

Learning through practice in biology education

Torstein Nielsen Hole

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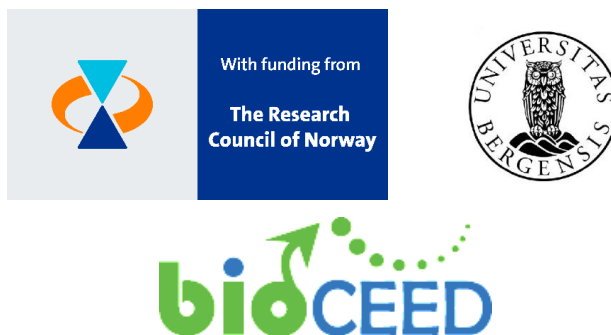
Scientific Environment

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Abstract

Work continues to be an important educational measure in higher education. It has received increasing focus both among policymakers, educators, and in educational science research as a valuable addition to campus-based, and often lecture-based, education. In biology, work placements are rarely employed, and the workplaces that are available to students are multifaceted and the distinction between practices at campus and practices at work may seem oblique at the outset. Both include sampling, analysis, and reporting of results. In other words, work as a learning measure in scientific disciplines is different from work in professional educations.

In this thesis, I investigate learning through work in higher education, principally among biology students. The investigation is performed through three independent studies. In the first study, I examine students' working practices in a field excursion using ethnographic techniques. The second study focus on a work placement course for biology students, and data was gathered through their blog entries. The third study consists of focus group interviews of students in Teacher education, Music Performance, and Aqua Medicine, a sub-program in biology that employs work placements. The third study allowed for a broader overview of other iterations of learning through work in several programs. In all studies, the aim was to gather students' accounts of their knowing in enacting practices. Furthermore, the analysis focused, at various levels, on students' accounts of personal epistemologies inside a sociocultural practice.

The analysis of interviews, focus group discussions, observations, and blog entries reveal important similarities between the way students enact biology through working practices in different contexts. These similarities concerned epistemological perception of learning in campus and complex learning in practices, such as those in workplaces and the field. At different levels, these complexities require students to make decisions whether in their sampling, and to gather necessary information to be able to complete their work. Furthermore, the different studies revealed different levels of engagement between students, teachers, supervisors, and others. In field excursions, students engage continuously with teachers, while they engage more continuously with supervisors and co-workers in work placements. Nevertheless, on the basis of students' accounts, I argue that the role of teachers is crucial for the students' experiences.

Whether this is direct engagements between teachers and students, or their overall facilitation of learning at campus and how it interacts with students' experiences and personal epistemologies in work.

By using varied expressions of knowing in the analysis of students' accounts of knowing in working practices, we found that dispositions, procedures, and concepts interact throughout students' work. This indicates that practices involve important experiences that affect students' outlook towards their own engagement with biology, and the disposition to pursue particular methods, careers, and otherwise intersect their working practice with their values. On its own, these are important contributions of work placement- and field excursion practices in biology students' education.

Preface

In *Educated*, Tara Westover (2018) gives an autobiographical account of her upbringing in a secluded religious household. During her childhood, Westover was bereft of access to institutions, teachers, literature and other resources and impulses that most societies strive to provide for its young members. Despite her cloistered upbringing, Westover managed to leave her sheltered family and attended renowned universities, even attaining a PhD, the pinnacle of modern institutionalized and formalized education systems.

Westover's story is relevant to frame this dissertation's discussion on biologists in pursuit of science in highly regulated and formalized educational settings. Westover does not give a one-sided admonishment of secluded or religious environments and the harm they visit on children. Rather, she makes the case that her upbringing contributed to her formation as an adult. She even encapsulates this with a quote from John Dewey (1897) at the outset of her book: "I believe finally that education must be conceived as a continuing reconstruction of experience; that the process and the goal of education are one and the same thing" ("Article three," para. 17). In other words, her varied experiences have been Westover's education. Her learning through attendance at top-tier universities are on one hand easily identifiable to onlookers through lectures and academic texts. On the other hand, her life history, for instance managing to self-educate, leave her family, and not least her work in a farm, cut off from modern society, were also vital experiences for her development.

Biology students attend a range of courses containing well-substantiated scientific content, they take part in fieldwork, and a few attend internships or other work placements where they are able to engage with science and biology in varied circumstances. They select study programs based on various motivations, such as interest, work-prospects or (perhaps more often than not) more convoluted reasons. Students' scientific work is born, and executed, in various circumstances in which they find themselves. Thus, evolving students' perspectives on knowledge, learning and science on one hand, and their conception of their own place in enacting their discipline on the other, intermingles with the contributions of life histories and circumstance. Individuals' engagement with knowing and knowing which they bring into new

circumstances (i.e., biology studies, workplaces, their place in society more generally) are here crucial to understand biology learning, and especially biology learning discerned through practice.

This thesis focuses on working practices in workplaces and campus settings that biology students engage with in their education, and which interacts with their personal outlook, knowing, and values (what we refer to as personal epistemologies). This outlook is born from students' origins and their immediate surroundings. Personal epistemologies do not only affect students' values and short-term attainment of conceptual knowledge, which is often the articulated focus of their study programs. Instead, Personal epistemologies is more profound as it is relevant to students' beliefs and value systems regarding use of methods, knowledge, and the contribution of biology to societal and local developments.

To access the potential that lies within work and practice, students must be afforded a wide scope of experiences; in occupational work, fieldwork, laboratory work, and so on. When students construe these varied experiences with teachers and peers, where assumptions and understandings about methods and legitimate knowledge are continually discussed, biology students can benefit from the power of practice in biology learning.

List of papers

- Paper I Hole, T. N. (2018). Working and Learning in a Field Excursion. *CBE - Life Sciences Education*, 17(2), 1–11. <http://doi.org/10.1187/cbe.17-08-0185>
- Paper II Hole, T. N., Velle, G., Riese, H., Raaheim, A., & Simonelli, A. L. (2018). Biology students at work: using blogs to investigate personal epistemologies. *Cogent Education*, 5(1), 1–16. <http://doi.org/10.1080/2331186X.2018.1563026>
- Paper III Hole, T. N., Velle, G., Helleve, I., Ulvik, M., Sætre, J. H., Brøske, B. Å., & Raaheim, A. Learning and personal epistemologies among students in three work placements. *Submitted*.

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Declaration of contributions

	Paper I	Paper II	Paper III
Research design	TNH , HR, PBE, AR	TNH , GV, HR, AR, ALS	TNH , AR, GV, MU, IH, BÅB, JHS
Data collection	TNH	TNH , GV	MU, IH, TNH , SL, KS, BÅB, JHS
Data analysis	TNH	TNH , HR, SB	TNH , MU, IH, BÅB, JHS
Data interpretation	TNH , HR	TNH , HR, GV, ALS	TNH , MU, IH, BÅB, JHS, AR, GV
Writing manuscript	TNH	TNH , HR, AR	TNH , MU, IH, BÅB, JHS
Comments on manuscript	GV, HR, AR, SB	HR, GV, AR, ALS	GV, AR, MU, IH, BÅB, JHS
Approved final version	TNH	TNH , HR, GV, AR, ALS	TNH , AR, GV, MU, IH, BÅB, JHS

Note. TNH = Torstein Nielsen Hole; AR = Arild Raaheim; GV – Gaute Velle; HR = Hanne Riese; PBE = Pernille Bronken Eidesen; SB = Stephen Billett; ALS = Anne Laure Simonelli; MU = Marit Ulvik; IH = Ingrid Helleve; BÅB = Brit Ågot Brøske; JHS = Jon Helge Sætre; SL = Sondre Lode; KS = Kari Smith.

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Introduction

In a review of science education (i.e., physics, mathematics, earth science, and biology) across most of the Western world, D.A. Roberts and Bybee (2014) find that there are two broad contending visions enacted in educational institutions that teach science. Vision one holds that science education is best enacted through incremental steps, where teachers focus on basics before moving on to more complex phenomena. Vision two focuses more on larger concepts, particularly interactions between societal concerns and science, and introduces procedures, vernacular, methods, and theory that are relevant to examine these concepts. According to Roberts and Bybee (2014), Vision one is more widespread, and many teachers find its approach more aligned with education policy and curricular organization.

To foster student learning, motivation, and integration of science into society, several science education researchers promote Vision two as an appropriate approach, because it assembles wide reaching complexities and problems for students, with the aim of helping them analyze and examine these (Roth & Barton, 2004; Sevian, Dori, & Parchmann, 2018). To enact Vision two, researchers have increasingly promoted the value of various contexts to afford students with experiences that allow them to identify and engage with various scientific phenomena as they occur in reality (King & Ritchie, 2012). Thus, students' working practices as they occur when students engage with science in- and outside of curricular administration has become more salient in science education.

Work and practice have had a fundamental role to play in many aspects of human development. Across societies' transition to modernity, young members of the community have developed their capabilities in appropriate circumstances in preparation for their eventual occupation. When their occupation required advanced knowing and internment into an established professional culture, with associated practices, students worked to learn and to gain occupancy (Dewey, 2011; Giddens, 1991). This educational thesis is founded upon thousands of years of human development (Hager, 2010), from farmers' development of knowing about crop cultivation, and medieval barbers' surgical capabilities, to modern pharmacists and civil engineers; in all of these instances, individuals have worked to enact the knowing

inherent in the occupation with which they wish to partake. Thus, the link between working and knowing has been pronounced in human endeavor. Likewise (or as a result), human knowledge (or knowing) manifests in diverse expressions. Not least are these expressions connected to the context of the activity. For instance, nursing students at some stage in their education practice nursing at a hospital, or other workplaces where nurses work, as it is held to benefit their knowing in crucial ways (Costley, 2011).

The current role of work placements in tertiary level education is in some aspects expansively researched, understood, and legitimized, and in other aspects novel. In this thesis, work placements refer to university-initiated and organized educative placements of students into workplaces. On the one hand, work placements are integrated without question in professional education, such as in teaching, medicine, and nursing. This integration has in these cases been investigated through extensive bodies of literature and studies over several years, and in line with increased segregation and specialization in work (see for instance Abbott, 1988). On the other hand, work placements are not commonly employed as a part of the curriculum in disciplines, such as mathematics and biology. A possible exception is MSc and PhD thesis work, which may be conducted in cooperation with private enterprises. There are also smaller integrated programs that implement some level of work placements, such as Aqua Medicine and Aquaculture and seafood, both of which are sub-programs in biology. In these cases, integration seem less formally structured than in professional education work placements (Brandt et al., 2008).

Biology, physics, or mathematics are disciplines related to scientific fields, rather than specific occupations. Implementation of workplace placements in these disciplines are thus still experimental, with unclear pedagogical antecedents. That is, issues such as assessment, campus intervention, and host recruitment are still being resolved (Billett, 2009c). These challenges are discussed by Velle, Hole, Førland, Simonelli, & Vandvik (2017) in our development of a work placement course in biology. Among the challenges, we point to the recruitment of varied hosts and addressing institutional criticism for implementing a work placement course, which some held to be inappropriate in a university setting. In response to the criticism, we emphasized that intended learning outcomes of the work placement course should reflect the overall

goals of the disciplinary educations, such as students' own role in enacting biology, as they do in work. As such, the goal was not for students to merely learn to work, but to engage with biology knowing in work.

In an effort to map practical experiences among biology students in the United States, Parker and Morris (2016) included enacting science through laboratory work and other means on one hand, and internships (i.e., trainee work) on the other. This inclusion underlines the ambiguous nature of work placements in scientific disciplines. Whether the different education structures in disciplines and certain professional educations are based on cultural differences about the nature of scientific, as opposed to occupational (i.e., workplace), knowing, or the esoteric nature of science, is unclear (Gibbons et al., 2010; Orrill, 1997).

Nevertheless, policymakers continue to promote close links between workplaces and higher education as a whole (Kennedy et al., 2015). The societal rationales for this recommendation seem to rest on a belief that such provisions will ensure relevant skill training, inform students about possible employment opportunities, and help institutions tailor their curriculum to industry needs (Abrandt Dahlgren, Solbrekke, Karseth, & Nyström, 2014; Ministry for Education and Research, 2017; OECD, 2018). Others have also suggested that employability may be ensured through increased knowledge on the part of the students about employers' demands for skill sets and how these skill sets can be cultivated while preparing for a future careers (Jackson, 2015; Støren & Wiers-Jenssen, 2016). In such a perspective, development of students' awareness of their own knowing (and personal epistemologies, as will be discussed) is crucial. This is especially true for students regarding their perception of what that they know and their perception of what they have the ability to learn, not least beyond the immediate demands of curriculum. There is some evidence to support the notion that there is a relationship between biology work placements and training in certain transferable skills (e.g., Scholz, Steiner, & Hansmann, 2004). This means that work placements overall may contribute to biology students' generic skills training, though this is hardly a sufficient understanding of the role of work placements for biology students' learning.

Although the above policy recommendations and findings set the stage for the importance of work in higher education, they also emphasize a somewhat limited view

of learning. That is, an emphasis on societal developments in which efficiency of core skills acquisition seems to be an overarching concern that may impede students' dispositions to engage (Hilt, Riese, & Søreide, 2018). The emphasis on specific skill acquisition may also lead teachers and institutions to emphasize Vision one in Roberts and Bybee's (2014) conceptualization, which in and of itself is not problematic, but represents a challenge insofar as the goal is to integrate science, and its practitioners, and the concerns of local communities (Roth & Lee, 2004). Further, there are reasons to consider societal concerns as one of several aspects of learning, as enacting working practices emphasize situated and personal dimensions to students' development (Billett, 2009d; Trede & McEwen, 2015)

To conclude, the structure of work placements in professional studies is different from disciplinary education, as professional studies are limited to engagement with their respective professional occupation. Biology is a scientific discipline that has no specific off-campus occupation to assign students to. Rather, there is a slew of potential occupations that make use of aspects of knowing associated with biology. Hence, disciplinary students' work placements will have the potential to be far more varied than profession students' work placements, and consequently less cohesive in its pedagogy. Furthermore, the sparse, but budding, implementation of work placements in biology education seems to be reflected in a need for increased available research regarding the learning processes of tertiary level biology students that engage in working practices.

Design

The aim of this thesis is to examine the relationship between tertiary biology students' situated enactment of work in practices, and their perception of their learning or knowing. This work is conducted in three specific cases that exemplify different practices with which biology students engage. Work is integral to human development, and a principal aim of educational structures, and is here examined as it occurs both in- and out of campus. This less than clear-cut division between campus and off-campus work, reflects the nature of biology as a scientific discipline that cannot be easily construed only as an occupational practice set within a limited context, such as a hospital for medicine (Parker & Morris, 2016). Hence, students' working practices are examined in two different instances of work placement and in a field excursion.

The research question that I aim to address in this thesis is, *how can biology students' enactment of biology in working practices contribute to their learning?*

By framing the research question in this way, I construe biology as a scientific discipline constituted by a set of knowing and practices that students, academics, and others enact to explore the natural world (Knorr Cetina, 1999; Lave, 1988). Campbell et al. (2015) holds that, “posing questions about the living world and seeking answers true scientific inquiry are the central activities of biology” (p. 48). Given this conceptualization of biology, I seek to examine a few limited aspects of work and biology learning, namely, field excursions and work placements. Thus, I focus on in-depth analyses of subsets of biology students to address the research question. Biology students' learning through working practice is examined in three independent studies, and presented in three corresponding papers.

In focusing on learning in working practices, I am principally focusing on the continual enactment of knowledge in practice, referred to as *knowing* (Duguid, 2005; Gherardi, 2009). Practice, as conceptualized by Reich and Hager (2014), “is sociomaterial, embodied and relational; that it exists and evolves in historical and social contexts shaped by power; and that it is emergent” (p. 422). This distinction is important to subsequent chapters as it focuses the methods, literature selection. This topic is further discussed in the theoretical framing chapter.

That practices relate to *work*, despite focusing on students and not solely workplaces, underpin the oblique distinction between campus on non-campus work in biology. My reasons for using *learning* in the research question is that learning, although it always requires further depiction as to what it entails in analysis, sets the sight for focusing on development among individuals, and is often used interchangeably in the literature (e.g., Kelly, McDonald, & Wickman, 2012; Strati, 2007).

Paper I reports a study on learning in a campus-initiated working practices in a field excursion. In biology, fieldwork is perhaps the established practice that most resembles iterations of workplace learning. This resemblance is constituted by situating students into new circumstances, working to complete specific projects, the participation in which students work together and with teachers to enact science, and coming to grips with biological practices with a focus on phenomena and ways in which biologists work

to investigate biological phenomena (e.g., Billett, 2004a; Lave & Wenger, 1991). To discern more closely how students work and learn in biology field excursions, I performed a semi-participatory observation over the course of the field excursion, including a semi structured group interview after the field excursion. I made use of short-term ethnographic techniques in this investigation (Pink & Morgan, 2013).

Paper II reports a study on a novel iteration of work in biology education, namely students' learning in off-campus work placements. In this course, students are awarded 10 ECTs (corresponds to one third of a semester coursework) for completion of the work placement and reporting through blogs. As far as I am aware, this course is novel in Norway and sparsely implemented in biology education overall (Brandt, 2005; Parker & Morris, 2016). The work placement is characterized by the large distinction among workplaces. The workplaces ranged from private research enterprises, public agencies, nongovernmental organizations, and upper secondary schools (for further details on the course, see Velle et al., 2017). To discern this particular iteration of biology practice, we gathered blog entries written by the students in connection with their work placements and analyzed them qualitatively with the aim to discern their sociocultural learning processes and personal epistemologies.

Paper III reports a study on the one integrated work placement already in use in biology; an integrated Master's program in Aqua Medicine. Aqua Medicine students attend courses alongside disciplinary biology students, but also attend a few specialized courses including work placements. The inclusion of this course is also a matter of utilizing the few available cases that are relevant to biology education. These work placements include working with fish farmers and joining Aqua Medicine Biologists as they work, particularly in fish farms along the Norwegian coast. This also enabled an investigation into work placements that have been enacted over time, as opposed to a novel work placement course as is the case in Paper II. Thus, this work placement resembles work placements in use by professional educations, which opens the possibility for a common approach to investigate overall experiences in multiple work placement programs. To investigate the relationships between biology work placements as they are expressed in Aqua Medicine and other work placements, we investigated two work placement schemes alongside Aqua Medicine: Teacher Education and Music

Performance. Common discussion themes was used in focus group interviews among all three groups to investigate their situated learning and personal epistemologies as they accounted for them in relation to their work placements.

The studies are not aimed to directly compare the various practices that students participate in, but aim to discern three iterations of work that biology students enact. Given that the focus is on biology students overall, Aqua Medicine is not analyzed specifically as a profession, but in terms of the relationship between biology and knowing, students' accounts of personal epistemologies, and working practices. Furthermore, by analyzing several groups of students in Paper III, broader understandings of work placements in higher education can be discussed.

Based on the three studies, I will discuss in this thesis the working practices in use by biologists, and the extent to which it has a role to play in future biologists' learning. Situated practice learning is particularly examined as it pertains to students' relationship to knowing and their understanding of their subjective role in enacting biological science (Brown, Collins, & Duguid, 1989; Sadler, 2009). Personal epistemologies, which addresses the way in which individuals' subjectivities come to bear and evolve through work (Billett, 2009b), are also examined in these working practices.

Assembling Key Background Studies

There are many research contributions to consider when investigating learning through practice in biology. This is evident at the very outset when considering the research question *How can biology students' enactment of biology in working practices contribute to their learning?* The term *learning*, refers to the many theoretical iterations of learning; *working practices*, refer to the activity in which I wish to investigate learning; *biology*, which refer to the scientific discipline in which students participate in practices, biology education also refers to a higher education context in which working practices take part (Billett, 2009c). In the following, I will outline various contributions to available understandings of practice learning in biology education. These contributions either report on empirical investigations, or indirectly through literature reviews.

To determine the current state of research into biology students' learning through practices, searches were performed in Google scholar, Web of science, and Science direct. Search terms included *biology*, *bioscience*, *learning*, *practice*, and *work*. Various terms for work placements, such as internships or service learning were also used. I also consulted handbooks or anthologies on science- and higher education (Abell & Lederman, 2014; B. Fraser, Tobin, & McRobbie, 2012; Marton, Hounsell, & Entwistle, 2005; Roth, 2010) and workplace learning (Billett, Harteis, & Gruber, 2014; Kennedy et al., 2015; Margaret. Malloch, Cairns, Evans, & O'Connor, 2010). The searches returned several studies on medicine and nursing education, which were omitted as they focus on the particular professional occupations that they train students to. As in other literature searches, key studies that are referenced several times, though not directly reached through the searches were also important to consult (Ó Dochartaigh, 2012).

Over the course of initial searches, it became apparent that there are few studies that directly investigate the situated learning of tertiary biology students in working practices. As such, I employed procedures as recommended by Boote and Beile (2005) by selecting overlapping theoretical perspectives, and here focus on highly cited work within these perspectives.

Through the search for relevant studies, it emerged that there are two distinct research traditions that examine practice in higher education, science, or biology. The

first tradition focuses on specific outcomes in relation to specific pedagogical measures, such as internships, field excursions, or work placements. These outcomes are conceived either in terms of skills, particularly transferable skills (Scholz et al., 2004), achievement (Hamilton-Ekeke, 2007), or through students' and teachers preferences (Dillon et al., 2006; Parker & Morris, 2016). Data in this tradition is typically gathered through survey batteries, and measures are often based on intended learning outcomes in education programs, rather than explicit theoretical measures (for recent efforts to develop theoretical measures see Nghia & Duyen, 2019; Whelan, 2017). Thus, this tradition ranges from theoretical foundations for measures, to more descriptive mapping released in reports (e.g., Brandt et al., 2008) as well as scientific journals (e.g., Scholz et al., 2004). This tradition often addresses policymakers' emphasis on efficiency in teaching and learning, and the importance of successful transition from schooling to employment (Brandt et al., 2008; Jackson & Collings, 2018; Ministry for Education and Research, 2017; OECD, 2017).

The first tradition also include a survey I contributed to as it attends to the same relationships as the other studies in tradition one (Hole et al., 2016). The aim of our survey was to map conceptions of teaching and learning among biology teachers, workplaces, and students in Norway, and among other things, document general conceptions of students and teachers regarding work placements. In the survey, both teachers and students strongly support the use of work placements in biology education, and this also aligns with other comparable Norwegian surveys suggesting this holds true across a broader range of educations (Bakken, Pedersen, & Øygarden, 2018; Bøyum, 2013).

The second research tradition focus on the processes of learning in workplaces, practices, or higher education. In science and higher education there is an expansive research approach that focuses on concepts and epistemologies (e.g., Entwistle, 2005; Posner, Strike, & Hewson, 1982; Virtanen & Lindblom-Ylänne, 2010), and in workplace learning there is a strong emphasis on individuals' engagement with context, knowing, and situated learning (e.g., Brown & Duguid, 1991; Cox, 2005; Fuller & Unwin, 2003; Lave & Wenger, 1991). There are some works that investigate the role of context in science education (e.g., Sevian et al., 2018), authentic experiences through

students' practicing of research (e.g., Wald & Harland, 2017), or how scientists enact research as a situated practice (e.g., Roth & Bowen, 1999).

Potentially relevant studies in science education that consider situated learning approaches often focus on primary or secondary education (e.g., Behrendt & Franklin, 2014; L. J. Rennie & Johnston, 2004). Adults' potential for agency and autonomy in their participation seems to be a specifically important aspect of practice learning, and is one of the distinguishing factors between work and schooling (Billett, 2004a). In biology education, there is an emerging research focus through Biology Education Research (BER), that directs attention more specifically on undergraduate learning (Singer, Nielsen, & Schweingruber, 2013). However, due to its relative recent conception, BER to date entails little research concerned specifically with students' learning in situated working practices, based on the searches detailed above.

