (including a bit of trash talk) of a welding lab.

I found myself in the welding lab for the first time in January of 2018 after having decided to enroll in night classes at DMACC the December before. I had gone through a spell of feeling sorry for myself, having been diagnosed earlier in the year with labral tears in my hips that made my favorite activities, such as cycling and swimming, uncomfortable if not downright painful. I had waited months for my first surgery, which had been scheduled for December 2017. But two days before the surgery, I got an infection, and the doctor told me the surgery would have to wait. For me, a university professor, waiting meant the surgery wouldn’t happen until May—after the spring semester. After two weeks of moping, I decided I simply had to buck up and find something that this body *could* do, something physical. And, for a reason I do not know, what popped into my mind was an old photograph of my grandfather standing among a group of men and women at Globe Shipbuilding in Superior, Wisconsin, my hometown. My grandpa had welded ships during World War II. Learning my grandfather’s trade felt right (figure I.1).

In regard to this book’s second narrative, I take off my welding helmet and carry out my role as a researcher at Wisconsin Indianhead Technical College in Superior, Wisconsin; Marshalltown Community College in Marshalltown, Iowa; and Lake Superior College in Duluth, Minnesota. For this study, I drew upon research on scaffolded learning theory, technical communication research on embodied knowledge, and

Figure I.1. Joseph Mackiewicz (my grandpa) and others at Globe Shipbuilding in Superior, Wisconsin.

Lave and Wenger's (1991) research on learning within a community of practice. I examined how teachers' verbal communication worked in tandem with their nonverbal communication to build students' embodied knowledge and their moment-by-moment enculturation into a professional community of practice.

Such a study of the technical communication—both verbal and nonverbal—that teachers employ is sorely needed. Although technical communication research has explored the discourses through which people acquire technical expertise (e.g., Fountain 2014), fewer studies have examined how verbal and nonverbal communication combine to support students' acquisition of embodied knowledge. Moreover, about 6.2 million people take classes in two-year colleges in the United States alone (Dougherty, Lahr, and Morest 2017), yet few studies have closely examined the development of embodied knowledge in career and technical education. Even fewer have examined skilled trades such as welding. This gap in the research is a problem because it means that we do not fully understand how teachers' verbal and nonverbal communicative practices—a sort of pedagogical technical communication—scaffold students' learning within the skilled trades.

Scaffolded Teaching with Verbal and Nonverbal Communication

This study of verbal and nonverbal communication in one-to-one pedagogical interactions about welding finds its theoretical basis in research about learning and, in particular, in the concept of scaffolding (Wood, Bruner, and Ross 1976). *Scaffolding* is a frequently employed metaphor used to explain the process of guiding a less-expert other to intended learning outcomes. More specifically, it is the process by which a teacher helps a student accomplish a goal that lies just beyond the student's current capabilities. Scaffolding has (at least) two goals: to help a student succeed in a present-moment task and to help them develop skills and knowledge that will enable them in the future to complete similar tasks with greater ease.

Scaffolded interactions demonstrate six major characteristics. First, for scaffolded learning to proceed, a teacher and student must develop a shared understanding of the task at hand. That shared understanding, in Puntambekar and Hübscher's (2005) terms, is intersubjectivity. Ongoing diagnosis, what Hermkes, Mach, and Minnameier (2018) called dynamic assessment, constitutes the second characteristic of scaffolding. Ongoing diagnosis allows teachers to make their input—their intervention—contingent on (or responsive to) the student's current understanding. Indeed, contingency is the third characteristic of scaffolded teaching.

In a contingent response, a teacher chooses among what have been called *tutoring strategies* (e.g., Cromley and Azevedo 2005; Mackiewicz and Thompson 2018) to intervene in the student's learning. These interventions fall into three overarching categories: instruction strategies, cognitive scaffolding strategies, and motivational scaffolding strategies. With these strategies, teachers give direction, support students in their thinking, and encourage students to continue in their efforts. This study employed a research-based scheme of 12 tutoring strategies to describe welding teachers' scaffolding of students' embodied knowledge and thus their membership in a community of practice. Table I.1 lists the tutoring strategies that I used in this study to describe scaffolded teaching. Of those 12, 11 are verbal. One strategy, demonstrating, is nonverbal.

Related to intersubjectivity, ongoing diagnosis, and contingency is the fourth characteristic of scaffolding: interactivity. Interactivity, which equates to initiating topics and responding to what an interlocutor has said, can be verbal or nonverbal.