Given that I aim to investigate learning processes that emerges in practice, and my ontological assumption in which I conceive of learning as an enacted practice, the second tradition is relevant for nesting research questions and to analyze findings. The first tradition still remains worth noting because it highlights the importance of researching work in biology education, due to the overall interest among teachers and students. Also, *what* (mapping general or societal trends, tradition one) and the *how* (learning processes, tradition two) are both worth considering in investigating practice in biology education. It is also important to note that tradition one includes the only studies that I found that explicitly deal with work placements within tertiary biology education (Parker & Morris, 2016; Scholz et al., 2004; Whelan, 2017). Hence, the inclusion of research from tradition one in the introduction chapter. Going forward however, I will focus on tradition two.

In Table 1, key perspectives in researching biology students' learning in practice are presented. Tradition one is represented in *Science education and skills*. The other theoretical perspectives in the table are more or less within tradition two, as these attend to the main focus of my research.

Other than *Science education and skills*, the theoretical perspectives in Table 1 are included because they seek to analyze learning in situated practices, and the enactment of science in tertiary contexts. Not included here is the theoretical perspective

within professions and expertise (e.g., Carr, 2014; Kotzee, 2014; Mulder, 2017), because these perspectives attend to tensions that exist between identity, professional judgments/morals, schooling, and work in a specific occupation with long-standing traditions of work placements. These tensions do not hold for biology which is a scientific discipline without a specific occupation. There is a potential exception for smaller sub courses, such as Aqua Medicine, however the aim of this thesis is to focus on the role Aqua Medicine has in a broader biological discipline, of which they share core curriculum. Also, professions and expertise perspectives tend to focus on ways in which to identify and develop expert knowledge. Expertise as a given category does not seem to blend with an investigation of learning (and knowing) in continuously enacted practices by biology students (Lave, 1996b).

The designation of the various theoretical perspectives derives from either explicit declaration in the various studies (e.g., *Sociocultural or situated learning*), or by inferring theoretical perspectives from assumptions that underlie the work by the respective positioning in the papers (e.g., *Situated subjectivities*). Some perspectives overlap more than others, such as *Sociocultural/situated learning in work* and *Anthropology/practice theory*, Jean Lave is for instance referenced in both categories. Both categories are designated separately due to their focus either on participation in the former, or on practices in learning in the latter. Other categories such as *Sociocultural/situated learning* and *Science education and contexts* both build largely on situated learning, but are distinguished by their focus on science in the latter or learning outside school circumstance (e.g., field excursions) in the former.

Table 1. Key perspectives and literature to examine biology students' learning in practice

Theoretical perspective	Literature examples	Learning metaphor¹	Type of findings
Sociocultural/situated learning in work	(Fuller & Unwin, 2003; Lave & Wenger, 1991; Rogoff, 1995)	Participation	Ways in which participation and learning co-develop
Cognition/concepts in higher education	(Posner et al., 1982; Trigwell & Prosser, 2009; Virtanen & Lindblom-Ylänne, 2010)	Acquisition	Causes and implications for diverging conceptions of learning or knowledge among students and teachers
Situated subjectivities	(Billett, 2009b; Hodges, 1998; Hodkinson, Biesta, & James, 2008)	Participation ²	Ways in which individuals' subjectivities form their participation or knowing in practice
Science education and contexts	(King & Ginns, 2015; L. J. Rennie, 2014; Roth, 2003)	Participation	Ways to and significance of integrating communities/context into science education
Science education and skills	(Blickley et al., 2013; Scholz et al., 2004)	Acquisition	Relationships between work and development of particular skills among students
Science and practice	(Ford, 2015; Knorr Cetina, 1999; Wald & Harland, 2017)	Participation	Ways in which enactment of science contribute to or effect learning
Anthropology/ practice theory	(Brown & Duguid, 2001; Gherardi, 2009; Lave, 1996b)	Participation	Ways in which individuals in organizations enact knowing in practices

Note. ¹Learning metaphor refers to two metaphors for learning as identified by Sfard (1998), in which acquisition refers to accumulation of knowledge, and participation refers to enactment of knowing in contexts. ²Although rooted in a participation metaphor for learning, this theoretical position explicitly attempts to deal with individuals' subjectivity and thereby address Sfard's (1998) critique that both acquisition and participation are valuable metaphors to investigate learning.

With the exception of *Science education and skills*, the theoretical perspectives presented in Table 1 employ a variant of constructivist positioning, whether it refers to development of concepts in individuals' mind in *Cognition/concepts in higher education*, or through participation in the other categories (O'Donnell, 2012). They arrive at their findings through qualitative interpretative research, in which meaning is discerned from participants through interviews, dialogue, or ethnographies (Creswell & Poth, 2018).

Most of the theoretical perspectives also operate in some way with Sfard's (1998) participation metaphor for learning. In the participation metaphor, learning is enacted continually through repeated instances of participation, which leads to gradual integration into a community, culture, or practice. It is also worth noticing that Sfard's (1998) learning metaphors do not distinguish between social and individual antecedents for learning, as the *Cognitive/concepts* theoretical perspective often focuses on the relationship between students and teachers, yet is classified as acquisition as it focuses on individuals' understanding of science as acquired. The aim of analyzing the theoretical perspectives with Sfard's (1998) learning metaphors was to gain an insight into the overall assumptions of learning employed in studies into workplace learning and biology education. The analysis also uncovers points of tension or complexities when the two metaphors are attempted to be resolved, as is the case in *Situated subjectivities*.

The aim of this chapter was to give an overview of key research contributions to understand learning through practice in biology education, and the process by which I have gathered these perspectives. The overview also provides some context to understand the ways in which I have arrived at my research design and approach to learning. The underlying tensions within some of the theoretical perspectives presented here will be further discussed in the following chapter, in which I will propose a use for the perspectives to address the overall research question.

Learning Through Working Practices in Biology Education

In this section I will outline how I have come to construe learning as I have been working to address my research aims. It is related to the background chapter presented above as the following aims to outline a theoretical construct to investigate biologists' learning in working practices. Due to the ontological and epistemological assumptions inherent in my investigation, which assumes that researchers approach problems on the basis of their theoretical assumptions (Alvesson & Sköldbberg, 2009), this section will also outline my view of learning. Considering the many perspectives outlined in the literature chapter, this is particularly important in order to show why particular approaches were selected.

As suggested in the previous chapter, there are several analytical approaches to learning. These perspectives are over the years often divided into sociocultural and cognitive perspectives (Billett, 1996; Fox, 1997; Mason, 2007). Cognitive learning theories focus on individuals' accumulation of knowledge, particularly through processes of the mind, it is often focused on individuals, but also consider social interactions in some circumstances. Sfard (1998) finds that these theories of learning fundamentally root their metaphor for learning in *acquisition*. Sociocultural theory conceives of learning as born out of context, in such a way that individuals, context and learning cannot be analyzed independently (Rogoff, 2003; Vygotsky, 1978). Here, Sfard (1998) finds that these theories root their metaphor for learning in *participation*.

Within a sociocultural view of learning, there is often an inherent critique of cognitive approaches to learning. For instance, Wertsch (1998) holds that many other (i.e., cognitive) learning theories overlook important aspects of learning by partitioning learning as processes inside individuals, where sociocultural theory treat learning as inherently linked with context. Sociocultural approaches to learning has in turn been criticized for treating individuals as a given, and thereby not sufficiently consider values, dispositions, and knowing that individuals bring into situations and thus over-emphasizing social interactions (Hodkinson et al., 2008).

When approaching learning through practice in biology education, I found the debates on learning salient. I quickly discovered during my analysis of the material in Paper I that students participated in working practices to develop procedures and

concepts to enable their work, and it was clear to me that their enactment of biology was inherently social (Billett, 2004b). At the same time, students' engagements with natural phenomena in the field were valuable learning experiences in and of themselves, whether or not they were negotiated in a social setting. These engagements with natural phenomena suggested various cognitive processes, not least in the relationship between students' situated material experience and their conceptual knowing (e.g., curriculum). I therefore adopted Rogoff's (1995) theorizing of participation, which emphasizes individual and social contributions to participation, and the way in which individuals appropriate their experiences to transform their engagement. I also found it valuable to focus on epistemologies as understood by individuals. In particular, the tacit dimension of students' learning, which consisted of them engaging with concepts socially and materially that they had a preconception of, which was developed further in conjunction with their experiences in field excursions. This includes work, such as reports, subsequent to field excursions.

Thus, I sum up my approach to biology students' learning in practices as the following. On one hand, individual students come into biology education to pursue knowledge, often independently, and come to work with biology through reading literature, working with statistical models, and observing and experimenting with natural phenomena in the field or in the lab. On the other hand, there is convincing evidence that points to science in general, and biology in particular as a collaborative enterprise, in which learning and enactment of biology is a participatory practice. First, Knorr Cetina (1999) has conducted an ethnographic study of scientists in work, and documented how their evolution of knowing derives from their practice of an epistemic culture. This includes ways to conceptualize problems, techniques to investigate the problem, and ways to disseminate them. Second, there is the collaborative nature of biological research, where there are very few instances of single author papers, and large research projects require participation of scientists with a wide array of expertise (Vermeulen, Parker, & Penders, 2013). Third, there is the participatory nature of work itself, where individuals come together to enact knowing in their joint enactment of practices. That is, analysis of working practices finds them inherently participatory and

contextual, involving various interactions wherein individuals share perspectives and ways of achieving their ends to successfully execute their work (Billett, 2004b).

Personal Epistemologies

Thus, I view learning through practice in biology as a sociocultural process. Particularly in ways that operate analytically with concepts such as practices, knowing, and participation. This harkens back to earlier Vygotskian perspectives that move between cognition, social settings, and culture quite freely (e.g., Scribner & Cole, 1973) and newer theoretical perspectives on practices, subjectivities and sociocultural contributions for learning (Billett, 2006; Gherardi, 2009; Hodkinson et al., 2008). There remain important issues to be considered concerning individuals' dispositions and knowing as they come into new practices that they engage in. Lave (1996b) offers these four points on practice and learning as a summary of her discussion among colleagues:

- i. Knowledge always undergoes construction and transformation in use.
- ii. Learning is an integral aspect of activity in and with the world at all times. That learning occurs is not problematic.
- iii. What is learned is always complexly problematic.
- iv. Acquisition of knowledge is not simply a matter of taking in knowledge; rather, things assumed to be natural categories, such as "bodies of knowledge", "learners", and "cultural transmission", require reconceptualization as cultural, social products. (p. 8)

Lave's second point may seem startling considering the many debates about the constituents of learning presented above. Lave here conceptualizes learning as a mere inevitable function of experience. The third and fourth points focus on the conceptualization of knowing as a more analytical task, that is, learning on its own is of little analytical value without considering knowledge (or knowing). Rogoff (1995) has for instance theorized on three levels of participation as a learning process in sociocultural theory, but she also alludes to the issue of knowing. In this complexity, individuals' participation at various instances affect their ability and dispositions to engage in practices, and how participation (i.e., learning), at some level involves a

transformation of knowing. That is, knowing is continually developed in the practice into which individuals participate, and thus transformed as individuals enact practices. Billett (2003) has developed Rogoff's and other sociocultural perspectives (e.g., Scribner, 1985) further, by emphasizing the role of subjectivities in engagement with workplace practices.

In Billett's (2001) perspective, individuals, come to engage in various expressions of knowing. He also includes dispositions among these expressions, and thereby emphasizes the values and life history of individuals as they come into working practices. I found this perspective useful to analyze students' learning in working practices. For instance, this approach attends to both cognitive (procedures, concepts) and situated (identities and values) processes of learning, that are often treated as divergent (Contu & Willmott, 2003). Particularly, Billett's (2009b) concept of personal epistemologies enables a discussion on the conceptualization of knowledge, which is a prominent tension in higher education. It seems that teachers and students conceptualize learning and knowing in different ways, where students tend to focus on facts and teachers emphasize scientific method and the underlying practice that scientific concepts derive from (Trigwell, Prosser, & Waterhouse, 1999; Virtanen & Lindblom-Ylänne, 2010). Furthermore, personal epistemologies also attend to the importance of students' sensibilities, which have been shown to be decisive components in enacting authentic science in higher education pedagogies (Wald & Harland, 2017).

Personal epistemologies have originally focused on cognitive developments in individuals' conception of knowing. Hofer and Bendixen (Hofer, 2001; Hofer & Bendixen, 2012) has focused on how individuals come to construct these conceptions as they encounter new and meaningful knowledge that develops and changes their original conceptions. Billett (2009b) and others (Barton & Billett, 2017; Kelly et al., 2012) have brought this concept into a sociocultural theoretical perspective, in which working practices develop new knowledge derived from the participation processes and other learning instances that are culturally constituted (e.g., Rogoff, 1995, 2003). These cultural constituents can consist of life histories, dispositions, and other contextual instances.

Billett (2009b) defines personal epistemologies as “individuals’ ways of knowing and acting arising from their capacities, earlier experiences, and ongoing negotiations with the social and brute world, that together shape how they engage with and learn through work activities and interactions” (p. 211). Billett goes on to position personal epistemologies as culturally shaped, and cognitively conceived. This is done by including socially mediated tools such as language, and personal conceptions of knowing, that individuals bring into situations such as work. “Brute world” seems to be included to emphasize physical environments in addition to social contexts in individuals’ learning (Billett, 2009a). As such, individuals’ accounts of knowing, including cognitive aspects, should be analyzed in terms of the sociocultural context in which knowing is conceived (Billett, 2011).

Knowing

Given a conception of personal epistemologies as subjective perspectives on knowing in situated practices, knowing must be further discerned as an analytic concept. That is, these efforts attempt to build a bridge between what individuals *do* (i.e., their practice), and what they *think* (e.g., personal epistemologies), to analyze knowing. Biology students do not merely mindlessly enact routine work as they engage in practices, they also engage complex knowing derived from many years of scientific research in changing circumstances (Berland & Cruet, 2016). To enact biology, students have to make use of these various expressions of knowing, and at some level redirect this enactment themselves, and not only at the behest of teachers and supervisors (Ford, 2015).

Knorr Cetina (2001) solves this tension between routine enactment and intentionality in science by employing the concept of epistemic object relationships, in which researchers conceive of objects of their research as incomplete, and dynamic, which invites further questioning and research. On one hand, Knorr Cetina’s (2001) approach addresses conceptions of knowing that are in tension between students and teachers in higher education (e.g., Prosser, Trigwell, & Taylor, 1994). And on the other hand, it addresses the diversity of knowing that derives from working practices (Lave, 1996b), and how scientific knowing is best treated as emergent, given scientists’ continual enactment of practices as they investigate concepts (Kelly & Licona, 2018).

Thus, to examine biology students' learning in work, an analytical framework of knowing has to be established that accounts for knowing as it is practiced in science on one hand, and as it is practiced in working circumstances on the other. Particularly given that the separation between the two is oblique, given the various iterations of routine work in which scientists engage (Knorr Cetina, 1999).

Strati (2003) also focuses on knowing, by drawing forward the tacit aspect or knowing that is enacted in the execution of work. He uses as an example the knowledge of a team of workers disassembling a roof, and there pointing to instances of knowing (how to act on the roof) and learning (daring to go up on the roof, talking with fellow workers). Strati's insights serve to illustrate the tacit knowing inherent in situated practices, because the workers on the roof are not able to articulate how they learned and what their knowing consists of in a way which allows others to take up their work. The tacit role of knowing in situated work also present itself as salient in researchers' practice, and biology students' learning, as they enact various methodologies they conceive of objects they study (i.e. object relations), cognitively develop their ideas, and engage in situated tacit knowing to successfully work out procedures that enable data gathering and analysis (Roth, 2005).

Strati's theorizing builds on Polanyi's (1966) notion of tacit learning, which originally focused on the personal antecedents to scientific knowing and practice (Polanyi, 1962). According to Polanyi (1962), individual scientists design their inquiries according to their situated experience and directed interest, not only as a mere function of data presented to them or available scientific knowledge. Strati and Polanyi's conceptions of knowing are useful to consider because they again bring up the relationship between the complexities of knowing (as depicted above by Lave, 1996b), and science and practice. The complexities of knowing that Strati, Polanyi and Lave bring up begs the question how to analyze these in practice settings. That is, conceptions of knowing that allow investigations into situated knowing, and accounts for the plethora of knowledge available to biology students, and their subjectivities (i.e., personal epistemologies) as they come to engage with knowing through various practices.

Ryle's (2009) conception of dual legitimate expressions of knowing, wherein one focuses on propositional conceptual knowing (knowing what) and the other focuses on

procedures and practice (knowing how), is one way to analyze knowing in students' accounts. In these expressions of knowing, it is important to underscore that the distinction between knowing what and knowing how are primarily analytical and not necessarily ontological. It seems clear in theorizing of the interplay between context and individuals' thinking that they are difficult to distinguish as they are experienced by individuals. This seems evident in early attempts to theorize these expressions (i.e., Merleau-Ponty, 2012; Polanyi, 1962; Ryle, 2009, all originally published in the mid 20th century), because in experiencing the world, individuals are also thinking and are directed when they engage in practice. Also, worth noticing here is the difference between expressions of knowing that various authors operate with, such as Merleau-Ponty's focus on a non-cognitive body and directed perception and Ryle's focus on constituents of knowing. That is to say, they consider an overarching theme regarding analysis of context and thought, but their approaches are distinct.

Ryle's (2009) two conceptions of knowing do not directly consider dispositions, life histories, and the background of individuals as they come into engagement with these expressions of knowing. Billett (2001, 2003) adds a third dimension to conceptual and procedural expressions of knowing, dispositions, in his efforts to account for cognition and situated activity in workplace learning. These efforts conceive of procedural and conceptual knowing as emergent and situated in practices (Duguid, 2005), analytically distinguishable, and emphasizes the usefulness of dispositions to determine individuals' propensities to engage with practices where knowing is constructed (Hodkinson & Hodkinson, 2004; Perkins, Jay, Tishman, & Perkins, 1993).

To address the research question in my project, it was necessary to adopt conceptions of learning that accounted for working practices both as enacted in science and in workplaces. This included moving the analytical framework towards knowing, and away from describing practices in and of themselves (e.g., Engeström & Kerosuo, 2007). To account for the complexities of practice, and hence approaches to practice (e.g., Guzman, 2013), I found it necessary to employ a framework that accounted for dimensions of knowing and subjectivities as they come to enact knowing in practice. Billett's (2009b) sociocultural approach to knowing in personal epistemologies afforded this avenue. Furthermore, this approach indicates that when approaching *learning* as a

concept, this is analyzed in terms of individuals' enactment of knowledge in practice, or as *knowing*.

Methods

In the following, I will discuss the methods used and the reasoning behind my methodological approach to address the research question. This also includes ethical considerations and particular limitations and strengths that may be drawn from my inquiry. Furthermore, due to the reflexive nature of my approach, it is worth noting that ethical considerations regarding my subjective role in enacting research, the distance between the practices I have observed, and my own role in participating in them, overlaps quite substantially with discussions regarding credibility and analysis.

Overview of Methods Used.

The research presented here was performed inside a conception of science as methods and assumptions, borne of various practices enacted by scientists (Knorr Cetina, 1999; Kuhn, 2012). Thus, it blends with the theoretical framing of my approach to biology as a set of knowing and practices that are enacted by biologists. This view of science entails that phenomena are out there to be investigated, and that data and analyses are dependent on researchers' particular theoretical approach (Alvesson & Sköldberg, 2009; Edwards, O'Mahoney, & Vincent, 2014). Furthermore, this approach attends to social constructivists or critical theorists' emphasis on researcher reflexivity, and thick descriptions when conducting credible research (Alvesson & Sköldberg, 2009; Creswell & Miller, 2000). This is provided that science is contextually emergent, given the values and subjectivities of those who seek to enact it (Polanyi, 1962).

As presented in Table 2, the findings in this thesis are substantiated through three independent, qualitative interpretive studies (Treagust, Won, & Duit, 2014). One study was performed through employing short-term ethnographic techniques (Pink & Morgan, 2013), the second study through qualitative analysis of digital content (Markham, 2018), and the third study through focus group interviews (Barbour & Kitzinger, 1999). In this chapter, I will focus on overarching issues pertaining to all three studies, whereas more detailed procedures are found in each paper.

All three studies aimed to investigate an aspect of practice, and students' interpretation of their knowing in relation to their enactment of these practices. Student participants were in some way engaged in biology studies, or as is the case in Paper III,

a sub-discipline of biology, alongside two other education programs. The aim of the studies was to focus on the relationship between practices and development of knowing. There is an analytical distinction here between examining practice as systems that generate learning concerning a given object (e.g., Engeström & Kerosuo, 2007), and examining enactment of practices as enactment of knowing (i.e., epistemologies). In Gherardi's (2016) terms, this distinction concerns focus on systems or focus on identities and subjectivities as individuals enact practices. Thus, I wish to examine situated knowing as it occurred in various working practices, and its relationship to students' approach to knowing provided in their accounts.

Table 2. Comparison of methods in the included papers in this PhD

	Paper I	Paper II	Paper III
Number of participants	15	36	22
Program	Biology (disciplinary)	Biology (disciplinary)	Music Performance, Biology (Aqua medicine), Teacher education
Geographical context	Svalbard	Western Norway, centered in Bergen	Bergen, Oslo, Hammerfest, Trondheim
Data gathering	Ethnographic techniques	Issuing guidelines and compiling blog entries	Focus groups
Analysis*	Dialogue with theory	Hermeneutic interpretive	Constant comparison

Note. *The analysis in all three papers are at some level hermeneutic interpretative. Where other procedures are listed, it refers to specific procedures employed as recommended for the methodologies used.

Paper I.

This study employed short-term ethnographic techniques to investigate 15 students' enactment of practices and their conception of learning in connection to a nine-day field excursion. I was embedded and participated in a specific field excursion

(Kawulich, 2005). Data was gathered by notetaking, photographs, informal interviews during the field excursion, and two semi-structured group interviews subsequent to the field excursion. The structure of the semi-structured interview was informed by the on-site analysis during the semi-participatory observation, and the theoretical framing of the study, to address the overall research question, which focused on the relationship between field excursion practices and knowing.

In the interview I posited questions such as “What did you learn? How did the field excursion go? What does fieldwork have to do with biology? Can you explain how you performed the sampling?” “The sampling” refers to instances that I had observed.

The analysis was performed in two phases, given the limited time in which ethnographic data could be collected it was important to commence analysis as soon as salient themes emerged (Pink & Morgan, 2013). These findings were discussed with the on-site teachers, and through correspondence with colleagues after the field excursion, but prior to the group interviews. The second phase included more comprehensive compilation of all gathered materials and selection of salient learning experiences as observed and otherwise through accounts given by the students. The findings were analyzed according to Rogoff’s (1995) conceptualization of sociocultural participation.

Paper II.

In Paper II the students were given guidelines to ensure that the students gave accounts of their work placement learning that fulfilled certain criteria for content and style. We performed a qualitative examination of blogs posts that 22 students wrote during a one-semester work placement course, for a total of 85 individual entries.

As we were in a position to set specific boundaries for the students’ entries, this procedure differs from investigations into digital societies that emerges outside researchers’ influence (Kozinets, 2015). In the guidelines, we provided specific questions for the students to address, such as “What are you doing? Did the work placement meet your expectations? What do the work placement do with your thoughts about being a biologist?” By keeping close communication with the students, we found that detailed questions were needed to help students write their reports (Velle et al., 2017).

As the data was readily available online (see <https://biopraksis.w.uib.no>), data gathering involved compiling all blog entries related to individual students into individual texts, including pictures, according to qualitative procedures to digital research (Kozinets, 2015; Markham, 2018).

The analysis involved two phases inspired by Billett's (2001, 2003) conceptions of knowing, within a sociocultural framework (Lave, 1996b), and Markham's (2018) recommendations regarding analysis of digital content. First, we mapped the individual students' dispositions and their relation to their engagement with work placement practices and their education. The second phase included designating individual students' accounts into expressions of knowing, whether conceptual or procedural and their dispositions in relation to their work in their work placement.

Paper III.

The study was part of a larger project, "Sammen for bedre læring / Together for better learning", which aimed to investigate learning in work placements across several distinct educations. We employed focus group discussions as recommended by Barbour and Katzinger (1999), using a common guide to gather students' accounts of their learning in Music Performance Education (nine students), Aqua Medicine (six students), and Teacher Education (21 students) work placements. The themes for the focus group was selected based on our aim to investigate students' explanation of their own learning in enacting working practices. We therefore asked them to detail their work placements (e.g., "what does the work placement consist of?"), and to focus on their learning (e.g., "what characterizes the ways you have learned in the work placement?").

The analysis was performed by means of a constant comparison procedure, in which prominent themes across all groups were selected (Onwuegbuzie, Dickinson, Leech, & Zoran, 2009). The procedure was commenced in two phases, first through selection of expressions of knowing and dispositions (Billett, 2003), and second through selection of prominent themes as they emerged from the students' accounts across the three work placements (Silverman, 2011). The emerging themes were also discussed through presentations of findings in different work placements in the project group to ensure their relevance across the different educational contexts. To analyze student accounts of knowing and personal epistemologies, we employed a framework of

conceptual and procedural knowing, and dispositions (Billett, 2001, 2009b; Ryle, 2009). We also positioned these expressions of knowing in a sociocultural frame to focus on the enacted and situated nature of students' experiences (Blackler & Regan, 2009; Gherardi, 2009).

Why were the selected methods chosen?

In the chapter discussing learning in working practices, several theoretical perspectives are presented that point to the multifaceted nature of practice. First, that learning is situated and complex as it is dependent on individuals' engagement with particular practices as they are enacted by various members (Billett, 2003; Gherardi, 2009). The aim to examine students' perspectives of their own learning as they engage with these practices therefore has to account for these complexities. Second, students' role as biology students, interred within a far-reaching scientific discipline suggests that knowledge and knowing is central to the students' experience. And particularly to address the research question, which focuses on the relationship between learning biology and practice.

Through three approaches in the three studies, I aimed to investigate somewhat different aspects of the students' experience. However, all three methodologies at some level aimed to gain insight into the students' accounts as a way to understand knowing (i.e. epistemologies) either through interviews or their own written words (Brinkmann, 2007). Students' accounts of practice and learning was gathered in a variety of ways, all of which addressed some aspect of the overall research question, but was tailored to attend to the specifics of the students' context.

Paper I: An investigation employing ethnographic techniques has the strengths of being able to document students' direct engagement with any given materials, such as the Arctic landscape, and social interaction in a situated practice (Angrosino, 2005; Pink, 2009). Thus, direct observation and interviews of students' experiences in a field excursion captured several tacit instances that could be developed further after direct observations (Kawulich, 2005).

Paper II: The use of students' blogs enabled data from a wide variety of workplaces, and thereby resolves issues of geographical spread and concurrent

experiences (Postill, 2016). The pictures and documents provided in the students' blogs also give some added insight into their experiences (Markham, 2018).

Paper III: Focus groups enabled a more direct overview of various work placement schemes, and was appropriate to gather an overall account of students' experiences in work placements and their discussions in groups regarding knowing in work placements (Wilkinson, 2016).

How do the Methods Substantiate Findings?

In the following, I will outline how the overall approach is appropriate to address the research question, and how material was handled to ensure the accuracy of their representation in the various papers. Reliability concerns the overarching strengths of claims, and the extent to which these claims can be brought to bear across contexts, while validity refers to the precision or credibility of any given research (Creswell & Poth, 2018). Both terms are useful to consider in any research, but are not without issues when securing them. This is particularly true with reliability, which conveys an expectation that may not be appropriate to all types of inquiries.

The nature of contextual studies.

Whether research should adhere to predefined procedures is still somewhat controversial (Feyerabend, 1993). This is perhaps especially true in qualitative research in which design has to stay sensitive to the particular context in which investigations are pursued, and sensitive to the participants which are being examined (Creswell & Poth, 2018). However, most seem to agree that any qualitative research is subject to the same expectations that apply to all research, that is, transparency of procedures should be maximized (Levitt et al., 2018; Silverman, 2013).

Maxwell (2004) argues that interpretive inquiries' sensitivity to context allows for explanations of complex phenomena. He states:

To develop adequate explanations of educational phenomena, and to understand the operation of educational interventions, we need to use methods that can investigate the involvement of particular contexts in the processes that generate these phenomena and outcomes (p. 7).

This assertion seems particularly pertinent to examinations of students' engagement in working practices, where a large number of more or less articulated instances contribute to students' experiences (Eraut, 2000). That is, as Gadamer (2013) argues, a hermeneutic interpretation allows for a more tailored approach to examine specific instances:

the aim is not to confirm and extend these universalized experiences in order to attain knowledge of a law—e.g., how men, peoples, and states evolve—but to understand how this man, this people, or this state is what it has become or, more generally, how it happened that it is so (p. 4-5).

Several comprehensive procedures have been developed over the years. As such, I have attempted to make use of the considerable advances that have occurred in short-term ethnographies (e.g., Pink & Morgan, 2013), digital data gathering (Markham, 2018; Pink et al., 2015), and focus group interviews (Barbour & Kitzinger, 1999; Wilkinson, 2016). In all these three methodologies, several authors provide concrete recommendations to consider while examining data, including recommendation for handling the subjective nature of the inquiries. That is, disseminating the researcher's vantage in the investigation, and allow readers to understand their strategy to a reasonable degree. This has provided a useful guide in my approach. However, given the wide disparity in context, students, and research question, adaptations have been constantly made. For instance, in case group interviews it was desirable for each case to be interviewed by authors connected to each individual case due to access to the various institutions that was examined, and familiarity with the students and the vernacular that the students used.

How credible research was ensured.

Returning to the notion of validity, and given the above outline of context-sensitive approaches, some researchers reject the notion of validity altogether. Perhaps as an expression of heated methodological debates in earlier decades, Wolcott (1990) finds validity to be a concept more pertinent in assessing measurements than to assess qualitative research. Like many qualitative researchers, he prefers the term credible

research (Creswell & Poth, 2018). Nevertheless, he offers several points to ensure credibility: *Talk little, listen a lot; record accurately; begin writing early; let readers “see” for themselves; report fully; be candid; seek feedback; try to achieve balance; and write accurately.* Whether one addresses these points as aspects of validity or not, they seem to blend well with common notions of validity in qualitative research. For instance, Hammersley (1990) holds that validity is “the extent to which an account accurately represents the social phenomena to which it refers” (p. 57).

Talk little, listen a lot refers to the sensibilities of a researcher in interaction with participants and allowing and encouraging them to convey their thoughts extensively. Wolcott (1990) goes on to point to his own experience of “presenting myself as a bit dense” (p. 128) to ensure that participants get their point across. This resonates with my own experience of interaction with participants in Paper I and Paper III in which posing somewhat obvious questions (e.g., “what is that green thing that you are handling?”). This could be a valuable avenue to encourage students to talk freely. In other instances, my sparse understanding of biology made any pretense of not knowing unnecessary, which could afford the students to talk freely and assume a role as experts.

Record accurately is important both in qualitative research that employs audio recordings (Papers I and III), and in fieldwork with notetaking (Paper I). Wolcott (1990) points to the importance of starting recording quickly after an observation, this was certainly helpful for me in notetaking and in writing transcripts from audio recordings. In Paper I and III, I soon found what I could remember important, to resolve or avoid ambiguities in my notes or in quality of audio recordings.

Begin writing early refers to the analytical quality of writing up qualitative research. And that the writing in itself is an important step in assessing research data. This has also been pointed out by others (van Manen, 2006), and I also found this was the case for me as the findings became clear when they were articulated in an overall manuscript that expressed theoretical framing, findings and discussions in a cohesive manner.

Let readers “see” for themselves, this point addresses a common issue when displaying qualitative findings, in that it is tempting to display large excerpts of the data material. This was a particular issue in Paper II, which included a large number of

contexts in the various workplaces and a large written material provided by the students. It was tempting, but unfeasible to present in a single article with limited word count and to directly address research questions. As such, we found it was better to display a few cases to give examples of our findings, this was also somewhat assuaged by the fact that the material was openly accessible online for interested readers. In all three papers, a combination of context descriptions or vignettes written by me and the direct utterances provided by the students were employed to balance these considerations.

Report fully. Wolcott (1990) argues that in order to accurately present findings, instances that were not readily understandable or addresses the focus of the research should be included. Again, limitations in space and the wish to focus the various studies made it unfeasible to adhere to this to a significant degree. However, in direct excerpts from students we made sure to also include surrounding utterances that were perhaps not directly related to the surrounding theme which the excerpt was meant to exemplify. Reporting fully also addresses the value of thick descriptions in disseminating research, in paper I and II vignettes were used to insert the reader into settings as I and co-authors perceived them. The aim of this approach was to substantiate findings from the patterns that we perceived within these descriptions (Kenneth Tobin, 2006).

Be candid continues the above discussion regarding subjectivity and reflexivity in qualitative research. Wolcott (1990) advocates, as many others (e.g., Hatch, 2002; van Manen, 1995), for inserting subjectivity clearly in research. The extent to which this can be disseminated in any study I found problematic due to the various levels at which I participated. In the case of Paper I, it was important to report some concrete instances, such as how various experiences became pertinent to me as a researcher in the field. In Paper II and III this was less salient because the data material was not dependent on my participation in practices. Nevertheless, in instances where subjective and value-based decisions were being made, it was important to make this clear with wording such as “should” or “must”. This point, as it regards to reflexivity, is also returned to in the analysis section below.

Seek feedback is perhaps a somewhat obvious point in any research. It is interesting that Wolcott (1990) includes it in a discussion on validity. However, given the importance of the writing process and continual assessment of findings, its role is

easier to discern. As shown in declarations at the outset of this thesis, several researchers have been consulted on multiple points during data collection and analysis. It has at several instances been decisive in redirecting and in reevaluating claims that I attempt to make in the various studies. In the case of Paper I, getting feedback on the interview guide and interview that was conducted subsequent to the field excursion was crucial to ensure that valuable data was gathered.

Try to achieve balance refers to researchers' responsibility to re-evaluate assumptions after analysis has commenced, and to consider whether the overall story that the study conveys adheres to what the participants wished to convey. Some researchers opt to return to the field in which studies were conducted, this was not feasible in many cases as students had moved on, however in Paper II the online material was always available to be reevaluated. Otherwise, reconsidering the material gathered in Paper I and in Paper III consisted of reevaluating all the material, and in Paper III various parts of the findings in the different programs were discussed several times in the project group and thereby addresses this point.

Write accurately seems a quite obvious point in any research, and is again interesting to add in a discussion of validity. Wolcott (1990) here stresses the importance of precision in wording and an overall word check. However, it is also important to address the importance of conveying contextual descriptions accurately. I found that it was useful to consult biologists when describing biologists in action to ensure correct use of terms, for instance the use of the genus name *Saxifraga* when describing students' work on plotting transects in Svalbard in Paper I.

Analysis and presentation strategies

In essence, hermeneutics refer to analysis of text by deriving meaning from subparts through considering the overall message of the text. Many hold that all qualitative studies are at some level hermeneutic (e.g., D. L. Rennie, 2012). This perspective also seem strengthened on consultation of various works on qualitative method that detail various procedures to deconstruct, contextualize, and synthesize data by consistently emphasizing the importance of participants' intended meanings (e.g., Creswell & Poth, 2018; Silverman, 2013). It is more convoluted when considering how theoretical perspectives should contribute to inform findings. Whether from grounded approaches

where theoretical preconceptions are purposefully avoided (Glaser & Strauss, 1999), to more iterative approaches where theoretical perspectives inform inquiry and analysis at various intensities (Levitt et al., 2018).

The analysis in the included papers have all taken an iterative approach, where the theoretical framing evolved prior to and during analyses, and analyses was performed in several phases. In Paper I, it was important to commence analysis quite early, due to the short-term ethnographic techniques that were employed (Pink & Morgan, 2013). This included discussions with other researchers, and summing up notes from everyday observations. In Paper II, the students' sensibilities, and a sociocultural framing in which their work took place, was discerned through separate steps. The material was then considered overall when synthesizing the findings into three themes. In Paper III, a similar procedure was enacted, but analysis also required ongoing input from researchers from diverse disciplines. Thereby, meetings with formal disseminations of preliminary analyses were vital to ensure that the students' perspectives regarding their learning in various work placements were accurately presented, and findings between work contexts compared fairly.

To surrender and to analyze.

Throughout my gathering of material, the collection process is difficult to distinguish from analysis. These processes are inherently interlinked in reflexive research, in which meaning is generated across researchers' engagement with participants and data (Pink et al., 2015). Although data gathering followed specific procedures, I engaged in thinking and meaning-making from the outset of the project. I continually thought about what people said, what I observed in terms of understanding the relationship to knowing in general terms, and in terms of biology education in particular. Whether in embedding in a field excursion, in which analysis is recommended to commence at the very start, issuing guidelines and reviewing new blog entries as they were published, and the focus group discussion.

Gherardi (2015) adopts Wolff's term of surrender to emphasize the importance of the actively engaged researcher, particularly in ethnographies concerned with practice. Gherardi conceives of this approach as an embrace of meaning making in-situ, in which meaning is not only derived from solemn recording, but a livelier engaging

approach. I found this true in terms of my engagement with biology students in the field excursion, where embracing their work with gathering data, and engaging with materials was meaningful. In these settings, my imagination invoked the role of a field excursion participant, and harkened back to my field excursion experiences as an undergraduate. Further, I shared students' exhilaration of natural phenomena, and their struggles to enact their research.

In engaging with the data material, I was consistently negotiating my preconception and theoretical perspectives with my subjective engagements and interpretation not only to make them transparent for readers, but also to discuss them in terms of their value for meaning making. Alvesson and Sköldbberg (2009) suggests four interpretive aspects that determine qualitative reflexivity: creativity in the sense of an ability to see various aspects; theoretical sophistication; theoretical breadth and variation; and an ability to reflect at the metatheoretical level. These aspects emphasize the practices of becoming a researcher, but also how tensions between embracing particular approaches to phenomena (i.e., a specific theoretical perspective) and considering different approaches lead to various challenges and opportunities.

Thus, on one hand I needed to embrace, as much as possible, the experiences of participants given the material available. On the other hand, subsequent analysis needed to account for whether this embrace clouded judgments and approaches that could reveal further and different meanings. Thus, the present theoretical approach to students' learning, that attends to multiple expressions of learning as they are expressed in situated practices, needs to be transparent for readers to understand findings.

Vignettes and context descriptions.

To describe various studies, and their context, vignette descriptions were employed in both the field excursion and blog findings section. This procedure was employed as recommended in ethnographic methodologies to describe context from the vantage point of me as a researcher (Hammersley & Atkinson, 2007). By combining these descriptions with more descriptive content such as interview excerpts and other word for word excerpts the aim was to provide contextual credibility. The vignette sections were also separated from the main body of text to ensure that the readers could follow the employment of this analysis.

In all three papers, considerable room was given to describe the various contexts in which the studies were conducted. This was done to center the findings within a particular context, and thereby allow readers to understand how these contexts interplay with the practices that students engaged in. This highlights the strengths of limited cases in that more space can be set aside for detail in contexts, and thereby increase the legitimacy of the research (as suggested by Maxwell, 2004). It is also a way in which readers can discern the extent to which our findings are relevant to their own circumstances, whether in research or teaching.

Ethics

Distance and embeddedness.

The overall aim of this thesis to examine the question of practice in biology education was executed through various points of distance to the focus of the inquiry (i.e., biology students engaging in practice to learn and develop). The research was conceived and completed where I was a PhD-student at an office space at the Department of Biological Sciences, University of Bergen, attending lectures, and otherwise interacting with biology researchers, technical-administrative staff, and students in the pursuit of their craft. Marty (2015) has suggested that educational researchers should consider three dimensions of distance toward participants and embeddedness in their research: *distance to fieldwork*, *distance to scientific community*, and *distance to oneself*.

Distance from fieldwork concerns the cultural relationship between researchers and the participants in a study, and is often discussed in terms of researchers' access to, and understanding of, various participants (Bruni, 2006; Latour, 1987). Marty (2015) refers to classical anthropological studies as an extreme case, wherein European researchers would stand clearly out in other continents with their pen and papers and foreign clothes. Given that studies into scientific communities are performed by scientists on (or with) scientists, this distance will not always be as salient as in classical anthropological studies. Marty (2015) asserts that "if the researcher is among colleagues in a higher education organization, with the same cultural background and conception of science, he/she is much less visible" (p. 20).

Distance to the scientific community, as described by Marty (2015), refer to the time spent in new research communities which reduces the time spent among colleagues who pursue similar research. The majority of my working time as a PhD student was spent at the Department of Biological Sciences, which certainly reduced the chance to interact with other educational researchers. As such, it was important to seek out meeting points with these communities, such as research group meetings at the Department of Education, University of Bergen.

Distance from oneself as a researcher is relevant consider to ensure that research is not weakened by researcher reflexivity. Marty (2015) raises the following question, “how can a global point of view about an institution be defended by an actor implicated in his/her everyday life?” (p. 23). Again, I did not participate in all biology work that biologists engage in, Marty suggests that a structured division of activities between research and embedded activity may aid researchers in obtaining a more distant to view of their research where needed. For instance through analyzing data at a separate location. In my case, the separation was somewhat oblique, as all writing and analysis was performed mostly on a biology campus. However, there was a separation between engaging with biologists as they worked in lecture halls, laboratory and fieldwork, and the workspace where I worked with analysis. Further, Trowler (2016) suggests that there is a continuum between researching scientific communities with which researchers have been students, and other parts of the University which are unfamiliar, as have been the case in my studies.

A salient expression of these distances is many biologists’ approach to method and science, in which they immediately saw value in researching their practices. I construed this as an expression of the inherent value in seeking knowledge about the world, not least when exploring teaching practices. However, some biologists expressed curiosity on the particular methods involved. Many biologists were eager to discuss educational matters with me, typically specific use of specific teaching methods, preferably with a quantitative measure to assess their value. As such, many valuable discussions ensued concerning the efficacy of my situated approach to learning, in which examining specific contexts are important and rarely provides a quantitative assessment.

However, this also led to less scrutiny on my particular design as opposed to the overall assumptions that underlie it.

Another salient example concerns the vernacular inherent among biologists with a similar educational background. As such, terms and concepts that were unfamiliar to me were used freely throughout. This was particularly an issue at the outset of my work, as I have gradually gained some knowledge of these concepts and procedures that are familiar among the members of any Biology department. This gradual familiarity is perhaps a salient example of sociocultural participation (Lave & Wenger, 1991), but also highlights the dangers of maintaining and evolving distance, in which some strengths in scrutinizing biologists' practices from afar gradually becomes scrutiny from inside.

It is here also worth mentioning the advantages of daily engagements with biologists, as it allowed me to understand various approaches to different biologists used, and their particular approaches to their daily work. Thus, I could design my research approaches to analyze these practices, and perhaps understand students' accounts regarding their work to a larger degree.

A final point that pertains to distance to myself, is the role I had in the development of a course in which I aimed to examine students' experiences (Paper II). As a developer of the course, I had a wish to see the course succeed. Students' engagement with important knowing as a result of their course-experiences would be a substantial contribution. In this instance, it can be relevant to reference sentiments that are common in action research: Researchers that affect change do not engage in research as a valueless observer, but with a clear goal to improve social practice (Brydon-Miller, Greenwood, & Maguire, 2003). However, this does not mean that any less rigor is needed in substantiating claims and accurately portray findings, aside from heightening the importance of reflexivity in conducting the research.

To summarize, distance from oneself (myself) has neither been negligible, nor exceedingly problematic, but has emerged intermittently dependent on time and place. And the ethical considerations presented here are also closely linked to researcher reflexivity and analysis procedures. Reviewing these distances myself, consulting original PhD project descriptions, and ways in which science education and educational

literature portrays concepts, have been important. The three distances raised by Marty (2015) intermingle, so that one can scarcely be fully discussed without the other. Both Marty and Trowler holds that there are challenges between levels of distance (or being an *insider* as Trowler puts it, 2016) and researchers' ability to capture and analyze data, mainly due to researchers' ability to disseminate and evaluate activities that they themselves take part in. All three papers included in this thesis operates with various levels of distance and practices in which I have participated. The overall thesis and design aim to examine a broader phenomenon perceived as both a researcher and a participant. Therefore, the above reflections are important to disseminate here.

Power relations.

Whereas distance plays an important role in data gathering and analysis when conducting studies in higher education, it is also important to consider in terms of power relations. Power is particularly an issue in relationships between students and teachers, and between junior and senior researchers (Trowler, 2016). The studies presented here are primarily focused on students, hence there are potential issues that are important to consider in the study design.

First, the degree to which students are autonomous in their decision to participate in the research should be resolved. Providing students with contact details and assuring them of the possibility to freely leave the investigation at any time is thereby important to articulate and make clear in a way that allows students to do so without ramifications. For instance, in Paper I, students were able to talk to me without other teachers present, and I was also prepared to conduct the research without disclosing to the teachers whether specific students wanted to participate or not.

Second, is the way in which students might want to present themselves to perceived seniors and alter their behavior because of a perceived power differential. Although oblique and difficult to detect, this may for instance be an issue in Paper II, where students disseminate their thoughts about their work placements not merely to contribute to the research project, but also conscious that it will be read by other faculty members in an institution in which they may want to pursue a future career. Here, establishing multiple encounters, and ways in which students could disseminate problematic or contrarian accounts of what they disseminated in their blogs helped

provide a sense of how the students chose to give accounts in the ways they did. Although not analyzed as content, conversing with the students during and subsequent to their work placements about their experiences helped provide a better sense of the antecedents of their accounts.

Data storage and consent

All participants were informed and gave consent for their participation in research per ethical guidelines by the Norwegian center for research data (Norsk Senter for Forskningsdata, NSD, www.nsd.uib.no). In Paper I, consent was needed due to the breadth of data gathered, especially on-site audio and photographs. In Paper III, no names were stored, so NSD did need to process the study after consultation. All personal information gathered was anonymized or deleted by 2018.

Paper II is particularly worth mentioning here, as it contains data which is publicly available at the outset. Through ongoing collaboration with NSD, we decided that the correct ethical procedure would be to gather active consent, and specific consent to use students' illustrations in the paper. This procedure was determined because blogging was done in conjunction with the course, so it was not voluntary. Further, according to L.D. Roberts (2015) creators of online content often perceive their readers as specific groups, and not as part of a public space. Further, they may not envision their content to be used in research, which increases the need for consent.

Presentation of Findings

In the following, findings from the three papers included in this thesis will be presented. The aim of this section is not merely to summarize the findings, which is more exhaustive in each individual paper, but to summarize them to in turn address the overall research question of the thesis. Individual papers are presented first, before summarizing some ways in which the findings interact.

Paper I. “Working and learning in a field excursion”

This study investigated students’ work and their learning in a specific field excursion. The research question was “*How does the students’ engagement with fieldwork practices influence their development of biological knowing?*” The paper also includes a discussion regarding the use of practice-oriented theories to discern students’ learning in field excursions.

By employing Rogoff’s (1995) conceptualization of three planes of sociocultural learning, three particular processes were identified, and further expanded in light of participatory observation and students’ accounts of their learning.

First, the guided participation in which students discern their own and group members’ role in working in the field excursion. A prominent example of this was students’ work with mapping plots. This mapping included species and soil compositions to achieve what students perceived as acceptable data for their research projects.

Second, participatory appropriation, which is the way students’ engagement with field excursion practices afforded them access to specific biological phenomena, which affected their perception of these, and the ways in which field excursion participation and biology education interact. Some prominent examples of this included witnessing the real-time predation (i.e., killing and eating) of animals in the field, and striking visual phenomena such as a green bird cliff in an otherwise brown and gray Arctic landscape. Phenomena such as death and the value of bird guano for plant growth, were at some level known to the students. However, by engaging with or observing them in real time, students were startled and otherwise discussed these concepts in a new light.