Table I.1. The tutoring strategies in this study's data

Category	**Strategy**	**Definition**
Instruction	Telling	Teacher directs the student in what to do, using little or no mitigation to lower the face threat of advice.
	Suggesting	Teacher directs the student in what to do, using more mitigation (often negative politeness) to lower the face threat of advice.
	Describing	Teacher relates the characteristics of a thing or action, sometimes with metaphor.
	Explaining	Teacher offers reasons for a given assertion or directive.
	Demonstrating*	Teacher shows how to perform a task.
Cognitive scaffolding	Pumping question	Teacher asks a question that gets a student to respond. Pumping questions vary in the extent to which they constrain a student's response; they can be open-ended or closed.
	Referring to a previous topic	Teacher refers back to the earlier topic or occurrence of an issue.
Motivational scaffolding	Giving sympathy	Teacher acknowledges that the task is difficult for the student.
	Being optimistic	Teacher conveys positivity by asserting a student's future ability to succeed in a task.
	Praising	Teacher points to a student's achievement with positive evaluation. Praise can be formulaic or nonformulaic.
	Showing concern	Teacher builds rapport with a student by demonstrating that they care.
	Using humor	Teacher kids around, tells jokes, or tells amusing stories.

*A nonverbal tutoring strategy.

Scaffolding encompasses two other characteristics. One is called fading. When the student clearly understands the material, the teacher transfers responsibility for learning to the student and leaves the support role. The other characteristic is one that van de Pol, Volman, and Beishuizen (2012) suggested. By checking on a student's learning, they said, teachers determine the extent to which their efforts at scaffolding have worked (203).

This framework of scaffolded learning guided this study of the verbal and nonverbal communication that co-constructed embodied technical knowledge in welding labs. Table I.2 helps to illustrate the differences between verbal and nonverbal communication. Verbal communication refers to language, whether written, signed, or spoken (as in the case

Table I.2. The subcategories of verbal and nonverbal communication.

Mode	**Type**	**Perceived**	**Examples**
Verbal communication	Spoken	Aurally	Tutoring strategies except demonstration
	Written	Visually, tactilely	Text in welding textbooks, on classroom whiteboard; braille script
	Signed	Visually	American Sign Language
Nonverbal Communication	Gesture	Visually	Deictic (pointing) gesticulations
	Paralinguistics	Aurally, visually, olfactorily, tactilely	Syllabic stress for emphasis
	Demonstration	Visually	Showing the procedures for changing a wire spool; showing how to change out a gas canister
	Images	Visually	Photographs and diagrams in welding textbooks; teachers' soapstone sketches on a metal table

of welding interactions). Language differs from other communication in that it exhibits characteristics that other forms of communication do not, including a lexicon and syntax. Like languages such as English, French, and Mandarin, signed languages such as American Sign Language, French Sign Language, and Chinese Sign Language have their own lexicons and syntaxes.

Nonverbal communication comes in many varieties, including images, such as the videos that welding students watched, the blueprints they followed to build test weldments (figure I.2), the photographs that illustrated their texts, and the symbols and icons affixed to equipment (figures I.3, I.4, and I.5). Nonverbal communication also contains the paralinguistic components of language. These are spoken features that communicate but do not change word meaning. For example, tone—pitch that inflects a word—is a paralinguistic feature, but in Mandarin, tone can change word meaning, making it a linguistic component of the language. I discuss paralinguistics in terms of aurally perceived communication such as word emphasis and laughter.