Third, apprenticeship, which manifested in the way students and teachers, and students among themselves, engage with various practices to operate successfully in the field excursion. One expression of apprenticeship was the way in which teachers ensured safety from polar bear attacks by ensuring group cohesion and that armed students were positioned at strategic locations. Otherwise, apprenticeship occurred between students who were familiar with field excursions and thereby had a general idea about what to expect (and thereby ways to act) and students who were not, who found that they needed some time to familiarize themselves with the work.

Students' participation amongst themselves and with teachers, and their real-time engagement with various scientific phenomena were two salient themes that emerged as responses to the research question. Situating these two processes within a practice-oriented theoretical framework, which likened participation in work and participation in field excursions, were valuable to construe how students learned (i.e., knowing). Another important point worth noticing, concerns ways in which practice and students' previous experiences interacted in their enactment of field excursion practice. This included engagement with tacit knowing (e.g., phenomena acted different than preconceptions suggested, and sampling required different procedures than initially planned), and the students' reflections on how these engagements developed their understanding of science in general and biology in particular.

Students' understanding of legitimate (i.e., useful, and precise conceptualizations of phenomena) knowing manifested in for instance in their regard for the value of engaging in real-time phenomena for research. The students emphasized their exhilaration and the contributions for their learning of concepts by engaging with them in the field. They referred to this as helping them "remember". These sentiments also tied into students' concerns for the potential dangers of pursuing reductive or laboratory-based data as opposed to going out into the field to obtain empirical data. Here, research conducted in field excursions can emphasize the value of capturing aspects of phenomena that otherwise may be overlooked in reductive (i.e., non-field based) approaches, as natural phenomena are more complex when considering them in their various contexts than their presentation in curriculum or other articulated sources.

To conclude, the study showed important ways in which students work and learn in field excursions. Whether in engaging in discussions of procedure and gather data, engaging with natural phenomena, and otherwise acting appropriately in field excursions by ensuring safety and appraising research designs. Although the work was planned by teachers, the field excursion still included several unforeseen instances, and students' engagements with teachers seem reminiscent of engagements with workplace supervisors or coworkers. The project the students engaged in needed to result in a specific product (a report) within time constraints as in workplaces. A potentially significant difference between workplaces and field excursion as practices may be the goal of the work, that is, it is directed towards students' learning first, whereas work placement practices are directed towards several different goals, such as a commercial product, services, and pay (Billett, 2004c).

Paper II. "Biology students at work: using blogs to investigate personal epistemologies"

This study addressed the following research question: *How do biology students describe their development of personal epistemologies in their work placement blogs?* On the basis of work placement blogs written by biology students in a novel work placement course (Velle et al., 2017), students' personal epistemologies were analyzed through examinations of various expressions of knowing: conceptual knowing, procedural knowing, and dispositions (Billett, 2001, 2003).

The students' accounts were summarized in three distinct themes: *Working in the face of adversity*, *participatory appropriation*, and *finding cohesion between workplace and campus practices*. In the study, we found value in examining personal epistemologies as a sociocultural concept, by grounding students' accounts of their learning to their particular circumstances. Students partook in diverse work placements, such as private research enterprises, environmental pressure groups, or government agencies. Students' subjectivities were expressed through their expositions of their life histories, and their expectations of their own learning in engaging with the work placement practices. Some connections between subjectivities and work interest were seemingly straightforward, such as an interest in marine life from early childhood and wish to participate in marine life research. Others were more convoluted, for instance,

one student discussed work placements as an integral part of their overall education, and then opened up the possibility that they may want to work as a scientist in the future as a result of their work placement in a research agency. Others focused more on the way in which working afforded access to personal epistemologies, which shaped their perception into ways in which they may use a biological approach (i.e., methods, knowing common in biology science) in work.

These personal epistemologies related both to the balance between time and quality, which became salient in a profit-sensitive workplace, or the considerations between environmentally friendly research practices and work that could increase revenue. These considerations seemed especially pertinent in a biology education context, in which sampling and precision often takes large resources to sort through. This is because the material may contain several confounding, messy, data, which require effort to overcome in order to quantify precise measurements. This is particularly true in enacting a research design for the first time, as is the case for many undergraduate students. The contrast to biology education at campus was stark due to the amount of time and quality requirements of data available to students in for instance lab-circumstances.

To summarize our findings we propose a conceptual model of students' learning that aim to incorporate the contributions of the contextual situation, personal epistemologies, and expressions of knowing to contribute to students' learning. Although work placements are novel, we suggest that the use of blogs is a valuable tool to assess and foster student reflection, and ways in which to foster personal epistemologies.

Paper III. "Learning and personal epistemologies among students in three work placements"

This study aimed to address the following research question: *In what way do the students' workplace experiences contribute to their accounts of personal epistemologies across different education programs?* The students discussed work placements in general terms, and in particular as it related to their disciplines. Three overarching themes emerged in analysis and we elected to present them as epistemologies to emphasize the role of students' accounts of their own knowing. The three themes

consisted of the epistemology of risk and a real chance of failure, the epistemology of enacting routines, and the epistemology of values.

The first theme concerned students' appraisal of authentic enactment of their work, in which failure has contingencies beyond negative assessments. This realization was not meant to indicate that all work has to be perfected. In the case of Music Performance students, they found that overall performance, designed and executed in a constrained timeframe, were more important than any one particular wrong note while playing. For Aqua Medicine students, analyzing fish health in workplaces introduced a level of uncertainty that was strikingly complicated compared to what they were prepared for from their laboratory exercises on campus. These complexities included harsh weather conditions in the fjords, variety of symptom signs, and time and monetary constraints, in which decisions impacting profitability and future careers presented pressures to be handled. For instance, whether populations of fish were too sick to be sold as food, which represented a considerable potential profit loss. For student teachers, enacting authentic lessons in which pupils' discipline and motivation had to be emphasized constantly were important, exhilarating, and challenging on many levels. Thus, time spent in discussing situations with students and other instances not directly related to presenting or disseminating subject matter was surprising to students.

The second theme, regarding the epistemology of routine, revealed how continuous work on specific procedures activated students' personal epistemologies and considerations regarding diverse sets of knowing. For Music Performance students, this could include appropriate timing of when and how to listen and interact with fellow orchestra members. For Aqua Medicine, it could include such tasks as handling and measuring fish accurately and reasonably efficient. These were tasks that proved more challenging than originally presumed. These procedures also elicited students to discuss dispositions, as they found it crucial to confidently interact with other workers at a fish farm by showing proficiency in routine work. For teacher students, these procedures emerged in planning and preparing for lessons. In this work, students found tasks such as conferring with colleagues in their preparation to be a valuable for their work placement experience.

The third theme concerned the way in which students' experiences evolved their thinking regarding their own role in their work, and their propensities to pursue practices in which they found value (i.e., corresponds with their dispositions), and disregard those in which they did not. For Music Performance students, it included such elements as interacting with audience, and integrating various stakeholders in performances. For Aqua Medicine students, the third theme included ways in which the work placements made students consider their own identities in interacting with communities along the sparsely populated Norwegian coast. In these communities, fish farming is an important employer and closely intersects various geographical cultural markers, such as dialect and vernacular, that was unfamiliar to some students. For teacher students, the transition from student to teacher became salient as they related their identity to their development from a student that had attended class in this way for many years, to a teacher who was supposed to facilitate students' learning.

Given the wide variation of educational programs included in the study, the findings substantiate a broad understanding of work placements in students' learning. A conceptual model was developed to summarize these findings, which emphasize contextual contributions, particularly those of workplaces, to students' learning. It is worth noticing the students' accounts of the difference between campus and workplace learning, in which somewhat derisive accounts were provided in their discussions. For example, that campus learning is misleading. This was true in Teacher Education, Aqua Medicine, and Music Performance.

Summary

The findings in Paper I contrast somewhat to the findings in the other studies, both because it encompasses participatory observation, and because it captures some of the teachers' role. Teachers' role is more pronounced in field excursions than in work placements as they interact with students continually and in a structured way (i.e., to address learning outcome goals, see for instance Kent, Gilbertson, & Hunt, 1997; Lonergan & Andresen, 1988). According to my findings, various actors such as work supervisors seem to take a more informal role than teachers in everyday interactions in work placements. However, there are salient similarities between the three working practices as accounted by students.

First, the way in which students discussed their conceptions of scientific method in general or biology in particular as a contrast between their more regular campus activities (e.g., lectures and curriculum reading) and its more direct enactment through work, whether in field excursions or work placements. More specifically, it is difficult to ascertain the degree to which these conceptions reflect students' epistemological appraisal of science primarily as a set of knowing as presented to them at campus, which is further developed as they encounter complexities in practice. These dynamics also seem to hold true among Music Performance and Teacher Education, though it is directed either toward instrument proficiency and curriculum as campus activities to be challenged in work.

Second, the participatory practices that students encounter in their learning, was directly analyzed in paper I and II, in which Rogoff's (1995) outline of participation served to frame students' accounts and my observations. Participation as a sociocultural concept includes the enculturation of participants as they partake in practices, and had a clear presence in all students' experiences. Thus, it serves to illustrate the value of sociocultural approaches to biology students' learning in practice, and further indicates interactions between individuals' cognition and personal epistemologies as they discuss their knowledge as enacted through working practices.

Third, analysis of students' personal epistemologies (Billett, 2009b), apart from their conceptions of science and their own learning through participation, reveals how individuals come to engage in practices as they are enacted in various iterations of work. As students engaged with various complexities such as exterior demands in workplaces, weather conditions, animal predation, or research methodologies, they invariably inserted themselves into these situations and negotiated their own role, both present and future, in enacting them. These negotiations could include elements such as the value of precision in contrast to profitability, or time constraints versus precision.

In Table 3, the studies are summarized in terms of the variety of knowing as it emerged through analysis. The table shows the contrasts between field excursions, work placements for biology students, and work placements in Aqua Medicine. The contents of the table are selected according to social, personal, and brute contributions for knowing, which constitute antecedents for personal epistemologies (Billett, 2009a,

2009b). To also frame the expressions of knowing into epistemological practices, a variant of Kelly and Licona's (2018) overview of epistemic practices in science education is also used in the selection. In their overview, Kelly and Licona show how various aspects of science pertain to epistemic practices such as evaluation, legitimization, and dissemination. The purpose of Table 3 is to make the links between working practices, learning, epistemologies, and science education clearer as they relate to the findings in the three papers. By design, some of the epistemic practices overlap with contributions for learning in the table, as scientific epistemic practices are contextual and enacted by individuals as they come to engage with science (Kelly & Licona, 2018).

Table 3. Representation of knowing and epistemic practices as found in the three studies

	Paper I	Paper II	Paper III*
Practice	Field excursion	Work placements	Work placements
Contributions to knowing			
Brute	Svalbard, nature, weather, smell.	Particular work places Laboratories, offices, weather	Weather, fish, geography (i.e., remote)
Social	Peer and teacher interactions. Institutional (i.e., University) contributions	Work supervisors, clients/customers, peers	Fish farmers, aqua medicine professionals, fish farm corporations,
Personal	Negotiations between individuals' life histories and field experiences such as natural phenomena	Negotiations between individuals' life histories, concepts, methods, and work placements	Own role in enacting a practice. Cultural engagements between local communities and the students' background
Epistemic practices	Role of field work in biology research. Enacting precise measurements. Understanding of scientific phenomena by observing them in reality	Time pressures and laboratory work. Requirements for precise results. Enacting biology methodology in various contexts	Negotiations between precision and other pressures (e.g., monetary). Disseminating uncertainty or certainty to stakeholder (e.g., corporations)

Note. To make the table representative and clearer to read the selection above is not an exhaustive representation of all observed instances in the papers. *Given that Kelly and Licona's (2018) overview focuses on natural science and engineering, the information listed here pertains to Aqua Medicine students in Paper III, whether or not they also have the potential to apply to other work placements.

Discussion

To discuss the findings and overall contributions to the aims of this thesis, I will focus on three main themes and outline how the three studies address them. The three themes aim to address the research question of the thesis, *how can biology students' enactment of biology in working practices contribute to their learning?* The themes also address salient findings that emerged in all three papers. Thus, themes are a product of the particular theoretical approach to learning (i.e., knowing) that I have used.

First, I will discuss how the studies in this thesis can contribute to our understanding of the relationship between knowing as enacted at work, and at campus, particularly within a biology education context. This is often drawn up as a particular issue in workplace pedagogies in professional educations (e.g., Helyer, 2011; Korthagen, 2010), and thus interesting to discuss with respect to a discipline education. Second, I will discuss more closely the role of personal epistemologies and how these have developed among the students that have participated in the studies. This section more directly addresses how an approach to personal epistemologies responds to the research question. Third, pedagogical and curricular implications that may be drawn from the studies' findings will be discussed. This is important to bring forward in order for educators and researchers to focus their research on measures that are useful to students' learning. Also, given that biology education has limited experience with work placements and using theories on workplace learning to inform their pedagogy (Scholz et al., 2004), it is useful to discuss this theme further on the basis of the studies.

The three themes overlap somewhat, given that personal epistemologies are relevant to understand the importance of context to learning, and that the contributions of context have pedagogical implications.

Enactment of Biology in Work and Campus Practices

As alluded to in the summary of findings, all three papers in some way reveal tensions between situated knowing and cognition. This tension is evident for instance between designing a research procedure at campus, and encountering challenges in its enactment by the students in the field excursion (Paper I). Students discovered that their conceptualization of seemingly simple objects like 'a rock', and thereby their procedures

for mapping the local environment, was both ambiguous and unresolved. Further, all students found complexities, such as time constraints, and in some cases profit motives or weather conditions, to impact the formation in which data gathering and analysis were to be conducted (Paper II and III). In all three papers, this was a marked contrast to their expectations of their work, and something they felt they lacked proper training in from regular campus activities. Among Aqua Medicine students, even though they discussed issues particular to Aqua Medicine professionals, such as prescription rights, their accounts of laboratory and sampling work seem to coincide with the accounts of students in field excursions and work placements in Paper I and II.

One way to resolve this tension is to simply designate particular knowing as limited to their circumstance (Lave, 1997), thus this tension is not solvable without subjecting students to the particular practice they wish to participate in. However, my findings also indicate a dynamic relationship between knowing, as engaged students in curriculum, lectures, and laboratory work at campus, and their enactment of biology at work. For instance, conceptions regarding death in field excursions, literature review of wildlife in work placements, or the measurement of fish involves long-standing developments. In these developments, students had in various instances engaged and developed their knowing during their situated experience in work and at campus. Thus, separating campus and work into separate sets of knowing does not seem to capture the complexity involved in students' enactment of knowing in biology.

Eraut (2004) argues that transference of knowing between campus and workplace settings is crucial to future research on the role of work placements in higher education. Other investigations into science education suggest that students encounter more generalized knowledge at campus, and then encounter more specialized or tacit knowledge in workplaces (Garraway, Volbrecht, Wicht, & Ximba, 2011). Billett (2017) has suggested that the domains of knowing that students interact with contain themselves either to societal, situated, or personal contributions. Typically, societal contributions emerge as canonical knowing (often conceptual knowing, or more or less articulated standards on behavior) disseminated in regular teaching activities. Situated knowing refers to the context-sensitive knowing that students engage in at work, and personal contributions refer to individuals' life histories and values with which they

construe work. These contributions need to be engaged with at various levels by students during the course of their learning, and not simply assigned to students' eventual enactment at workplaces in which they will encounter situated knowing (Billett, 2017). To bring this discussion further towards science and epistemologies, Hammersley (1990) in his discussion of the relevance of research to practice, argues that available research is overestimated in its potential effect in any practice. Although more knowledge can be made available, and its enactment increasingly sophisticated, it eventually requires specific divisions of labor.

Hammersley (1990) uses the case of cancer research as an example of the knowledge gap that exists despite considerable effort, and the requirement of specialist doctors, nurses, and others to enact research that emerges. The students' accounts together with my own observation of students' enactment of biology highlight the complexities of practice that are made apparent to the students as they enact biology in working practices. In some ways, these complexities can seem reminiscent of Schön's (1987) proposed dialectics between canonical accounts as provided in school, and their working enactment in professions. Here, working experiences represent the actual knowing relevant for any given education. However, biology students' engagement with knowing during their overall education entails a diversity of engagements with knowing and complexities across several situations, in which various procedures, concepts, and dispositions are useful in their task to enact biology. Even when considering multiple education programs in Paper III, the students' accounts are not strictly dichotomous when contrasting their knowing in workplaces and knowing in campus. Rather, they seem to think differently about what and how they learn (i.e. epistemologies). As one student iterated regarding learning in field excursions:

Yeah, you can sit inside and learn all the theory though it is truth and that is what is happening outside. I think that for me personally it is, you are learning it in a totally different way when you are out, and I just think it's a lot more easy to get "in" and to remember when you are out there where it is actually happening, and you can see it and relate to what you see and learn. (Paper I, p. 6)

Given our sociocultural positioning of personal epistemologies, it entails that personal epistemologies are derived from and remade in their enactment in context. Lave's (1996a) discussion of the relationship between situated enactments and disembodied teaching outlines the complexities of considering these contributions. In other words, biology students' practices, whether in field excursions or work placements, derive knowing for all participants in the practice, where the impact might vary among students, teachers, and work supervisors (and others). Nevertheless, students all contribute at some level to the practice and enactment of biology, as evidenced by their employment of methodologies, literature, vernacular, and approaches that constitute biology. Further, as Säljö (1993) argues, cognition must at some point take into account the context in which individuals are situated. Although students' conceptions of scientific research and biology knowing are challenged when enacted in differing contexts, there is still value in their conceptions and, according to their accounts, further value when these conceptions are challenged and reshaped in practices.

To conclude this section, I bring up Polanyi's (1962) notion of researchers' subjectivity in their learning. The relationships between students' learning in campus and their enactment of biology in work seems explained by Polanyi's (1962) emphasis on individuals' lives, theory and approach to their learning. Their approach emerges on the basis of their particular sensibilities, but is also dependent on the content knowledge available to them. This further underlines the importance of including varied expressions of knowing when analyzing students' learning in working practices, since situated experience, content knowledge and individuals' sensibilities intersect in students' learning.

The role of personal epistemologies in biologists' practices

Whereas epistemologies refer to general conceptions of knowing and how knowing can be disseminated, personal epistemologies encapsulates how individuals' identities intersect with experiences and life histories to constitute their own role in enacting knowing. Personal epistemologies have been investigated in cognitive studies that focus mostly on given knowledge (e.g., Hofer & Bendixen, 2012). In our analysis, personal epistemologies have been treated as a sociocultural concept due to our focus on context in conjunction with their developments of personal epistemologies. Hence, we utilize

the term developed by Billett, who maintains that “Personal epistemologies are defined as individuals’ ways of knowing and acting arising from their capacities, earlier experiences, and ongoing negotiations with the social and brute world” (2009b, p. 211). Billett is careful to emphasize the social and cultural contribution to personal epistemologies, and thereby reshaping Hofer and Bendixen’s (2012) conceptualization. This is done by including workplace contexts and life histories in his account of personal epistemologies (Billett, 2009b).

Hofer and Bendixen (2012) express a concern that researchers tend to conflate learning and individuals’ conceptions of epistemologies. Both concepts are closely associated, and Hofer and Bendixen include learning as one of many sub- processes within individuals’ development of personal epistemologies, such as motivation. This distinction is worth noting when referencing students’ accounts as depicted in this thesis and in Billett’s (2009b) framing of personal epistemologies. As noted, Billett (2009a) supposes a relationship between brute, personal, and situated contributions for learning and personal epistemologies. In explaining their learning in practice, all students gave accounts of their learning (e.g., how engagements with various phenomena helped students “remember”, Paper I), and epistemologies related to a specific situation, in this case working practices (e.g., ways to behave in an orchestra among Music Performance students, or ways to hold and measure fish and challenging conditions for Aqua Medicine students, Paper III). In our analysis, we have focused on categories of knowing (Billett, 2001; Duguid, 2005) as expressions of personal epistemologies. In these analyses, accounts concerning individuals’ expressions of themselves, of learning as a general concept, and the enactment of science in general all attends to personal epistemologies, and are relevant for their enactment of biology in work. Thus, Hofer and Bendixen’s warning of conflation seems less pertinent in this particular approach. However, it is worth noting due to the many iterations of epistemology in research, and the particular ways a theoretical construct can shape findings.

The ways in which students developed personal epistemologies was a central finding in all three papers. These emerged through analysis of the various dimensions of knowing accounted for by the students (i.e., procedural and conceptual) and how students continuously intersected their own dispositions into these expositions. For

instance, students had various developments of their enactment of work in a field excursion (Paper I), both in terms of designing and maintaining a project and then continuing to explore the role of field work in biological research. One student, for example, was critical of what they perceived as an increased emphasis on reductionist approaches. That is, research that may be carried out without gathering data through fieldwork (e.g., computer modeling and laboratory work). Another student argued that hands-on (i.e., field-based) research was undervalued, and used their own field excursion experiences to illustrate the strengths of engaging with real-life phenomena directly, thus inserting themselves into an epistemological debate both concerning research practices and legitimate knowing.

It is here important to interject that students' development of their personal epistemologies are not in itself an explicit aim of science education. Rather, personal epistemologies develop in various ways depending on individuals' life histories and their situated experience. First, the practice-oriented conceptualization of learning upon which my examination has been founded, emphasize knowing as continual engagement by individuals. Hence, students do not achieve personal epistemologies, rather, they enact them as they engage with knowing in practices. Second, as Ford (2008) has warned, that while valuable, students' engagement with their own conceptions and belief of knowing and learning, must be continually criticized and discussed by peers and not least by teachers. That is to say, and as Ford outlines, students may initially not want to engage with the antecedents of the learning with which they engage. In this way, students may rather wish to focus on memorizing facts rather than epistemologies (see for instance, Virtanen & Lindblom-Ylänne, 2010). It seems apparent here that the students' engagements in working practices, as depicted in all three papers, shows the value in critically examining research designs, and furthermore the meaningful biological data that can be extracted from particular designs. Third, in developing various beliefs about scientific knowing, teachers and others may add nuance to claims that can be brought forth and thereby foster a continual learning process.

Thus, simply fostering student curiosity is not sufficient without also fostering engagements between students and teachers on knowing in the context of the scientific practices which both parties engage in. This is in line with Mascolo (2009), who argues

that providing the role of primary actor on either teacher or students in higher education learning is a dead-end, as both teachers and students must participate to enact a learning process.

For instance, students make several claims about knowledge and learning in the blog accounts that would likely benefit from more scrutiny and discussion about epistemology. Likewise, students make several claims about learning and knowing in terms of field excursions, which challenges fundamental assumptions about biology, and was made increasingly valuable on the basis of students' discussions with teachers and peers on scientific methods. This occurred both in work placement settings and in subsequent activities (e.g., through students' blogging). Students gave accounts such as:

Not taking people on stage with me or take people with me home, but the focus from now on, after this project, will be directed towards those listening to me. (Music Performance student, Paper III, p. 17)

How should they take me seriously if I cannot even handle the fish? Well, to be able to help them throw the net and to collect fish and feed the fish and do these sorts of things. Well, it is a bit stupid to just stand and look like some idiot, you have to contribute. (Aqua Medicine student, Paper III, p. 19)

I have discovered that patience is an important factor while performing experiments, and often you have to do things again and again to get precise results (Biology student, Paper II, p. 8)

It is here worth noting the variety of participants that have engaged with students in workplace and field excursion practices, such as coworkers, supervisors, ship crew and others. The students' accounts in various ways emphasize their engagements with supervisors and coworkers as important to their understanding of their own learning in work. I also added a Music Performance student to exemplify the broader ways in which work and personal epistemologies intersect. Both in biology, Music Performance, and Teacher Education, the students' experiences in various ways involved students'

thinking of knowing, and their own role in enacting knowing as a practice. Apart from engaging students with the practices and knowing that constitute biology, their contextualization in engaging in biology also enables a view of biology beyond immediate campus teaching, populated by teachers with research careers. This personal epistemological advancement indicates further avenues, and work, in which biology can be employed. This is particularly evident in Paper II, in which biology and students' capacities are found to be useful in a wide variety of working situations.

Pedagogical and curricular challenges and implications

To examine broader pedagogical claims (i.e., the design and implementation of education) that may be brought forth on the basis of this thesis, I will return to the dual visions of science education presented in the introduction. As argued by Roberts and Bybee (2014), Vision one emphasized incremental procedures of science, and vision two emphasized the way in which scientific concepts interact with the world surrounding science. Both visions seem salient in the students' experiences. At first, the emphasis in Vision two on integration between scientific procedures and societal concerns seems pronounced in students' accounts of themselves as scientists, engaging in worthwhile practices. These included contributing to assuage societal needs and otherwise maintaining personal values in their work, and otherwise debating the role of biology in society. Personal epistemologies also refer to individuals' conception of knowing in and of itself, indicating esoteric conceptualizations of science, such as those found in Vision one are also contributing to the students' formation of themselves as scientists. This is seen at least through the enactment of scientific practices in field and work placements.

Further, engagement with various stakeholders was a prominent aspect of the work placements attended by students in Paper II. Here, one student found that considerations of hunters, local communities, and municipality policies were decisive in mitigating clashes between conservation and traffic interests. Another student worked more directly with a private enterprise that produced manure, in which both environmental concerns and the profitability of the company had to be negotiated. The student found that solely focusing on environmental concerns could come at the expense of the enterprise's ability to be financially viable. All of these experiences seemed novel

to the students and they contrasted them with their learning at campus where broader concerns seemed less salient.

These examples overlap with concerns of how (i.e., pedagogically) science and society should merge. In a somewhat radical proposition, Roth and Lee (2004) argue that science is best enacted as one among many aspects of societal developments, including stakeholders and other societal considerations. This assertion is based on a study of a particular societal challenge related to water distribution, in which science intersects with multiple dimensions of knowing brought forth by a conglomerate of scientists, local communities, and indigenous groups to tackle the problem of an insecure water supply. Roth and Lee argues that these considerations should be an integrated part of science education at the outset, thus promulgating a version of vision two of science education (D. A. Roberts & Bybee, 2014). These considerations seem to blend well with the notion of personal epistemologies, and the role of learning among science students. Given that working include engagement with varied stakeholders such as coworkers, local communities, and interest groups.

Course descriptions and educational researchers that focus on learning outcomes, often tend to emphasize independent enactment and dissemination as the top-tier of attainment (e.g., Caspersen, Smeby, & Olaf Aamodt, 2017; Krathwohl, 2002). However, focusing on practice and enactment as a mode of learning seems underdeveloped, given the students' accounts in all three papers regarding their mode of learning on campus. This is evidenced by their surprise at the complexities they encounter as they engage in working practices, both at workplaces and in field excursions. By focusing on enactment of biology teachers attend to contributions of context, the situated enactments of learning, and to the complexities of phenomena. All these points are illustrated in the studies in this thesis. For instance, in Paper I the situated enactment of biology serves to illustrate students' engagements with phenomena. This is also present in Papers II and III which also includes pressures from economic and other situations, such as workplace coworkers. Furthermore, these experiences seem to blend with the value in vision II in Roberts and Bybee's (2014) overview of science education pedagogies. That is, practice attends to engagement with content and the enactment of content in a complex world.

Given the opportunities for learning provided by affording students access to working practices, it is important to interject the limits of working as a pedagogical method. First, all the accounts offered here do not suggest that teachers play a superfluous role in students' learning in work. Rather, students' conceptions of personal epistemologies are gainfully developed when they consider contrasts between their learning by teachers and their learning in work (as found in Paper III). Second, students' work when enacting science are often subject to direct discussions with teachers as they enact science, as is the case in Paper I, or their discussions of their work placement learning with teachers and supervisors (Paper II and III). Third, campus settings also allow for specific practices in which students can participate that also constitute important learning.

To elaborate on this third point, it is relevant to bring up Ford's (2008) nuance on sociocultural learning theory's propensity to elevate practice in students' learning. He states that engaging students in the machinations (i.e., scientific practices) behind all scientific concepts is unfeasible. Rather, he argues:

For a grasp of practice, students should engage in authentic generation of scientific knowledge. For learning content, students should be supported to identify the dimensions of its information in terms of coordinated facts, methods, and values (p. 419).

Thus, engaging in scientific practice is crucial to learn how science is enacted. Though leaning the practice underlying all concepts proffered by curriculum is untenable, simply by the nature of time required to fully enact only a few scientific methods. However, given the findings in all three studies in this PhD, practice perspectives should not lead educators to teach practice in one instance and subject matter on the other. Rather, students engaged with scientific procedures, concepts, developed their values, and critique of science across their work. In essence, separating the two into different didactical procedures to be enacted at separate times makes little sense, provided students are afforded access to engage, and discuss their knowing with peers and teachers.

To conclude this section, I wish to draw attention to the analysis of concepts, procedures and dispositions made in Paper II and III. This way of analyzing made clearer the contributions of biology in particular contexts, and students' role of engaging biology content and method. Thus, those seeking to enact work placements or otherwise support students' enactment of practice in biology education should consider the role of concepts, procedures, and dispositions in their enactment. And further, the extent to which students reflect on their formation of personal epistemologies (though perhaps not in these terms) in working practices, the use of blogs is one among many ways to foster and assess these reflections (Paper II). In considering these contributions, and ways in which teachers and others may interact with these, educators can make use of the wide potential that exists in using practice in biology education.

Limitations and future work

Several methodological issues are discussed in the methods chapter. In this section, I wish to focus on particular approaches that could be relevant, to address some potential weaknesses and concurrently outline potential frameworks for further research.

The findings in this thesis are drawn from three specific aspects of practice in biology education. Immediately, it becomes apparent that there are several more aspects of practice in biology education to examine in order to engender more knowledge regarding students' learning in these situations. For instance, laboratory work, an important practice in biology, are continuously enacted at campus and in many work placements. A longer-term investigation of students as they engage in varied instances of lectures, fieldwork, and study group practices are also relevant to examine.

The investigation focuses on quite distinct practices, and all the student groups that are included attend different education programs. This reflects the broad concept biology is. As such, there is no single course or student group that would accurately reflect biology as a discipline (Hole et al., 2016). This also means that the findings are potentially experienced as particular to each individual group, for instance the specific experiences that Aqua Medicine students take part in, as students in a program who have specific expectations of future occupation and work. Nevertheless, all the included studies investigate practices that make use of biological knowing, and students who engage in learning biology.

Only one of the included papers report students' activities as they occur through direct observation. Given the thesis' focus on situated practices, it may seem problematic to substantiate findings on students' reports of their learning subsequent to the actual activities. This is somewhat remedied by the focus on personal epistemologies, which students can relate after-the-fact, and may be difficult to discern directly as students engage in practices (i.e., making students talk about their knowing as they are enacting practices). Nevertheless, further ethnographic-type investigations into students' activities, for instance of a laboratory heavy course, with subsequent interviews regarding their accounts of learning may be fruitful to consider in further investigations.

All studies are focused on Norwegians, though Paper I and II includes different nationalities. Although the analysis in various ways aimed to capture the contribution of individuals' lives to their participation in practice, nationality or ethnicity was not among those focuses. Further study on the role of travel, and the role of novel contexts such as expatriate stays, are therefore warranted (see for instance Goodenough, Rolfe, MacTavish, & Hart, 2014). As is a focus on different biology educations with different emphasis. In Norway (and Svalbard), cold weather, marine life, and sparse population are for instance important to the students' experiences, which could be contrasted or expanded with studies in other contexts.

Furthermore, different theoretical frameworks could have been relevant to apply to investigate students' learning. This includes frameworks from tradition one and tradition two as depicted in my literature review. For instance, there have been efforts to quantify accounts of personal epistemologies to understand workplace learning (Bauer, Festner, Gruber, Harteis, & Heid, 2004). To map trends among biology students these efforts would have been valuable. It could also be worthwhile to adopt an apprenticeship framework (e.g., Fuller & Unwin, 2003) as advanced in the wake of Lave and Wenger's (1991) work to more concertedly investigate the relationships between biology students, teachers, coworkers, and supervisors in workplaces as processes of enculturation as biologists through students' participation, and the extent to which it applies to science in contrast to other workplace situations (for a discussion on this in biology, see Davies, 2016). In the current framework, these relationships are examined

as part of the larger sociocultural practice in which students participate to create knowing. Finally, the emerging framework of authentic research in students' learning (Oberhauser & LeBuhn, 2012; Wald & Harland, 2017), while closely associated with scientific practice (Ford, 2008) is still quite valuable to investigate concretely the role of authentic research experiences to students' learning. This would hold for research-focused activities as depicted in the various papers in this PhD thesis.

Conclusion

To address the research question, I have proposed some theorizing about students' engagement with knowing in working practices. I have argued that analysis of different contributions of learning is valuable to depict students' learning, and that designating one aspect of learning to one particular circumstance (such as working practices) is insufficient. This also seems to hold true in multiple work placement programs as shown in Paper III. Students consider their own approach to learning, and how their enactment of multiple expressions of knowing is facilitated in particular ways in working circumstances.

Furthermore, there are important similarities between work in a field excursion and work in work placements, as well as important distinguishing characteristics. All of these are important for consideration, and one is not promoted here as a substitute for the other. Rather, analysis of students' accounts of knowing as they have enacted them in practice, yields important insight into how their experiences intersect with students' formation as biologists. Whether it comes to the design of their research, the actual implementation of procedures, their consideration of their own role as biologists, and the role of biology content in working life.

The findings reveal conceptions of knowing that are relevant to explain both pedagogical affordances in work, and the practice of science as students engage in research in their practices. Overall, pedagogical structure, dispositions, and research approaches seem to emerge as the three most salient themes for educators and researchers to consider in investigating and developing biology students' engagement with workplace practices. That is, reasonable facilitation of biology activities that engage with research procedures, phenomena, and societal developments in which students can engage with teachers, work supervisors and among themselves. As they engage with these practices, students should be encouraged to consider their own sensibilities and dispositions in enacting biology, and how their overall approach to knowing informs their approach to their work.

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Papers

Paper I

Working and Learning in a Field Excursion

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ABSTRACT

This study aimed to discern sociocultural processes through which students learn in field excursions. To achieve this aim, short-term ethnographic techniques were employed to examine how undergraduate students work and enact knowledge (or knowing) during a specific field excursion in biology. The students participated in a working practice that employed research methods and came to engage with various biological phenomena over the course of their work. A three-level analysis of the students' experiences focused on three processes that emerged: participatory appropriation, guided participation, and apprenticeship. These processes derive from advances in practice-oriented theories of knowing. Through their work in the field, the students were able to enact science autonomously; they engaged with peers and teachers in specific ways and developed new understandings about research and epistemology founded on their experiences in the field. Further discussion about the use of "practice" and "work" as analytical concepts in science education is also included.

INTRODUCTION

In several empirical disciplines, students, teachers, and researchers travel out into the field to engage with real-life phenomena, gather data, and otherwise enact science. Field excursions are often lauded as crucial learning experiences by students and teachers, despite the relatively high costs of this pedagogical approach (Boyle *et al.*, 2007; Goulder *et al.*, 2013; Harland *et al.*, 2006). In the past few decades, a large body of literature has accumulated that examines individuals' emergent knowing as they engage with working practices. In conjunction with this, several theoretical contributions have argued for an increasingly advanced distinction of knowledge dimensions, which lends credence to pedagogies that afford students (and others) with access to learning by working in varied circumstances (Duguid, 2005; Fuller *et al.*, 2005; Kennedy *et al.*, 2015; Nicolini, 2012; Polanyi, 1966). However, such perspectives have not yet been applied to investigate field excursions in tertiary-level biology training or similar empirical disciplines, despite the fact that field excursions resemble work, with an emphasis on enacting knowledge and laboring together to create knowledge (Billett, 2004). The emphasis on work is important to note in contrast to advances in understandings of museum or science center learning. Here, context and personal dimensions are emphasized as important analytical contributions (Rennie and Johnston, 2004), though there is less emphasis on the students' enactments of science practices to understand their learning. In addition, adults act with greater agency and can contribute substantially to knowledge production in their activities, which increases the need for a specific examination into tertiary education.

In work, individuals move out into workplaces, which consist of practices nested within a culture, dependent on the specific circumstances in every given organization (Gherardi, 2009). Similarly, one of the main characteristics of field-based learning is the actual movement of students into new contexts. It is therefore appropriate to consider a "situated" (or sociocultural) conception of knowledge and learning. This term is perhaps best known in Lave and Wenger's (1991) work; they discern learning in terms of individuals' "situatedness" in working communities. These are working

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communities into which individuals gradually integrate by employing tools, vernacular, and other practices inherent in the community in which they are participating.

King and Ginns (2015) have shown how situated knowing is a crucial affordance in middle school students' field excursion experiences. The authors found that students' application of context helps them to engage with scientific concepts and aid teachers in their pacing and facilitation of a more scientifically driven pedagogy (e.g., to question, discover, and otherwise engage with real-life phenomena). Roth's (2005) work on scientists' classifications displays how scientists develop their working knowledge through situated procedural tasks. These procedures are in reality important decisions with scientific ramifications. One example is species taxonomy, in which scientists work as best they can to advance transparent and well-founded knowledge through working with available materials, even though the researchers' situatedness and personal knowledge (i.e., the scientists' life history and other surrounding circumstances that are hard to convey in text) certainly affect, or even steer, this work (Polanyi, 1962).

The theoretical contributions noted above do not clearly define the pedagogical value of field excursions in higher education, though the sociocultural conceptions of learning suggest that field excursions' situated and material affordance can manifest itself as tacit knowing, which means that important learning is not easily discernible through verbal means (Strati, 2003). The students work with science in field circumstances, they enact scientific culture, and develop situated capabilities. Thus, mind and context work as a unit, or as described by Wertsch (1991): "The sociocultural approach to mind begins with the assumption that action is mediated and that it cannot be separated from the milieu in which it is carried out" (p. 18).

The present paper is a contribution to the field of biology education research and specifically a response to calls for increased knowledge about the role of field-based pedagogies in biology education (Singer *et al.*, 2013). It uses sociocultural learning theory as a lens to examine particular aspects of students' learning during a specific field excursion. Practice-oriented theories of knowledge and knowing emphasize the legitimacy of work in individuals' learning. In the current investigation, these conceptions are employed to investigate students' work performed in relation to science education. Although the investigation is centered on biology education, the findings and methodology can be useful to consider in other disciplines that employ field excursions in their training.

The research question that the investigation aims to address is: How does the students' engagement with fieldwork practices influence their development of biological knowing? The use of the term "knowing" when referring to the students' development of knowledge, new conceptions, and fresh ways of thinking (i.e., learning) indicates a focus on the emergence of the students' tacit, situated, and conceptual capacities. These capacities consist of understanding how to make use of scientific tools, knowing, and practices (i.e., knowing *how* to enact them) and expanding knowing of concepts and propositional knowledge (i.e., knowing *that*; Duguid, 2005). The phrase "engagement with fieldwork practices" connotes the sociocultural activity through which the students come into contact with, work, and enact scientific knowledge (i.e., biology).

The present work builds on ethnographies of work and learning (e.g., Lave, 1988; Lave and Wenger, 1991) and scientific culture (Latour, 1987; Knorr Cetina, 1999; Roth and Bowen, 1999). These works have documented various practices (of knowing) among scientists in laboratories and otherwise in their everyday life, but they have not focused on students' situated learning in fieldwork especially and sociocultural learning theory in general. Lave (1996) has highlighted how learning emerges as individuals access new experiences, that is, engage with practices. Practices pertain to patterns in individuals' behavior; they are often routine and ingrained in culture. Culture pertains to symbols, artifacts, and institutions, whereas practices refers to the enactment, the activity, which constitutes work and learning. In this case, the practice of enacting of science (using knowledge, phenomena, and methods prevalent in biology) in a field excursion. It is important to distinguish between individuals' engagement with *practice*, the *culture* in which they are a part of, and the *community* by which practices are enacted. Often, empirical data are mostly concerned with practices, because they are more easily discerned, and from these data, broader understandings are inferred. In this conception, culture and knowledge are constituted by the practices of its members (Gherardi, 2012).

Short-term ethnographic techniques were employed to investigate fieldwork as a cultural practice (Pink and Morgan, 2013). Ethnographic methods excel in uncovering and documenting routines, practices, and other patterns of human behavior—in this case, students' activity in a specific, limited circumstance. The present investigation was performed through direct participation; the author was embedded in a 9-day high-intensity field excursion to gather observations. These observations were later structured and further developed in interviews to enable a triangular approach to develop the observation findings.

CONTEXT

The field excursion took place over 9 days during early autumn on Svalbard, a sparsely populated archipelago in the high Arctic where permanent habitation is sustained by the mining industry and a university center. Given the ease with which researchers can access high Arctic conditions, and Svalbard's location between the permanent ice sheet and receding ice, the archipelago is subject to high research activity in diverse scientific disciplines (for an overview, see the Svalbard Science Forum, n.d.).

The Students, Teachers, and Ship

The excursion included both marine and terrestrial biology content. Lodging was provided on a ship, which was moored along the coast to enable sampling, outdoor lectures, and observations at different sites. The ship typically sailed during the night to new sites. All students had shared cabins and access to common rooms, the bridge, and a mess deck.

Fifteen students from Europe and North America, aged 20 to 25, all of whom consented to be part of this study, participated in the field excursion. All teaching (and therefore, all collected material) was conducted in English; most students had a different native tongue but were proficient in English (i.e., all could carry out a discussion on the subject matter). The field trip was part of a bachelor's-level, single-semester, course. The students had completed at least two semesters of tertiary-level natural

science education before enrollment, one semester of which had to consist of biology subjects. The field trip occurred at the beginning of the course, with 1 week of course work before the trip. The students had not encountered one another before the course.

Three experienced tertiary-level biology teachers led the field trip. These teachers have conducted research and taught extensively in the area previously. Binoculars were freely available and much used, allowing the students to investigate birds, cetaceans, and the topography during their free time on ship. Both students and teachers often used the bridge and the open deck to make these observations. They were able to ask the captain and first mate questions about the ship and the local area. In the evenings, the students planned future sampling activities, handled collected samples, and digitized data.

Activities during the Field Trip

The field trip was a component of a larger course, of which the articulated learning outcomes included the ability to undertake sampling, the ability to understand key characteristics of the Arctic flora and fauna, and the planning and conducting of a research project based on data collected during the field excursion. The teachers expressed an expectation that the field trip would make an important contribution toward developing these capabilities.

The students were divided into four groups, and each group's project comprised research methodology and dissemination. Each project had specific aims that were developed by its student group. The aims involved data gathering, such as mapping the occurrence of species and environmental variables in various habitats, for example, soil composition, humidity, temperature, and vegetation prevalence. During the trip, the students collected samples and other data for subsequent laboratory analyses on campus. The projects were completed and assessed by dissemination through oral presentations and reports; an accepted report (graded as pass/fail) was required for the students to be admitted to a graded course exam.

Each group's research goals and collection methods were organized and planned by the students, although the teachers authorized major decisions, such as where the ship was to be moored each day, and gave input on relevant sites for sampling. Hence, the students autonomously planned much of the field activity on land and instigated several field activities, most of which were discussed with teachers and fellow students.

The teachers planned visits to sites that were deemed interesting in a biological, cultural, and historical sense. These included visits to bird cliffs, glacial moraines, and other sites to investigate associated fauna and flora. Overall, the teachers' principal concern was the successful planning and completion of the students' research projects, which would also contribute to the students' knowing about and handling of Arctic flora and fauna (i.e., research and field skills). The teachers frequently talked to the students about occurring phenomena as the class moved from one area to another throughout the field trip; the close proximity between students and teachers on the ship afforded many opportunities for such encounters.

METHODS

The data were collected through semiparticipatory observation during the field excursion and through two group interviews

that were conducted 2 days after the excursion. Thus, the investigation employed a triangulation procedure wherein the interviews validated the observations. Every evening during the field excursion, the notes from the day in the field were compiled into a document containing information about observations and subsections with reflections about what the observed activities signified in terms of expressions of knowledge-building practices. Notes were gathered during the onshore components of the course and audio recordings were gathered once the students were stationary for long periods of time, for instance when working with sampling plots. Photographs were also taken throughout. For instance, the students' particular work with gathering samples using frames was examined through 1) direct observation of the students' actions; 2) listening to their conversations; 3) photographing their actions; 4) asking the students to narrate their handling of the material as it occurred; 5) asking the students about their work directly subsequent to it; 6) asking the teachers about the students' work; and 7) interviewing the students about their experience subsequent to the field excursion.

The interviews comprised two semistructured group interviews with seven students in each session; each session lasted approximately 1 hour. One student was unable to join the interview. The interviews were audio-recorded and later transcribed. The aim of the group interviews was to facilitate students' comments on the observed activities in the field. The interview guide was created through consultation with subject teachers to ascertain that the themes would make sense to the students as intended. The teachers also deemed that the students would be at ease with discussing their individual conceptions about their activities in the field, even in cases in which their conceptions were contradictory. The same interview guide was used for both groups. The interview was structured to facilitate general discussions about field-based learning and about concrete experiences in the field and therefore functioned as a validation and expansion of observational findings (Creswell and Miller, 2000). The interview data were transcribed verbatim. Names are pseudonyms in all excerpts. Sounds without distinguishable meaning are not included in the excerpts to make the reading clearer (recommended by Silverman, 2013).

It is worth noting that the interview process presumably had an effect on the students' attainment of learning from the course. In essence, the act of interviewing the students might trigger reflective learning processes, thus the research method approaches what Angrosino (2005) holds to be interactive; the research method has an impact on the participants. The students were informed at the outset of the study that no information would have an impact on their grades or course assessments.

Analysis

Both observations and interviews discerned working practices in which the students participated. Practices that the students indicated were of particular interest or that seemed to be decisive learning experiences for the students (e.g., occurrences of students talking about the novelty of the experience or instances the students themselves highlighted to be important learning) were developed further with thick descriptions. For instance, recordings of student utterances and context documentation were employed to make better sense of the material (Watson, 2012). The analytic focus was to identify knowing as it emerged

TABLE 1. Example excerpt of data compilation and analysis^a

Time and observation	Interview questions	Analysis (description of practices)
13:48: Difficulty in finding a new area. Some discussion. Observation/recording of plant group led by Stein (Jen, Alice, Karin, and Grant)	Have you worked with sampling in this way before?	John talks about how they determined different items in the frame through discussion. They would compare their findings and discuss how they came to one estimate of cover as opposed to another and then make a decision based on a common understanding of the subject matter.
Group members display gaps in measuring temperature and identifying feces	Was this different in any way from previous experiences?	
13:51: Discussion. What sort of feces are these?	What did you think of your sampling as a method?	
Discussion about whether they are from a fox or a ptarmigan.		

^aThe example shows how observations consisting of note taking and other materials translated into interview questions. The resulting transcript was then analyzed descriptively, as shown in the “Analysis” column.

through students’ engagement with and enactment of field-based practices, that is, their sociocultural learning activities. This was further founded on Polanyi’s (1962) notion that individuals’ situated engagement with practices is a decisive component to discern (personal) knowing. The data were categorized by division into meaningful subparts of instances that examined scientific activities as they were observed and the students’ comments on these instances (Silverman, 2011).