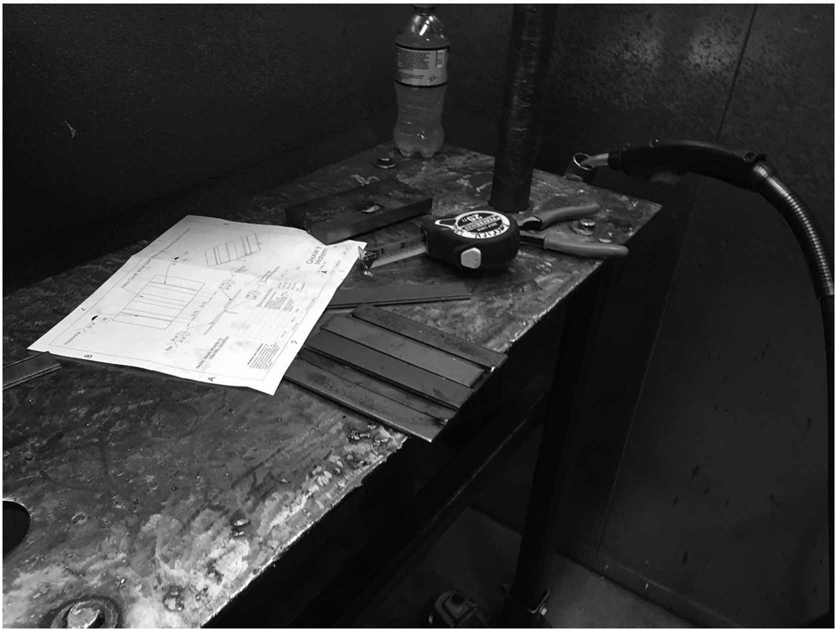

Figure I.2. Blueprint on a student's table. Also on the table: coupons, a tape measure, welpers, and a bottle of Mountain Dew.

Figure I.3. Icons on a welding machine. A welding gun for GTAW rests on top of the machine.

Figure I.4. Icons on a bandsaw. Note the turtle at the top right to indicate a slow speed.

Figure I.5. Icons on the emergency wash. Note the elephant to indicate a spray.

Nonverbal communication is also produced in a variety of ways with the body, including through gesture. Gestures are perceived visually, so in welding interactions, they occur simultaneously with spoken verbal communication. In this study, I analyzed teachers' use of four types of gestures, specifically, gesticulations: iconic, metaphoric, deictic, and beat (McNeill 1992). I analyzed how teachers used these gesticulations in combination with the 12 tutoring strategies listed in table I.1 to scaffold students' embodied knowledge. I discuss and illustrate these gesticulations in detail in chapter 2. But, briefly, iconic gesticulations represent concrete items or actions in the world, whereas metaphoric gesticulations present abstract concepts as if they had concrete form. Deictic gesticulations, in essence, are pointing. And beat gesticulations are rhythmic movements of the hands in time to speech.

As Dix (2016) wrote, "Semiotic systems of language, such as visuals, gestures and actions also scaffold and mediate learning," creating what Sharpe (2006) called "message abundancy." In analyzing these nonverbal elements of communication, my analysis accounts more fully for the co-construction of embodied technical knowledge that occurred during one-to-one welding interactions.

A Typical Day in the Welding Lab

A typical day in the welding lab didn't necessarily start in the lab, the space where students spent most of their time. Rather, it might have started in the classroom, where students gathered to watch a video or, sometimes, to hear a lecture. In my experience, as each semester wore on, class started less often in the classroom. Instead, knowing what we needed to work on, we students simply went straight to our booths in the lab and got started on our welding practice.

It's important to point out that the students who gathered in the classroom weren't necessarily—and often were not—studying the same welding process. Officially, we were enrolled in different classes, but we met at the same time in the same space with the same teacher. Welding programs, including the programs that participated in this study, schedule multiple classes simultaneously mainly because doing otherwise would create small and thus untenable class sizes. For example, when I studied oxyacetylene welding in the summer of 2018, other students in the welding lab learned GTAW[2] and SMAW.[3] But the practice of mixing students has several benefits. First, students can begin a program at the start of any semester in the academic year, and they have more course options available to them during any given semester. More important, at least to me, newer students can learn from more advanced students. In my classes, more advanced students (including students who already worked as welders) frequently helped newer students like me. In my first few semesters, I often sought help from Serge,[4] who worked as a welder with the National Guard. In my later semesters, my friend Sullivan, who had a welding job at John Deere, frequently offered advice and encouragement. And throughout my program, I got ongoing help from my best welding buddy, Ryan, who had worked in welding for years.

Of course, this mélange of students creates a challenge for teachers: Especially in the lab, they must be nimble in their teaching as they move from one process to another, ready to help a student with GTAW and then switch to help a student learning SMAW, for example. However, when I asked him about whether the variety tired him out by the end of the day, Tom pointed out that welders' work experience, including his own, frequently serves as preparation for this: "We were a small job shop, which meant I was switching between processes, techniques, all that stuff multiple times every day. So I was kind of trained to be ready to do that."