The initial ordering of subparts commenced at the very outset. As in other investigations using ethnographic methods, the act of observing and reflecting over the course of the data gathering is a crucial part of the analysis (Hammersley and Atkinson, 2007). Several instances were striking as being particular, useful, and salient experiences that pertained to the students’ learning trajectories. As recommended when employing short-term ethnographic techniques (Pink and Morgan, 2013), findings were continuously discussed with peers and preliminarily analyzed with theoretical framing on-site; I shared thoughts on the material with the on-site teachers and external researchers to get feedback on the initial findings and the general theoretical framing. High-intensity implementation of theoretical perspectives is recommended when there is limited time available to gather data (Pink and Morgan, 2013). Initial findings highlighted, first, that salient knowing-in-practice consisted of students’ participatory processes, particularly those connected to group work during sampling (e.g., how to enact research procedures in the face of unforeseen events); and second, that there was value in the direct observation and tactile interaction with several basic, though foundational, biological phenomena (e.g., the smell of walrus permeating the beach and observing death when predator meets its prey). To advance these findings, probing questions (e.g., “Tell me more about the collaboration with your peers when working with sampling”; “Tell me about your thoughts concerning the observation of the skua that attacked the ptarmigan”) were posed to the students in the group interviews.

Initially, it was clear that sociocultural processes were facilitated by students’ engagement with phenomena, their participatory, group processes, and their cultural integration into the role of a biological scientist, all of which is well understood in sociocultural theory. They also engaged with materiality through personal engagement with phenomena (e.g., by observing, touching, and otherwise deriving biological knowledge from field materials). The initial analysis made use of descriptions of the materials. The first analysis is exemplified in

Table 1. After the first analysis, it became apparent that, in order to account for the activities of individuals as they come to engage in participation in groups and in communities, it is necessary to adopt a comprehensive understanding about learning in these instances. Rogoff’s (1995) three-pronged analysis of sociocultural learning shows how analysis can treat different circumstances in different units. She dubs these layers “participatory appropriation,” “guided participation,” and “apprenticeship.” These are concepts that have profound cognitive and cultural ramifications, as Rogoff holds that the three concepts cannot be understood separately, though they can work as analytic units. Rogoff’s model is an underappreciated iteration that attempts to account for sociocultural learning and includes analysis of individuals’ knowing. Therefore, this analysis responds to a pervasive critique of sociocultural learning theory: that it fails to consider individuals’ subjectivity, dispositions, and will to participate in practices (e.g., Billett, 2007; Mason, 2007; Sfar, 1998).

The entire body of material, consisting of both interviews, observation notes, photographs, and audio recorded in the field, was analyzed by employing Rogoff’s (1995) overview of sociocultural learning. This analysis was performed with Nvivo; the software was employed to organize and give an overview of the material. Different iterations of data (e.g., interviews and observations) could pertain to the same theoretical dimension.

Findings

The students’ sociocultural activities are discerned according to Rogoff’s (1995) three dimensions of learning. This division is analytical, though all aspects co-occur in different activities, as continuously emphasized in Rogoff’s discussion of the three dimensions. For instance, students working in plots enact apprenticeship, guided participation, and participatory appropriation processes, as will be presented in the following sections.

Biologists Discussing Rocks: Guided Participation

Guided participation is held by Rogoff to be an “interpersonal process in which people manage their own and others’ roles, and structure situations (whether by facilitating or limiting access) in which they observe and participate in cultural activities” (1995, p. 147). Participation is often the hallmark term of sociocultural theory, and learning is discerned by examining the procedures students use when participating in an activity (e.g., Roth and Lee, 2004).

Students' participation in enacting a specific aim (i.e., conducting their research projects) was a prevalent iteration of the students' practices. Specifically, this dimension emerged in how disparity in the students' understanding resulted (seemingly) in lower-quality data and unclear characteristics of samples. The students therefore identified the need for a cohesive understanding of the subject matter (i.e., sample collection) that was discussed and developed collectively. Further, the students reached this cohesive understanding through communication about conceptions in the group. This interaction, wherein the students sought other students' opinion about gathering samples, was observed frequently during the field course. Students read up on methods and then frequently took the role of experts in their particular data-gathering sessions.

The ship arrived at a new location every morning. Here, the students and teachers were set ashore and walked inland to predetermined sites considered suitable for the sampling of plants, soil, and vertebrates. The student group whose samples were to be collected organized the rest of the students into groups and marked sampling sites with wooden frames. Each framed plot involved investigation of plants, soil, fungi, and other environmental factors. The prevalence of species was used to assess the context of a specific site (e.g., humidity, soil temperature, and light availability). The determination of samples in the field sparked several discussions about what actually constituted "soil" or on the prevalence of a species and so on. The group members often found that their subjective assessments varied wildly. One student might identify soil to cover 70% of the frame, while another might identify 70% to be sand. Students also discussed plant identification and how the wooden frames should be placed to give an accurate

description of the area (e.g., "snow-bed slopes" and "flat land"). Again, students found that no incontrovertible solution could be found, leaving the students to make decisions as best they could on-site.

The preceding descriptive summary is based on observations of the students' work during the field cruise. The students created the necessary data sheets on campus before going into the field to perform data sampling. This caused a disparity between the design and its implementation in the field. Students quickly realized that certain indicators, for example, percentage of moss in the plots, were exceedingly difficult (i.e., time-consuming) to measure and thus affected the number of plots that could be investigated. Time and efficiency were thus found to play an important role in data collection, and more so in Arctic conditions, where weather and safety remain an issue. Further, species identification emerged as a skill that requires specific training to assess plots precisely, and the students instructed one another on helpful characteristics to advance the process. They found that the ability to accurately describe a plant on campus does not guarantee taxonomic ability in the field, where plants are frequently immature or damaged.

The collaborative activities in the field demonstrated how the students discuss different aspects of data sampling in groups (see Figure 1). Throughout the sampling of soil crust, the students displayed an ambiguous perception about the characteristics of gravel, soil, dirt, and sand. The students, after identifying this ambiguity, found that they needed to reach a common understanding to enable efficient and systematic samples. One student explained this collaborative process as follows.



FIGURE 1. Students worked extensively with frames to map the environment. This task proved more challenging than the students had envisioned before the field excursion. The illustration shows students mapping percentage coverage of willow (*Salix*), saxifraga, mosses, and lichen. The students developed procedures to determine coverage using what they found to be acceptable error margins. The students' efforts were also hampered by the relatively small size of high Arctic flora, which made several plants difficult to detect.

Grant: Yeah, and also that you make an agreement that you, if there is something that there is a disagreement about what is soil, what is stone cause we had a place with a lot of like gravel, small stones. And then it was like, just felt like just most important thing that every group did the same. Then they just went around and "okay when the stone is smaller than this one, it is soil" so as [we] had like agreement.

These are guided participation efforts, wherein individuals work together toward a joint goal, whether tacit or explicit (Billett, 2004). In this case, it served to develop the general learning outcomes of the course (e.g., to develop research capabilities) and the students' dispositions toward participating in resolving a scientific problem. The students developed their procedures continuously; in one instance, students employed an average of the different students' assessments: one student would surmise a frame to consist of 30% gravel, while another surmised 70%, giving an average of 50%. While no fully satisfactory method was established,

the students continuously attempted to increase the precision of their assessments and identified problems with their procedures. For example, the large disparity between 30 and 70% might indicate that they used drastically different procedures to observe the gravel itself.

Epistemology and Death: Participatory Appropriation

The second of Rogoff's (1995) analytical concepts, individuals' participatory appropriation, is concerned with the following: "through participation, people change and in the process become prepared to engage in subsequent similar activities. By engaging in an activity, participating in its meaning, people necessarily make ongoing contributions" (p. 150). Individuals can participate in activity, though they can also choose to disassociate (Hodges, 1998). This is a negotiation in which individuals discern their own stance toward participation. In this case, participatory appropriation applies to both how biology practices accommodate students' dispositions and understandings and whether biology is a valuable pursuit for students, both to create new knowledge (i.e., epistemologically) and as a personal trajectory (e.g., a pursuit of value for their education).

In the interviews, the students were asked to detail diverse learning experiences concerning both field skills and phenomena they encountered (see Figure 2), such as glaciers and how the surrounding geography and biota can be shaped by glacial influence. The students frequently referred to learning experiences as "a process of remembering." The students seemed to employ the term interchangeably with "learning." Others have shown how researchers are better served by not accepting terms used in interviews at face value, but rather by evaluating the contents of interviewees' utterances (Marton and Säljö, 2005). Specifically, different settings were of varying quality in terms of enabling the students' remembering. The students explained this in the following ways:



FIGURE 2. Observation of bird cliffs was made possible with access by ship. The green coverage below the cliffs to the left marked the presence of birds (i.e., there is guano that encourages plants). This was a striking contrast, as nearly all landscape observed from the ship was brown, black, or gray.

I: Can you tell me more about what helps you "remember"?

Rob: Well, just that you are seeing it for yourself and you don't really know what it is, but you are trying to explain it by using things to learn [...]

I: What about the senses?

Kim: I think it was the...

Rob: Yeah, yeah, like the shore.

Kim: Yeah, exactly.

Rob: And you could smell it.

Kim: It gives you much better memory if you have, if you have seen it, and you have that visual memory in your mind rather than just trying to remember words.

In this instance, one student iterated how the "visual" aspect of field-based education makes remembering concepts easier. This conception associates learning with sensory experience and variety in sensory experience with aiding development and learning; this certainly alludes to the difference between observing an illustration and observing phenomena in real time, due to the level of abstraction. Further, the students highlighted the visual sensory aspect, because learning is perceived by the students to be dominated by the memorization of facts and concepts during lectures and other campus-based education practices. The students emphasized the difference in learning in the field excursion, especially the ability to observe phenomena as they occur:

Mira: Yeah, you can sit inside and learn all the theory though it is truth and that is what is happening outside. I think that for me personally it is, you are learning it in a totally different way when you are out, and I just think it's a lot more easy to get "in" and to remember when you are out there where it is actually happening, and you can see it and relate to what you see and learn.

The above iteration shows that Mira perceives her learning experience to be different in field-based contexts as opposed to campus-based contexts. The statement "it's a lot more easy to get 'in' and to remember" is an abstract statement and indicates that Mira has some difficulty articulating what constitutes the perceived difference. However, Mira's iterations about seeing what is "actually" happening implies that previous knowing about realities, or ontologies, might be insufficient or perhaps imprecise.

It seems that the students engaged with their surroundings in a manner that led them to nuance and develop their understanding of science education. The students made several remarks about the role of scientific method in biology. For instance, when asked about the value of field excursions in biology education, one student mentioned: "The fear is that biology might drown into laboratory work. Because there is [...] clearly a notion going towards much more laboratory work,

much more microbiology and molecular biology.” These are sentiments about epistemologies, in which, on the one hand, field-based activity facilitates situated knowing, while on the other hand, reductionist approaches, represented (perhaps unfairly) by microbiology and molecular biology, employ field-based skills and knowing to a lesser degree.

These conceptions of research method also underpin new conceptions of biological phenomena, with field experiences inducing an adjustment and further development of knowing. In particular, students previously understood that predators maim, kill, and eat their prey, but knowing about these phenomena progresses subsequent to engaging with such events.

One student mentioned how nature documentaries display animals killing each other. However, watching this occur in the field excursion was perceived as different and novel. When the students explained these experiences, they emphasized the uncertainty of the occurrences. Death could or could not occur, without human authorization or intervention. Thus, the students’ conceptual understanding of death as ceasing to live had not changed, though this knowing seems to have generated increased connotations about the pain, sounds, and other inarticulate aspects of a predator eating its prey. Beyond any individual organism dying, comes the role death plays in biological systems and in evolution, that is, how a change in adaption can mean survival or becoming food for predators. A fate that can occur at any point:

Grant: Also in a sort of heartless way. Like this made me realize that you can’t be like, “oh I want it to survive because it’s cute” cause everything needs to feed. Like, it’s not like you need to keep everything cute alive cause, then all the stuff that eats it dies [laughs].

Kim: Or a cute little thing kills all the other cute little things.

The above statements from two students indicate their field experiences with death. The indication is that cuteness is not a basis for survival. This is a further revelation about the natural world being subject to enormous pressures at several points, all of which fuel evolution. Thus, the students gain access to a profound body of knowing that advances their thinking about biological systems.

Keeping Guns Loaded: Apprenticeship

The third analytic unit of Rogoff’s (1995) three-pronged understanding of sociocultural activity is apprenticeship. “Apprenticeship” is a term perhaps most commonly associated with work and working communities. Lave and Wenger’s (1991) notion of legitimate peripheral participation and situated learning was developed as a variant of the apprentice metaphor. Lave and Wenger and Rogoff are careful to distinguish their theorizing of apprenticeship from a master/novice conception. They emphasize that different members of a working community contribute with different capacities, so that an individual’s development in an apprentice process is not simply linear, but dynamic. One can imagine that, in a fieldwork community, there are students with specific expertise who contribute in other students’ activities and teachers with varied interests and capacities who engage and contribute with varied levels of intensity.

Rogoff (1995) warns that the apprenticeship aspect of academic life is difficult to analyze, given that researchers themselves are embedded inside this culture. She defines apprentice-

ship as the following: “it focuses on a system of interpersonal involvements and arrangements in which people engage in culturally organized activity in which apprentices become more responsible participants” (1995, p. 143). This conception of apprenticeship thus closely resembles Lave and Wenger’s notion, in which apprenticeship learning is understood as increased levels of participation. These increased levels of participation pertain to individuals’ ability to undertake and change practices within the community that they are engaging in (Gherardi, 2009). It is therefore worth noticing that students emphasized epistemology and research method in general during their interviews. Their tutoring of one another during the sampling with wooden frames and their increased levels of autonomous research work may be construed as part of an apprenticeship process. This seems to strengthen Rogoff’s (1995) argument that apprenticeship, guided participation, and participatory appropriation are processes, wherein one process cannot be fully comprehended without also examining the other two. Here, another contribution is the teachers’ facilitation of methods, vocabulary, and dispositions (i.e., appropriate values to bring to working with biology) to the students’ experience. An example of the communal aspect of the field excursion, that which Rogoff has termed apprenticeship, is given here:

The teachers decided several of the stops on the cruise, one of which was the walrus beach, this is a location where walruses remain over long periods of time to find food, breed, and where polar bears attempt to attack and eat them. The location’s most striking feature was the permeating smell: It was putrid and sweet, and mixed with the salty smell of the ocean to create a smell I have never smelled before. The teachers smiled, and told us about the origin of the smell: the walruses’ feces. There were no walruses there at this time of year, though the teachers, in addition to the mirth about the smell, were quick to organize students because the presence of walrus smell also served to attract polar bears. One student with a gun had to be positioned at the start and another at the end of the column of students as we moved around the area.

The students were all trained to handle guns before being allowed on the cruise, to guard against polar bears. In the above excerpt, the teachers act both as facilitators for access to novel areas with interesting characteristics and as models for the proper way to behave: in some areas, polar bears can be more prevalent than in others. This was one such area. Working in an Arctic environment requires this sort of presence of mind and repeated assessments about potential dangers from both wildlife and weather. In some instances, weather and polar bear danger can interact, as low visibility (e.g., caused by fog or snowdrifts) can make for a very short warning interval before a polar bear appears.

The following excerpt displays a group’s exposition about the development from the planning phase on campus to how the field excursion turned out. Two students were concerned about the sampling process, while Mira seemed less concerned about the convoluted nature of sampling, as she had performed the procedure previously. This displays the dynamic relationships among the students; different students found themselves to have specific capacities and experiences beneficial to the group as they engaged with their work. The students took the initiative at different turns; as the following extract illustrates,

no one student assumed a permanent leadership position. Thus, the students' experiences show a dynamic apprenticeship as advanced by Rogoff (1995), wherein one student exhibits familiarity with a specific setting (i.e., a field excursion). As suggested by Fuller *et al.* (2005), participation in work is not a finite process, in which individuals develop in order to fully participate and then stop. Rather, all members of a practice undergo development and change as they progress in their work. Thus, while Mira conveyed familiarity with conducting fieldwork, she certainly stood to learn, as she would engage in fieldwork in the high Arctic for the first time.

Mira: I mean I have experience with fieldwork; I did it like three times. So I kind of [saw] that everything will be easy in the field because I know how fieldwork can work out, we just think about, "oh I want to test out this factor and this factor" and then you, it doesn't come out the way you want it to be, so I think that was really good [...]

Paula: I think like in the beginning it took some time to actually get to know how, what actually, what to do, but once that was done it was quite alright.

Lea: and then also be able to take things as they come on the cruise in the field.

Mira: Yeah, yeah, definitely.

Lea: Like to be able to collaborate about making a new decision. "Okay we need to do it in another way," "we could do it like this," "okay that will work."

DISCUSSION

Students Participating/Working as Scientists

The aim of this paper was to examine how students' work in a specific field excursion pertained to their learning of biology; this aim was formulated in the following research question: How does the students' engagement with fieldwork practices influence their development of biological knowing? Learning was examined as a sociocultural activity, that is, how it emerged through situated, participatory processes. This approach was argued to be appropriate, because field excursions by definition center around the movement of students into new circumstances in which they can engage in biological practices, circumstances that encompass both the physical environment (i.e., the walrus beach or bird cliffs) and interactions with other members of the field excursion (i.e., students and teachers).

This three-part analysis has put emphasis on how individuals (i.e., participatory appropriation), participation processes (i.e., guided participation), and institutions/community (i.e., apprenticeship) interact to create learning circumstances. All of these aspects are present in the students' experiences, meaning that an investigation of the students' learning in a field excursion should examine all three aspects of the students' experience to capture important learning activities. In her conceptualization of the tree dimensions, Rogoff (1995) put emphasis on the individual dimension, participatory appropriation, as this was a more novel sociocultural concept. In the present study, the students' discussion of their dispositions (i.e., values toward working with and utilizing specific sets of knowledge), their development of their scientific understanding, and their participation through working in a science project were particularly salient aspects of their exper-

ience. Therefore, in correspondence to Rogoff's (1995) emphasis on participatory appropriation, the present study discusses these personal aspects of the sociocultural activity in the field excursion. This manifests as personal knowing, in which individuals advance their knowing as they enact biology; they sense, they work, and they engage the convoluted realities of practice.

According to Polanyi (1962), the assessment of a performance is a constant source of contention, particularly among those proficient in a particular discipline, whom one would think had a well-defined parameter by which to determine excellence. In terms of biological knowing, the quality of data collection is determined by some more or less transparent measures, such as statistical robustness of the research design and cohesiveness to established theoretical concepts. Method literature in biology (as in other disciplines) consistently underlines the importance of disseminating these factors (see, for instance, Sokal and Rohlf, 1995). In contrast, as shown by the students' experiences, the quality of the data collection is determined by several situated practices: for example, choice of study design, organisms, and sites most appropriate for attaining the research aims. As experienced by the students as they attempted to conduct research, a biologist, like many other empirical researchers, also benefits from assessing the circumstances surrounding the *context* of the sample, that is, location, weather, and common cohabiting species. These are appraisals that are performed through developing diverse dimensions of knowing, not least tacit knowing. In addition, subsequent to data collection, knowing about and familiarity with these circumstances may help biologists interpret results. All of these points were salient in the students' accounts and in the observation of the students' activities. Their initial planning was altered as they came to grips with the materials they were supposed to investigate.

The students' interpretations of the available materials were developed in a process in which their experiences were construed through participation; an agreed-upon procedure was established, consistently challenged, and re-established. This was particularly clear in their work on sampling plots, wherein basic concepts such as what constitutes a stone versus sand were subject to change. The students' engagement with these challenges indicate that repeated discussions led them to appraise their own knowing, in particular concerning concepts they had engaged during course work such as properties of Arctic flora and bird cliffs. This knowing developed as the concepts were challenged and understood in the context of the field-based community, that is, a relationship evolved between sociocultural activity and conceptual learning (Kelly and Green, 1998).

In some aspects, the students' experiences seem to reflect Schön's (1987) proposed dichotomy between professionals' lucid planning of activity on the one hand and the more convoluted enactment of the activity on the other. In Schön's (1987) conception of learning, education is merely an ad hoc preparation for actual activity, which is only learned in situ, that is, through work. Increased learning is attained in direct confrontation and repeated interaction with the convoluted realities of practice. On this basis, it seems clear that a comprehensive characterization of biology learning in the field must include an analysis of tacit knowing. Here, it is also worth noticing that the students' experiences are also characterized by sensory experiences. This is in line with sociocultural theory, in which the material world plays a decisive role in activity (and in learning).

Smell, which was so important on the walrus beach, is one such example and is perhaps underappreciated in discussions of situated learning (see, e.g., Low, 2005).

In sum, the students' emergent knowing was constituted by experiences that were formed and developed through working with various practices and reflected upon individually and in concert with peers, teachers, and other coparticipants (Lave, 1997). As the students' narratives show, the students construed several of their experiences in relation to other phenomena with larger consequences. For instance, one student argued that natural sciences should include more than laboratory work, while others emphasized their emotional reaction to observing the real-time consequences of how killing and eating are parts of natural systems.

Teachers and Students Participating in a Joint Practice

Given that the field excursion examined here showed several important learning processes, some ramifications for teaching and learning will be discussed. Particularly, practice-oriented theories of learning have been criticized as inadequate in their efforts to examine education settings (e.g., Lave and Wenger, 1991), due to the difference between teacher and student practice (i.e., the teacher teaches, the students study the curriculum). Following this discussion, a sociocultural conceptualization of field-based learning is suggested (see Table 2).

The analysis suggests that the students pursue knowing on the basis of their individual dispositions rather than via a predetermined process; new knowing is approached based on prior personal experiences to make sense of the reality that students immediately construe (Polanyi, 1962). Thus, biology teachers can exploit field excursions to aid students' conceptual learning in this regard. Students are afforded with access to circumstances that are novel; they are also given access to and participate in genuine biology work. The students then negotiate their participation in these practices, based on their subjectivity and their exhilaration in the commencement of the work.

Teachers often describe their teaching as an activity separate from the students' activity of learning (Sunal *et al.*, 2001). In the case of field excursions, students and teachers are coparticipants in a joint activity, even though their roles are formally different. Teachers are more or less responsible for the facilitation and organization of fieldwork-related activities, and students are (expected to be) focused on carrying out whatever fieldwork activities the teacher has planned. However, during the enactment of the fieldwork, students and teachers coparticipate at several instances; they discover new materials, they investigate them, they observe phenomena, and they discuss

the work's significance. As Rogoff (1995) observes in her discussion on apprenticeship, new members to the active working community can engage dynamically. This means that teachers and students can aid one another's progress in science, though teachers certainly influence many of the activities (and therefore the learning) that takes place in a field excursion. Billett (2004) has proposed that participation is a salient metaphor to understand learning in work, because it necessitates examining both the way in which individuals work together and the foundation from which the individuals decide to engage in participation (i.e., their dispositions).

It is important here to interject that the participatory practice that manifests itself in a fieldwork setting is not strictly confined to the field. The participatory process arose on campus as students planned and developed their projects. Overall, the students' formation and identification of themselves as biologists derives from their construing of biology-related practices across their project-based work. Hence, fieldwork as a tacit learning process is not strictly a process that occurs by chance during noncampus activities. For instance, the students were active participants in their group research projects and became observers when teachers selected sites and led students to locales of which they had no previous knowledge.

Cox (2005) suggests that advances in organizational learning in modern institutions are characterized by increasingly detailed learning outcome descriptions and assessment. Indeed, the practices that arise in prolonged curricular activity are both steered by a teacher and planned according to learning outcomes. Field excursions certainly carry an element of both, but also provide engagement with practices more dependent on a joint enactment of language, tools, and other activities that constitute working in the field of biology.

The students' work in the field excursion represents an activity that aids personal integration of diverse expressions of knowing into a more cohesive conceptualization of biological science. This was achieved by the sampling and investigation of phenomena (death, bird cliffs, or the smell of walrus) as they occurred in the field. This development is similar to Knorr Cetina's (1999) accounts of knowing in scientific communities, where different cultures within disciplines build and develop scientific knowing and scientific methods through complex procedural and participatory practices to which the members of different sciences adhere. To enact these activities themselves, students must experience and mediate through interaction with peers, teachers, and others (Mascolo, 2009).

Brown and Duguid (1991) hold that learning in working practices is a function of tacit knowing as much as curricular or

TABLE 2. Sociocultural learning in field excursions

Expression	Associated knowing
Participatory appropriation	Advancing conceptions through observations and experiences Discerning how particular observations, (i.e., a bird of prey killing another bird) are parts of a greater phenomenon (i.e., natural selection) Expressing how their capacity to work in the field is relevant to enact science.
Guided participation	Coming to grips with common methods and approaches (i.e., practices) prevalent in a particular field, in this case biology Activity was directed in concert, to participate in biological fieldwork with associated knowing.
Apprenticeship	Self-identity as biologists, enacting biological practices in concert with teachers and fellow students Through extended interaction with teachers and peers, students increased their participation with practices.

articulated activity. Thus, it is significant that the findings presented here encompass diverse sets of knowing; these engagements are pronounced in field excursions, as students work comprehensively on practical tasks, research methods, and ways of thinking about biology—for instance, their observation of bird cliffs and autonomous enactment of a short-term research project. A field excursion is a learning *activity*, wherein the students have agency and an opportunity to construe their actions into a larger context, that is, their biological knowing—for instance, how sampling can translate into increased knowledge about the surrounding areas and the ecology present there. However, field excursions can also take the form of passive observation (Kent *et al.*, 1997). Such field excursions can be defined as classroom lectures taking place outdoors. This emphasizes the need to include students as participants who can enact practices themselves in field excursions, something that is difficult to do if the students are afforded no agency. Given this caveat, the identified sociocultural processes with associated expressions of knowing are summarized in Table 2.

CONCLUSION

Students were afforded access to extraordinary circumstances by being able to travel, work, and learn in high Arctic conditions. This certainly affected the development of knowing, but practices found in a specific case may not be immediately transferable to all university institutions with regular funding. The strength of short-term ethnographic research is the emphasis on documenting and further developing in-depth data points, with the aim of advancing theory development and, in this instance, biology teachers' thinking when they undertake field excursions.

With respect to the research question "How does the students' engagement with fieldwork practices influence their development of biological knowing?," the investigation shows that field excursion experiences can have an important impact on individuals' trajectories as cultivators of disciplinary knowing and can affect students' thinking about subsequent investigations, projects, and work. Through sociocultural analysis, various learning activities were discerned, and it is apparent that various aspects of situated knowing were prevalent in the students' experiences.

Further studies must be performed to determine the transfer of this knowing to different circumstances, though the post-field excursion interviews seems to point to dispositional and conceptual advances in the students' learning, especially in terms of stances toward epistemology and the role of fieldwork in science in general and biology in particular. To provide these affordances, students must enact science themselves. They must work and through their own agency construe their own role as biologists who contribute to new knowledge about the natural world.

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Paper II



STUDENT LEARNING, CHILDHOOD & VOICES | RESEARCH ARTICLE

Biology students at work: Using blogs to investigate personal epistemologies

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Abstract: This paper reports an investigation of biology students' discussion of knowing in work placements, as accounted in blogs. Twenty-two blogs, containing 78 individual entries, written in conjunction with a work placement course for students in a tertiary level biology program, have been analysed in the study (The blogs are publicly available here: <https://biopraksis.w.uib.no>). The aim of the paper is to increase understanding of how work placements shape biology students' personal epistemological trajectories. The analysis is performed by employing a theoretical lens that emphasizes the situated nature of knowing, as enacted in working practices. The blog accounts consist of the students' appraisal of their own learning and knowing in work placements, situated in biology undergraduate education. The investigation suggests that the students' personal epistemologies develop in an interplay with context and personal epistemologies to shape their trajectories toward biology knowing. These trajectories have been analysed in terms of their procedural, conceptual, and dispositional dimensions. The use of blogs as a data source is argued to be appropriate to analyse personal epistemologies. Other strengths and weaknesses of this design are discussed.

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All authors are involved in the Center of Excellence in Biology Education (bioCEED), in which developers from education science, biology, and other academic disciplines work together to evolve higher education pedagogies. One of the main aims of bioCEED is the integration of content knowledge, societal developments, and practical work in biology education.

PUBLIC INTEREST STATEMENT

Work placements are, as of yet, a sparsely implemented measure in tertiary biology education, with a large variety of potential work experiences in which biology students can partake. This is a salient contrast to professional education programs, such as medicine or teaching where all students attend specific workplaces in their education.

This study aimed to examine how work placement experiences intersect with biology students' personal epistemologies. We found several valuable procedures and concepts that students have engaged with, and which impacts their understanding of themselves and their values when engaging in work. We also propose a conceptual model that underlies the relationships between the contexts of work, knowing, and personal epistemologies. We urge researchers and educators to consider the model and our other findings when implementing work placements for biology students in tertiary education. As it outlines the diverse contributions to students' learning in work placements.

Subjects: Work-based Learning; Higher Education; Science Education

Keywords: science education; personal epistemologies; workplace learning; digital method; higher education

1. Introduction

This study addresses the following research question: *How do biology students describe their development of personal epistemologies in their work placement blogs?* Based on an analysis of biology students' blog accounts we propose a new conceptual model of biology students' development of personal epistemologies as a sociocultural concept. Particularly, as to how personal epistemologies pertain to workplace circumstances.

Work placements (i.e., placing tertiary students in workplaces during their organized education) are increasingly implemented as a legitimate educational provision in higher education (Costley, 2011; Kennedy, 2015). This increase is a likely effect of a higher number of students in higher education, thereby underpinning the need to secure employment for students after graduation, which has increased the need for measures to secure employment for students after graduation (Mok & Neubauer, 2016). Aside from the emphasis on employability, cultural (i.e., situated, relevant here as students engage with contexts in work) contributions for learning as they relate to students' situatedness into work placements should be examined (Loftus & Higgs, 2010).

The affordance of work placement training in biology education has so far received little attention. The few studies that have been carried out, have pointed to some possible benefits, such as increased skills training and preference among students for increased workplace integration (e.g., Parker & Morris, 2016; Scholz, Steiner, & Hansmann, 2004). To examine cultural contributions to learning, the emphasis is put on students' enactment of science as they participate in practices. This enactment can be captured through students' epistemological accounts. The role of epistemological development in work placements has a particular interest because students' epistemologies can be a crucial component of science education (Berland & Crucet, 2016; Collins, Brown, & Newman, 1989; Roth & Roychoudhury, 1994). It is generally believed that the advancement of epistemologies will precipitate students' independent scientific knowing (i.e., seek out and appropriately handle new knowledge without teacher supervision, see Deng, Chen, Tsai, & Chai, 2011). Epistemology refers to theoretical frameworks about the nature of knowledge, and individually held beliefs that derive from individual life histories. Individuals' thesis of epistemology are referred to as *personal epistemologies*, Hofer describes it as the following:

[Personal epistemology addresses students' thinking and beliefs about knowledge and knowing, and typically includes some or all of the following elements: beliefs about the definition of knowledge, how knowledge is constructed, how knowledge is evaluated, where knowledge resides, and how knowing occurs. (2001, p. 355)

This description is helpful to conceptualize the core of personal epistemologies, though it pertains especially to individual students' perspectives, and does not account for circumstances in which the students are situated as they develop their personal epistemologies. In the present study, we examine biology students' development of epistemologies in relation to their work placements. Thus, there is a need to expand available knowledge concerning students' enacted epistemologies in workplaces, particularly the manner in which workplace circumstances contributes to scientific (biological) knowing. Here, scientific knowing refers to the practices by which biologists develop available understandings about the world, this includes concepts and procedures that are continuously enacted and remade in practices by biologists (Kelly & Licona, 2018; Knorr Cetina, 1999; Kuhn, 2012). It is not limited to research Institutes, and applies to all enactment of knowing of the natural world in communities, workplaces, and otherwise in individuals' lives (Roth & Lee, 2004).

Workplaces are, among other things, characterized by the enacted practices of its members (Nicolini, 2012). Practices emerge through patterns of human behaviour, constituted of individuals enacting symbols, for instance through “instrumental, linguistic, theoretical, organizational, and many other frameworks” (Knorr Cetina, 1999, p. 10). Knowing is enacted through a practice of understanding (Chaiklin & Lave, 1996), that transcends traditional school-oriented learning metaphors, towards a situated conception of learning. Situated learning refers to knowing that emerges as individuals find themselves in new circumstance (Lave, 1997), when they come into contact with materials and practices which individuals might participate in. Roth (2003) has developed sociocultural theorizing in the sciences in particular by advancing that science should not be restricted to researchers’ labs, but an integrated facet of local communities. Based on this theorizing, situating students into workplaces, where they can participate in practices and enact science themselves, should be encouraged.

Based on a situated conception of science learning, personal epistemologies in work can be construed as they have been advanced by Billett (2009); to be inexorably linked to enacted, situated practices, that must be analysed through context (i.e., as a sociocultural practice). According to Billett, “personal epistemologies are seen as including how individuals’ ways of knowing and acting arise from their capacities, earlier experiences, and negotiations with the social and brute world across their life histories” (2009, p. 231). Billett provides an account of how individuals engage with knowing derived from their workplace experiences, with what seems to be a clear emphasis on individuals’ situatedness to conceptualize this process. Thus, Hofer’s (2001) conceptualization of personal epistemologies will here be amended to include an account for the situated practice in which individuals enact knowing. This precipitates an account for individuals’ subjectivity (i.e., their backgrounds, their dispositions, and their beliefs about their own stance in the practices for which their personal epistemology develops) as they participate in work.

Finally, by examining students’ blog accounts, we aim to expand on the available literature on ways in which to investigate digital experience (Pink et al., 2015). When properly structured, for instance by providing clear guidelines, blogs are found to be a useful avenue through which students can reflect on practices and their own learning (Jones & Ryan, 2014; Stoszowski & Collins, 2017). As such, they suit our purposes to examine students’ epistemologies in relation to their work placement experiences. Our aim is not to promote blogs as a particularly beneficial way in which to examine students’ accounts, but one among others that can be useful given appropriate structure and student contribution. As Hew and Cheung (2013) have found in their review, blogs as an educational measure seems to be more dependent on its particular pedagogical method rather than the digital nature of blogs specifically. Thus, we wish to contribute to available understandings of blogs and assessment through blogs.

2. Methods

2.1. Context and data source

A sociocultural analysis of personal epistemologies in work placements, requires the opportunity to follow actors in their daily routines. This requires access to events as they occur and repeat themselves in context (Eraut, 2004), and preferably narrated from the perspective of the participants. The biology students in work placements were geographically scattered, which made a participatory approach to data collection demanding. The solution in the present study was to build on students’ individual accounts from their everyday work practices, as they are presented in blog entries. The blogs were written as part of the students’ course assignment and were by teachers expected to promote student reflection. At the same time, the blog entries constitute the main material for assessment, that is, as part of the course evaluation. In research terms, the blog entries reflect the interaction between the students and their contexts as it proceeds in a situated practice. They are written alongside the work placement and specify students’ unfolding experiences and their developing views on their own participation and knowing.

Data collection based on internet resources has been advanced by several researchers who argue that practices can be discerned through digital media, documents, and other digital expressions of behaviour (e.g., Hine, 2000; Kozinets, 2015; Postill, 2016). That is, digital data is as legitimate as non-digital expressions, though gathered in a different format than traditional inquiry. In the present investigation, the work placement experiences occur regularly, over time, and in several locations (i.e., workplaces) simultaneously. Hence, the students' blogs allow for data collection of the specific and simultaneous instances that are relevant for the study. The blogs thus constitute a site for exploring the development of personal epistemologies, it is not a study of how these epistemologies are impacted by the digital (Markham, 2018).

2.1.1. Students

The 22 participating students (19 women and three men) were all enrolled in tertiary level biology education. The eschewed gender balance represents the over-representation of women in this particular course, a fact that also holds for biology in general. Gender was not analysed in the study. The majority of students had finished two semesters of tertiary level biology studies at the time they participated in the study. At this time, the students have also completed courses in philosophy, mathematics and chemistry. The participating students were aged 20–30 and were either enrolled in a Bachelor of Science or a Master of Science programme. All participating students were Norwegian nationals, except one student from North America. The blog entries are public accounts accessible through the internet. Students' active consent to participate in the study was secured through e-mail- and telephone correspondence, 22 of a total of 23 students agreed to participate. The procedure to obtain students' consent was determined in consultation with the Norwegian Centre for Research Data (NSD, <http://www.nsd.uib.no/nsd/english>).

2.1.2. Workplace course

The students attended a selective university course implemented every semester across 2015 and 2016 to provision work placements for biology students in a Norwegian University (the course development is detailed here, Velle, Hole, Førland, Simonelli, & Vandvik, 2017). The students were assigned a work placement by the course teachers based on a three-line application form. The course was assessed as pass/fail based on completion of both the workplace attendance and a report, which comprised the blogs, an oral presentation of the work placement, and a short reflection note. Workplace attendance was assessed by the work placement host, while the report was assessed by the course teachers.

2.1.3. Blogs

Blogs are public, often periodical, composite representations that can integrate expressions, such as written texts, pictures, and videos. Blogs, like journals, are often written concurrently, and seldom refer to a far-removed instance. Frequent use of photographs, hyperlinks and other expressions further emphasize the situated nature of blogs.

One strength of blogs as data sources is transparency, since readers can question and interrogate into claims made about the students' expositions (Snee, 2008). The students also narrate their experiences conscious that the entries are public. The data are self-reported which means that the students' perspective on experiences and participation are prioritised. However, the public nature of the blogs, which are easily discernible by work placement hosts and peers, can be expected to reflect an account which can be collectively accepted. The students' reports of their thinking and their activities are also substantiated by photographs, and short end-of-term presentations (which the researchers were able to attend), of which no discrepancy between these expressions and blog content were revealed.

The data consists of 85 blog entries. The students were asked to write an average of 400 words divided among four entries. Students could also choose to write three entries, provided that they responded to all tasks, and had a similar overall word count. Nineteen students wrote four entries each three students wrote three entries each. This adds up to 189 pages of written material

including pictures. The blogs were published on a site administrated by teachers; students could publish entries themselves once they were given author privileges at the commencement of the course. The blogs were hosted on a single site to ensure that readers could easily find accounts of various workplaces, to ensure the quality of the webpage, and to ensure that inappropriate content such as personal characteristics could be edited if needed. To date, editing by teachers has not been needed or carried out in the course. Students were asked to include a picture or illustration in every entry. The students were prompted to write the entries as popular science, meaning that it should be readable by non-biologists. References were allowed but not encouraged. To give the students a better understanding of the expectations for the blogs, it was emphasized that they should write about their learning, and not overly detailed accounts of the technical procedures of their work. To provide structure for the blogs, the following expectations for each of the blog entries were given (these could be responded to interchangeably, though this was a suggested succession):

- Before the work placement: In the first blog entry, the students were tasked with presenting themselves, and their expectations of the work placements.
- During the work placement: In the second and third blog entries, the students were asked to narrate experiences, with an emphasis on what they had learned. The students were also asked to discuss whether they became curious about exploring new knowledge as a result of their experiences.
- After the work placement: In the fourth entry, the students were asked to sum up their workplace experiences, whether it had impacted their thoughts about being a biologist, and whether it had fulfilled expectations.

Pass/fail was based on whether the students had responded to the above. The students were able to edit their blog entries freely until the point where they were assessed by teachers at the end of the course.

2.1.4. Workplaces

The students could apply to several work placements (see Table 1). These consisted of both public agencies, private research enterprises, and non-governmental organizations. All work placement hosts were selected based on whether they made use of biological competence, and had available work tasks for students. The hosts had to appoint a supervisor, with whom the student had everyday contact. A supervisor was necessary to ensure that course teachers and students had a contact person, and to ensure work hosts' responsibility to supervise the students. The students needed to attend 140 h of work to pass the course. Time used to write blogs, and other related work came in addition to this.

Table 1. Overview of student distribution in workplaces

Workplace	Students	Explanation
Science centre	3	Contains part research, parts public/tourist affordances, and education
Research institution	12	Contains both parts public, and fully private institutions concerned with a wide array of research activity, from marine to terrestrial to other types of biology an interdisciplinary research
Nongovernmental organization	3	Public advocacy group. Contain both environmental work and collaboration with local schools.
Enterprise	1	Industry and start-up.
Governmental agency	2	Enforcement and polling of local wildlife laws.
Education	1	Schools and training.

The students participated in a large variety of practices, both inside a particular workplace and between different companies. For example, one student worked on research on marine resources, another worked as an assistant upper secondary school biology teacher, one in a small research station in a rural area, and another in a municipal environmental agency. Although most students attended research institution workplaces, the work tasks within these varied. First, the research institutions focused on different disciplinary domains; one conducted most of its research in the marine domain, another on terrestrial research, and another focused on both terrestrial, marine, and aquatic research. Also, within each domain some students worked more on research (i.e., the actual gathering and analysis of data with an aim to publish in peer-reviewed journals or other commissioned reports) while others worked more on dissemination and public outreach within a research institution (i.e., collaboration with local schools, municipality, and other activities founded in biological science without an explicit aim to publish peer-reviewed research). Thus, students engaged with work in office-, field-, and lab-settings throughout their work placement periods.

3. Analysis

To make sense of students' personal epistemologies in their work placements, the blog entries have been analysed as texts including images. The images provide additional empirical information. Both text and images were analysed within a hermeneutic interpretative approach and with a reflexive and continuous relationship to theoretical concepts and ideas (Jackson & Mazzei, 2018). The analysis process commenced during the design of the study and continued throughout. The blog entries were all compiled into a single document for each student. The blog entries were imported in their entirety including images. The analysis consisted of two phases, one initial compilation and a second where the material was construed through the sociocultural lens. Analysis in both phases was supported by the use of Nvivo (NVivo for Windows, version 11.4.1).

The first phase consisted of representing several successive points of time regarding individual students' experiences, blogs allow for inquiring into aspects of students' epistemological development. Due to the large number of documents, we initially read the texts to get an impression of the whole content. To map practices as students engage with them, the students' expositions were in the first phase of the analysis construed by identifying i) how they first introduced themselves and their interests, and ii) how those dispositions manifested, or were otherwise negotiated in response to their participation in workplace practices. Thus, we gained an overall estimation of the students' breadth of experiences and compiled an overview of students' workplaces. The first phase also revealed students' inherent dispositions as they engaged with their respective workplaces.

In the second phase, Billett's (2009) perspectives were employed as a lens to both analyse personal epistemologies as they emerged in students' accounts of their work will, and to identify the nature of the scientific endeavours the students enacted. An ordering of knowing had to be established to make the data useful to address the research question. Billett (2009) advances that implementing differentiated dimensions of knowing can help account for personal and social contributions to personal epistemologies. The students' accounts were analysed in terms of knowing that was enacted, propositional, and related to personal and situated antecedents to their work placement.

Given the sociocultural nature of personal epistemologies in workplace practices, the analysis needed to provide an account for the contributions of situated activity as well as conceptual contributions that are inherent to scientific culture, that is, propositional knowing. The notion of knowing how and knowing what was introduced by Ryle (2009), and is a well-suited ordering of knowing as it lends legitimacy both to propositional knowing and situated activity, and their intertwined nature (Brown & Duguid, 2001). The notion states that individuals can know concepts regarding a phenomenon, and procedures by which the phenomenon is enacted. Both concepts and procedures are more or less interdependent, yet clearly distinctive (Ryle, 2009). To account for

individuals and their relationship to the circumstance, individuals' dispositions are also included. The inclusion of dispositions is in line with more recent theorizing regarding individuals' knowing and their engagement with practices, whereby the ability to apply knowing in work has little worth without individuals' propensity to actually engage with any given activity (Billett, 2001; Hodkinson & Hodkinson, 2004; Kennedy, 2015). Thus, biology students can, as an example, know traits of any specific plant species (e.g., typical length, appearance, and geographical distribution), the procedure by which information about this species is accumulated (e.g., research, taxonomy, other biology practices), and the value and cultural role of working with, and employing knowledge about the species (e.g., environmental concerns, use in agriculture). Students' accounts of their knowing related to these activities will be the focus of the present investigation.

Thus, we selected instances of procedural and conceptual knowing, and instances where students narrated dispositional content, and compiled these into a table to create an overview of how the students' experiences could be construed to represent knowledges of different epistemological character. Images were treated as "parts of the culture" and analysed with reference to its relation to the text. For instance, the students often provided illustrations that displayed the procedural creation of a product. The illustration could, for instance, display the situated nature of the work, that is, the local community or workplace in which the work took place. The blogs could otherwise give other textual representations of thoughts and beliefs about the biological knowing that was enacted in the work that the students participated in.

Findings were analysed continuously by engaging peers and theoretical perspectives during the investigation (Pink & Morgan, 2013). In the present study, this was done by discussing the findings in groups and applying the theoretical lens as described above to continuously discern students' epistemological accounts. The initial findings were presented in symposia with other researchers and authors, to ensure that the framing into procedural, conceptual and dispositional units made sense to the given data, and to make sure that the results align with the students' utterances. As suggested by Creswell and Poth (2018), the themes were established by discerning patterns in the students' expositions, this includes reading and challenging findings continuously (i.e., as we performed in symposia and through repeated interactions with the material).

4. Findings

The students' accounts revealed three distinct personal epistemological developments. In the present findings, not all students described all three themes in their experiences, though at least one of the three was present in all students' expositions. No students described an opposite experience from the three themes that emerged.

The themes adhere to well-described concepts; (i) tenacity, working in the face of adversity (Kwon, 2017); (ii) subjective, or personal willingness to change to accommodate to the new practices in which the students participate (Rogoff, 1995); (iii) finding cohesion between campus- and workplace-based practices (Gherardi, 2009). The students' appraisal of these practices should not be conflated with Piaget's (1964) notion of equilibrium. In Piaget's conceptualization, new experiences have to be accommodated in relation to previous experiences. Rather, Gherardi (2009) holds that "a field of practices arises in the interwoven texture that connects practices to each other, and that this texture is held together by a certain number of practices which provide anchorage for others" (p. 524). So that practices in campus and at various workplaces interact as students enact biology in work.

The diversity in experiences is an important first characteristic of work placements for the students, and perhaps reflects the diversity of workplaces that employ biology. Personal epistemological developments for students will at times be specific to certain circumstances, while others transcend several circumstances. For instance, one students' work placement in

a municipal environmental agency consisted of both species taxonomy, report writing, and local community outreach to ensure the safe passage of deer across roads with heavy traffic. To provide a comprehensive overview and to reflect the digital ethnographic techniques utilized, both short vignette descriptions, illustrations, as well as excerpts from the students' blogs are provided below. All excerpts are translated from Norwegian.

5. Working in the face of adversity

Several students worked on projects that followed the ebb and flow that accompany project work. In encountering challenges, the students had to mobilize values, such as willingness to engage in and overcome difficulties. Kwon (2017) suggests that this disposition is an expression of agency in working experiences. An account from a student's work on a project on marine resources is presented below. It is our summary from two different blog entries.

Blog 1 vignette.

The blog entry starts with a short biographical note. There is a picture of a creature seemingly growing on the seafloor. By reading the rest of the blog post it is clear that it is a tunicate, a marine invertebrate. The student goes on to account for how she has been assigned to a private research institute that has an ongoing research project on tunicates. The student then goes on at some length about tunicate properties, their anatomy, behaviour and other traits. She also includes a second tunicate picture that visualises tunicate anatomy. The experiment she will partake in aims to explore how tunicates can help clean wastes from fish farms.

Blog 3 vignette.

The third blog entry first displays what seems to be a laboratory setting. Two gloved hands are holding on to pincers above a tunicate lying on a white, sterile surface. The student writes that it is "lovely when we are starting to learn things", and "we are just able to do what we are asked to do without [supervisor] having to show us how we do it." The student then goes on to discuss the state of the experiments. We learn that one experiment is to take place indoors while others are performed outdoors. The student also gives some additional information about tunicate behaviour, she describes how the experiment has to accommodate for the life phases of tunicates. There is an additional photograph of a person looking through a microscope, and a picture of a person working on a tank. Presumably, the tank contains tunicates and have been treated with different materials to determine the tunicates' ability to filter waste from fish farms.