Except for the summer semester in which I studied oxyacetylene welding, I'd arrive at school before 6:00 p.m., the start of class. I was usually a little worn out from the workday. During my first few semesters in the program, my classmates were mainly men in their 20s. Before class started, they showed each other oddball YouTube videos on their phones and ate Panda Express and Taco Bell. Sometimes they talked about the drinking they did the weekend before. Sometimes they talked about life in the military. Sometimes they talked about their current welding jobs or jobs that were available. One night I walked in to a job-oriented conversation to hear one of my classmates say, "They can suck my dick for 10 dollars an hour." Such talk went from surprising to routine very quickly. In later semesters, though, the atmosphere in the classroom became less bawdy and more subdued. After a few of the more boisterous students graduated, students tended to sit quietly and look at their phones. In addition, more women started showing up in the classroom, and this demographic change might have made the men in the class less prone to shock talk. In my third semester, another woman student, Samantha, appeared. In semesters thereafter, at least one other woman—and sometimes two or three—were with me.

The labs that I visited differed in their setup, but they shared some features. Each had a large sink for washing up and a first-aid kit (figure I.6). Each had a store of brooms (figure I.7). Welding students are expected to sweep out their booths at the end of class. Each had individual welding booths that lined the walls (figures I.8, I.9, and I.10). Each booth contained a metal table for welding (figures I.11 and I.12). As part of cleaning, each student grinds down the table after class so that it is smooth for the next student. Over the table was some sort of an extraction pipe to remove fumes (figure I.13). Each booth contained a welding machine, made by one of the three main manufacturers: Miller, Lincoln, or ESAB (figures I.14 and I.15). Somewhere in each lab was an "oven" for SMAW electrodes, namely 7018,[5] that needed to be kept from atmospheric moisture (figure 1.16). Usually near that oven was a bank of other electrodes, such as 6010 and 6011 electrodes, as well as filler rods of various metals and sizes (figure I.17). Resting somewhere in the middle of each lab was a large tank of water for quenching and cooling hot metal (figures I.18 and I.19). The labs also contained at least one large metal table that students could use to measure a piece of metal for cutting or to look over a blueprint (figure I.20 and I.21). More commonly, in my

Figure I.6. Sink and first-aid kit at DMACC.

Figure I.7. Brooms for sweeping up after class.

Figure I.8. A row of booths and welding machines at LSC.

Figure I.9. Students in side-by-side booths at LSC.

Figure I.10. Welding booths in the lab at DMACC.

Figure I.11. A welding student in front of his table and stool at LSC.

Figure I.12. A welding table in the lab at DMACC.

Figure I.13. Ventilation in a booth at NTC.

Figure I.14. Miller welding machines at NTC.

Figure I.15. Miller and Lincoln welding machines at DMACC.

Figure I.16. An oven for 7018 electrodes at DMACC.

Figure I.17. Canisters of filler rods.

Figure I.18. Quenching bath for hot metal at LSC.

Figure I.19. Quenching bath for hot metal at DMACC.

Figure I.20. Metal tables in the middle of the lab at LSC.

Figure I.21. Metal table in the lab at DMACC.

classes anyway, students gathered around the big metal table, often with newly welded and water-dunked coupons held in welpers,[6] to talk about their work. This ubiquitous metal table is, then, a meeting space.

In managing their time in the lab, teachers tended to move from booth to booth, demonstrating, observing, answering questions, diagnosing problems, helping students set up, and retrieving materials, such as gas tanks, that students need. Tonya said that she had been using this method of touring the lab since her early days as a welding teacher's aide:

TONYA: The first class I ever taught as an instructional aide, the instructor met me at the door. There were 25 students . . . and uh, he said, "Put your hood on, start in this number one, show them what they need to do . . . and we'll meet somewhere in the middle." We met in the middle and he said, "Go back to booth number one. He's doing it all wrong now."

Ted explained his strategy for moving around the lab in more detail:

TED: I try to do every class period, because of course I have 18 students, I try to at least give every student five to six minutes . . . every time. No matter what. Whether I go in there and I watch them. Whether I go in there and I check their weld after they're done. Whether I run a bead for them. Whatever it might be. I try to at least give them that much. Then what I try to do is go back to the ones that need a little bit more time, and I go back to them. Then I come back and say, "Ok. Let's try this. Here's what we need to do."

While teachers tried to rotate systematically through the booths, they frequently got stopped by students with questions. Such a question might lead a teacher to go with the questioner to their booth to diagnose a problem or demonstrate a weld. Or, a teacher might be pulled from their lab circuit to observe some other task, such as a bend test.[7] I'm not sure I ever saw a welding teacher visit each booth in turn without interruption.

The types of one-to-one interactions that teachers had with students in the welding lab fell into four categories. In the first category were interactions that took place when the teacher visited the student's booth on their tour around the lab to check on students' progress. In excerpt I.1,