These vignettes display one initial pre-work placement blog entry and one entry further into the work placement period. The student was focused on providing straightforward conceptual knowledge about tunicates, while the pictures showed both tunicates and others focused on how the students engaged in laboratory procedures. In other words, they focused more on work rather than the subject of the work. As the project advanced, the students encountered difficulties:

Unfortunately, experiments do not always follow the course we wish, [but] then there is nothing else to do but to start again. We were unlucky and many tunicates died after a cold weekend. It was too cold and they froze in their tanks. We had to remove all the dead animals, clean and wash all the equipment and wait for new animals to be old enough to restart the experiment. [...] I have discovered that patience is an important factor while performing experiments, and often you have to do things again and again to get precise results.

The above excerpt displays a crucial advancement of personal epistemologies. The enactment of an experiment requires a correct execution of consecutive actions, founded on understanding of scientific knowledge. And even if an experiment is carefully planned, the student realised that unforeseen critical events may occur. The student emphasizes the rigorousness and tenacity required to complete a successful experiment. When her test subjects died, the student had to repeat the experiment at the cost of several days of work. Thus, the student has come to engaged

with the values (research ethics, will to complete work) and approaches required in the context (i.e., workplace) in which she found herself.

6. Participatory appropriation

Rogoff (1995) has shown how a considerable dimension of individuals' participation in socio-cultural activity derives from an accommodation of the practices for which the individual participates. She refers to this as *participatory appropriation*, and holds that individuals' development intersects with practices of communities. Rogoff emphasizes that participatory appropriation "contributes both to the direction of the evolving event and to the individual's preparation for involvement in other similar events" (1995, p. 153). Thus, the students came to engage with workplace practices, they emerged as biologists: in the blogs the students showed how these practices precipitated future work, learning and biology knowing. These advancements pertain to development of personal epistemology, or as Billett holds "[students'] intentionalities when engaging in activities and interactions and the subsequent responses to them" (Billett, 2014). Below is an example of a student's propensity, as she came to engage with the workplace practice that coincided with her interests:

The last time the trawl entered the ocean, it raked the ocean floor. This was not supposed to happen, but for me, it didn't hurt that much, because up with the trawl came a cacophony of life, which one will never encounter among the pebbles of [the local lake]. You'd better believe that I was on deck and having a great time with just observing the many amazing lifeforms. It was as if seven-year-old me was back, eager to live and to learn.

The above excerpt displays a dramatic account of the work of a species inventory. It seems clear that the student found the experience to be exhilarating, especially in how it afforded her with engagement with real life biology. These sentiments tie into her previous blog entries, where she professes a deep interest into marine life, something that steered her higher education choices. Here she states:

After spending several hours and days along the coast with my nose pointing down, the choice for higher education was easy. It had to be (marine) biology. Being able to work with what you like is probably every workers' dream, but what sort of jobs can a biologist really have and what do you do? Hopefully, [the work placement] will help me get better insight.

One student found that the interaction with local communities, co-workers, and other persons associated with the work was an important workplace experience. For instance, one student who worked with the municipality conservation office found that some hunters were hostile to assessment and control, while others found it to be an opportune moment to relay old war- and hunting stories. Another aspect of the personal investment required by the students, was a perceived alignment between values and conceptions about useful work, environmental impacts, and advancing a financially viable enterprise: "I felt like I worked with and for the local community for causes I truly believe in and support. I'm talking about renewable and environmentally friendly resources and practices that aim for sustainability".

7. Finding cohesion between workplace and campus practices

Kennedy (2015) suggested that there is an inherent tension between knowing as conceptualized in what she calls Academy settings and Practice settings. This tension has been examined by theorists such as Dewey (2011) in the early 1900s and can be traced as far back as Aristotle. This tension is a potential crisis of epistemology that individuals can encounter during their work placements. On one hand, knowing is authoritative, validated, and propositional, while on the other hand, it is experiential, situated, and derives from participation in practices. These perspectives blend with the analytic assumptions of knowing employed here, which comprises both procedural, conceptual, and dispositional dimensions (Billett, 2009). These dimensions apply to all settings the students have engaged in. For instance, procedural knowing is often associated

with working, and conceptual knowing in turn associated with academic settings (Duguid, 2005). Rather, procedures and concepts emerged throughout the students' working experiences. Given the students' individual life histories, dispositions emerged as a matter of course during their experiences. The cohesion between settings, however, remains a pressing issue, not least for science education where there is tradition to remain esoteric (Knorr Cetina, 1999).

Considering their everyday activity as biology students, it is perhaps not surprising that the students frequently give accounts of their learning by contrasting experiences in the workplace with experiences at the campus. In the blog posts written before the work placements, students iterated how they wanted to "actually do biology". One student stated that "it's incredibly cool that I am allowed to use the knowledge I have acquired in the last two years, and finally exhibit it. Everything you learn in lectures become so much more real and exciting when you are able to see it in front of you". Another student iterated how the work placement could spur further studies: "the more knowledge I gained through the biology study, not least [the work placement course], the more I wish to know and acquire even more knowledge. Perhaps I want to be a scientist?" Once the students started their work placement, some found that the more conceptual knowing they had engaged with at campus aided them in more procedural tasks. For instance, one student iterated:

The learning curve has therefore been a steep one, as I have to familiarize myself with all aspects of a very broad field, including—but not limited to—the factors that affect the health and condition of soil and the different nutrients that plants need. As such, I find it useful and beneficial to have background knowledge in ecology.

The students' pictures also effectively displayed the procedural knowing prevalent in their work activities. One student displays this by showing the working process for creating pamphlets concerning marine life, and another displayed the processing work for creating fertilizers from horse waste.

One student found that the initial planned work tasks had to be amended and transformed during the work placement, and iterates:

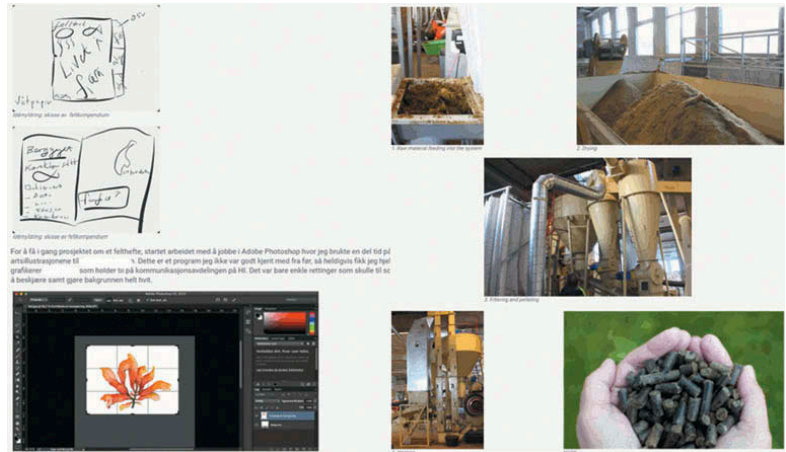
I was tasked with reading up on how to estimate the stock of deer in [the local city], by using faeces-taxonomy. I quickly discovered there was little available literature on the subject, and even less related to deer, that we were supposed to read about. We then decided to freeze that project in favour of smaller projects and working on smaller, but more, tasks instead. Now, the focus is to update the mapping of deer trails in [the local city]. The method that we will use is to use maps in the wildlife registry and investigates where there are most [car] accidents with deer.

As shown in the above excerpt, finding that their learning transformed over the course of the work placements, ties into other students' experience with adversity and problem-solving over the course of their work placements. According to students' accounts, they had to mobilize new procedures and new concepts in conjunction with their tenacity to complete their work. As the excerpt above suggests, when the student refers to "we decided", these shifts occurred in consultation with supervisors.

In Figure 1, the students explained the procedures they employed at work through illustrations. In both cases, they show successive steps to arrive at the finished product. In their written accounts, the students explain how these procedures are enacted in various ways to create a useful product, as a particular salient aspect of their engagement in work.

The students' accounts of activity show a close proximity between design, procedures, and analysis. This was, for example, shown by two students who narrate their experiences with completing a tunicate experiment. This experiment is performed (procedurally) on the basis of

Figure 1. Students display their working procedures using pictures. To the left is shown the working procedures of a student who constructed a pamphlet. To the right, another student depicts the successive steps to create manure.



conceptual knowing about the need for fish feed in commercial aquaculture. Likewise, this procedure at first fails and is amended by engaging conceptual knowing about tunicate development. By carrying out these amendments the students engaged with biology knowing, both procedurally and conceptually.

In this work placement, it is also clear that most of these dimensions of knowing are engaged by the students in regular courses at the campus. Indeed, statistics, laboratory work and taxonomy are considered to be core competencies in a comprehensive biology education (Singer, Nielsen, & Schweingruber, 2013). Thus, procedural and conceptual knowing is afforded to the students prior to their work placements, the students' accounts emphasize a development (i.e., enactment of statistics, laboratory work, and taxonomy) in relation to their work placement.

8. Discussion

It has been suggested that novel contexts and engagement with new circumstances are of particular value in the development of scientific knowing (Rennie, 2014). These authors particularly refer to the enacted nature of many scientific activities, such as sampling, laboratory work, and otherwise gathering data about the natural world. This enactment represents practices in which students should engage to develop their scientific knowing. Roth (2003) also suggests that students' engagement with communities is helpful to advance their understanding of themselves and of the viability of scientific knowing. This could, for instance, be to support communities in how to handle local challenges such as pollution, clean water, and power supply. In this perspective, the development of scientific epistemology is not simply a personal trajectory. It derives from societal underpinnings, and the community in which the student finds him- or herself.

Given the primacy of context in our examination of individuals' personal epistemologies, it is worth noting that the blog entries are concerned with individuals' trajectories into a new circumstance. The entries are cast in a context of previous education experiences, potential employment opportunities in their work placements, and enactment of biology in work. The blog entries display the students' thoughts about biology as a scientific discipline, its role in societal developments, and its efficacy to solve difficulties at hand. That is, general statements about epistemology. In the following, it will be argued that these sentiments regarding science are closely interlinked when understanding students' personal epistemology.

The analysis shows how dispositions and personal epistemologies intertwine during the students' work placements, this manifested both in response to challenges and through participatory appropriation. For instance, environmentally conscious students perceived that the use of different methods has to be economically viable on one hand. On the other hand, the results can provide an alternative to current practices which are not environmentally friendly. Both considerations have to be fulfilled for the workplace to be at all viable for the student, both as a present and future workplace. The alignment with epistemology is relevant because certain expressions of knowing are relevant in order to investigate phenomena, and this knowing is enacted (i.e., practiced) at campus prior- and subsequent to the work placement, and employed at the workplace.

Thus, some instances of work placements advanced students' thinking toward research-oriented conceptions of knowing. For example adapting approaches (i.e., research design) based on results, procuring and using appropriate tools and literature, and seeking out new knowledge (i.e., from peers, supervisors, and others with applicable skills) were required to advance the quality of their work.

9. To work and to enact biology: a conceptual model

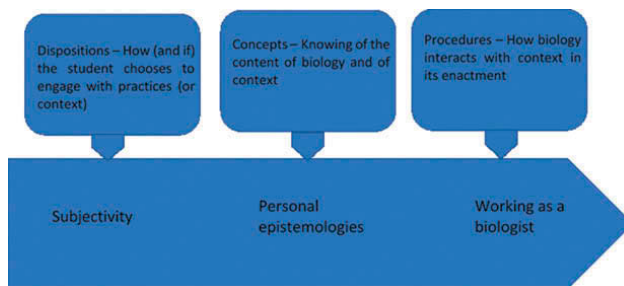
The analysis has shown how students emphasise their personal values in their accounts; how these values developed prior- and subsequent to their work placement. This emerged through the students' focus on how previous experiences align with current choices (i.e., choice of work placement) and then deliberations about future career trajectories.

As epistemologies are here discerned by three major expressions (procedural and conceptual knowing, and dispositions), it is evident that the students have engaged in activities which have developed diverse expressions of knowing through work (i.e., the students have engaged with practices where this knowing was enacted). The students' dispositions were accounted through life histories. For example, for one student, interest in marine life and diving, has led one student on her current path in marine biology, whereas occurrences in work placements have impacted their subsequent desires for approaches to knowing. For example, species identification is a practice with nested conceptual and procedural knowing that has an increased relevance to future work. Participating in practices that integrated relevant (i.e., for individual students) capabilities, values and potential for steady employment permeated many of the students' accounts.

Given that individuals' personal epistemologies precipitates the way in which scientific knowing is employed, and brought to bear in response to challenges (Kelly & Licona, 2018; Schommer, 1990). It is worth noticing that the students detail development of personal epistemology in face of adversity, and personal development (i.e. participatory appropriation). This can be suggested based on students' appraisal about how knowing with which they have previously engaged (particularly at campus settings) is useful when responding to workplace challenges, and that they had the ability to engage both conceptual and procedural knowing while fulfilling occupational obligations. According to the perspectives on personal engagement, increased emphasis on personal epistemologies as defined here can help create a cohesive learning strategy for individuals. In respect to the students' expositions of their learning, these are useful in biology education, where somewhat complex conceptual representations and procedures can be enacted, and otherwise engaged with through working (see for instance the many levels of expert knowing required to complete the students' research project on tunicates).

Finally, the situated nature of the students' experiences should not be undervalued when considering individual students' development of personal epistemologies. Students finding themselves in circumstances both novel and exhilarating, is fully in line with theories on situated learning. Within a sociocultural framework, expositions of context are also expositions of learning (Rogoff, 2003). Given the wide variation in a circumstance in the biology students' workplace, it is crucial to recognize that this is also an epistemological expression. It is significant that the elicited accounts of learning go to great detail about how new contexts affords access to new practices

Figure 2. Conceptual overview of students' development of personal epistemologies in their trajectory to develop as biologists in work. Context interplays in all dimensions and reflects the sociocultural (i.e., situated) theorizing that is foundational to understand students' development of personal epistemologies in work. Subjectivity refers to individuals' standpoint, and the life history that proffers them in their trajectory towards engaging with biology knowing.



and thereby new learning. We propose a conceptual model to illustrate the contributions of knowing in context to the students' personal epistemologies and their development towards becoming a biologist (see Figure 1).

The conceptualization in Figure 2 should be of particular interest in tertiary education pedagogies, as students' dispositions are increasingly emphasized alongside conceptual and procedural knowing (Hodkinson, Biesta, & James, 2008). By providing links between various dimensions of knowing and dispositions as they are engaged in work placements, blogs can be a fruitful avenue through which these aspects of knowing can be facilitated and assessed. Furthermore, we did not aim to find whether or not work placements provide specific outcomes in comparison to campus-based pedagogical measures. However, we suggest ways in which work placements provide specific experiences. In these experiences, students find their conceptions of knowing developed and they consider ways in which their overall education is useful in various occupations.

10. Conclusions and limitations

The present study has shown how blogs can function to explore students' personal epistemologies. Through the students' accounts, important aspects of learning during work placements have become clearer. These aspects emerged as students' engaged and enacted their work in the face of adversity, such as project setbacks and financial limits. The participatory appropriation in which students engaged in their work. And their accounts regarding the relationship between campus and workplace epistemologies. Through these themes, students engaged in specific applications and integrations in their knowing. They also gave accounts of knowing in relation to personal values, and volition to engage with specific sets of practices (and knowing). This shows the primacy of individuals' dispositions as they come to engage with work. The advancements presented by work can also respond to challenges presented by the diverse dimensions of biology knowing (all those practices the students come into contact with during their education), and thus assuaging the partitioned conception of learning (i.e., weak connection between work and campus) that can arise in science education.

In ending, we wish to highlight specific limitations to our study. First, we base our findings on students' self-reported experiences. As argued in our method section, we deem blog accounts valuable without including other measures to further question students on their experiences, such as semi-structured interviews. Second, the public nature of blogs can skew students' accounts in favour of less problematic, but nonetheless salient experiences in their work placements. However, we do not wish to engage various experiences as more or less interesting and students' accounts should be taken as honest. Third, more in-depth examination of various workplaces could lead to

deeper understandings of particular students' experiences. This calls for future ethnographic-type studies on biology students' experiences in work placements.

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Paper III

Learning and personal epistemologies among students in three work placement settings

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Abstract

Recent development in policy and learning theory encourages higher education institutions to counterintuitively send their students out of campus and into work placements. To address this development, we propose a conceptual model to frame students' learning in work placements. In this paper, we report on students' engagement with various aspects of knowing through practice in work placements. We employed focus group discussions to gather students' accounts of their knowing in the three higher education programs: Teacher Education, Aqua Medicine, and Music Performance. The students' accounts of knowing were analyzed as personal epistemologies. Thereby, we aimed to focus on how enacted practices in work develop students' appraisals of knowing and subjectivities. Three prominent epistemologies were present across all three student groups: risk, enactment of routines, and values and on the basis of their experiences, the students better understand how to enact their knowledge and what knowledge to pursue further. On the basis of these findings, we hold that there are key educational processes that arise in the interplay between students' situated enactment of practices, knowing, and personal epistemologies.

Introduction

In recent years, work placement learning has received renewed policy focus internationally (e.g., OECD 2017). Increased integration has taken place in traditional professional programs, such as in university and hospital collaboration in health care (Kennedy et al. 2015). In other academic disciplines, these advances in integration between University campuses and workplaces are salient (e.g., Parker and Morris 2016; Trede and McEwen 2015). Increased emphasis is put on the role of work placements to prepare students for employment, and the unique situated contributions to their learning that can be facilitated through work placements

(Billett 2014; Helyer 2011). Thus, higher education institutions are seeking further avenues through which students can partake in society and work, as they are enrolled in campus-based institutions.

To examine students' learning in work placements, we position our approach by drawing on practice-theory and recent advances in personal epistemologies in work. Practice-oriented theorizing of learning (or knowing), has advanced that students learn as they engage with practices and integrate into working communities (Brown and Duguid 1991; Lave and Wenger 1991). Gherardi (2009a) argues that workplace researchers can benefit by emphasizing *practice* as an analytical unit to understand workplace learning. Moving the focus to individuals' participation in practices, highlights the need to examine individuals' agency and propensity to participate (Gherardi 2016; Hodges 1998). Students engage in workplace practices and engage with a wide set of knowing (Duguid 2005). Analyses of knowing do not only involve specific techniques engaged at a particular site, but also other developments in individuals' sensibilities as they engage in and reflect on their practice.

This analytical turn in practice theory blends well with Billett's (2009a) advancement of personal epistemologies in workplace learning. Personal epistemologies are individuals' perception of learning; how they engage with knowing and how this knowing develops as they participate in various working practices. Barton and Billett (2017) conceptualize personal epistemologies as "In essence, they comprise what individuals know, can do and value which then directs how they think, act and learn" (p. 113).

Knowing and personal epistemologies in work placements

Personal epistemologies are in this paper conceptualized precipitated by practices in which they are continuously developed (Billett 2009a; Strati 2003). Hence, we approach personal epistemologies from a sociocultural perspective. A sociocultural approach to personal epistemologies emphasizes the interplay between individual and contextual factors for

individuals' appraisals of knowing, and their own role in enacting knowing (Magolda et al. 2008). We capture this by emphasizing a situated and emergent role of knowing, and how this can be framed by focusing on various expressions of knowing as accounted by the students. To examine personal epistemologies in workplace settings, it is necessary to discern various expressions of knowing that might emerge in students' accounts of their learning.

The notion of two codependent, and equally valuable dimensions of knowing can be traced to Ryle (2009, first published 1949). Ryle found the dimensions of knowing to be expressed as knowing that a thing is (conceptual knowing) and how this thing could be used by individuals (procedural knowing). As an example, knowing of multiplication entails both the capability to compute, and conceptual knowing about the thesis that substantiate the computation. Duguid (2005) maintains that procedural and conceptual knowing are emergent expressions of behavior, and not categories of knowledge that can be contained separately. Brown and Duguid (2001) go on to claim that "research often seems to evade this contrast rather than confront it" (p. 198). They suggest that practice-oriented theories provide a way to bridge the analytical continuum between forms of knowing and individuals' personal epistemologies, which explains how individuals engage with knowledge in practices.

Given that knowing in workplace practices manifests itself in diverse expressions, these expressions are often analyzed as tacit or procedural on the one hand, and articulated, standardized or conceptual on the other (Duguid 2005; Eraut 2000; Gascoigne and Thornton 2014). These two dimensions are sometimes treated as given categories. We treat them as emergent expressions: knowing is developed, halted, and further nuanced over the course of individuals' lives, and dependent on contexts in which individuals are situated (Duguid 2005; Polanyi 1962). Students' engagement with practices in workplaces yields particular engagement with these expressions of knowing, in which students must enact complex

practices and encounter knowing particular to the setting of their work placements (Billett 2003; Lave 1996).

Finally, accounts of students' participation in work placement practices need to account for individuals' volition to engage with these working practices, and whether individuals transform practices rather than conform to existing practices as a matter of course (Gherardi 2009a). As outlined by several sociocultural theorists (e.g., Rogoff 1995; Wertsch 1998), individuals' engagement with knowing in practices depends on social and historical underpinnings, which determine the individuals' propensities to pursue actions and working knowledge, and which we conceptualize as individuals' dispositions (Prawat 1989).

Research question

In this paper, we examine three education programs; Aqua Medicine, Teacher Education, and Music Performance Education. Particularly, we examine the way in which groups of students within such varied programs discuss personal epistemologies in relation to their work placements. The three settings are more or less defined professions, with long-standing academic antecedents (i.e., scholarly work upon which curriculum is based) and were chosen to provide a multifaceted perspective of students' engagement with workplace practices.

We address the following research question: *In what way do the students' workplace experiences contribute to their accounts of personal epistemologies across different education programs?* Thus, we contribute to the available understanding of learning in work placements by focusing on students' perception of knowing.

Context

The included education programs offer varying types of work placements to their students and qualify students to a specific profession. Research of individual work placement settings

incorporated in the present study are available for Music Performance (Brøske and Saetre 2017) and Teacher Education (Ulvik et al. 2018). Brøske and Sætre (2017) focus on the role of societal integration in Music Performance Education. Ulvik, Helleve, and Smith (2018) focus on the dichotomous perception of learning between working and campus settings in Teacher Education. In the present study, we focus on iterations of knowing as personal epistemologies as they emerge in work placements in and of themselves. We gather information from students across both programs, as well as Aqua Medicine

Music Performance Education

Music Performance Education is organized as a four-year bachelor program and an optional two-year master program. The master program offers a range of work placements, of which two are included here. One is a week-long *multi-activity project* carried out collaboratively by students and teachers and a range of partners in a Norwegian municipality. The project entails planning and giving concerts for new audiences in a variety of venues and is based on a high degree of collaboration with local musicians, children, and teachers. The second work placement, the *professional orchestra placement program*, is an elective master course for which students apply on the basis of an audition. Over a period of two years, students participate as orchestra musicians in professional orchestras during twelve week-long rehearsal and concert projects. Each student is appointed a supervisor from the orchestra, which normally is one of the orchestra musicians.

Aqua Medicine

The profession program in Aqua Medicine is a five-year integrated master program. It contains much of the content of a disciplinary biology program and focus on fish health throughout, in which most courses are compulsory. The program provides training in diagnosis, prevention, and treatment of illness and injuries in aquatic organisms, with special emphasis on farmed

fish. Upon completion of the program, the students can apply for the title of Aqua Medicine Biologist. An Aqua Medicine Biologist has prescription rights to treat and handle aquatic organisms. The program comprises two work placement periods of 15 and 12 days, primarily in fish farms. During the first placement, the students work in an aquaculture farm in order to familiarize themselves with aqua culture work. During the second placement they work as Aqua Medicine Biologists, with emphasis on fish health diagnostics. The work placements are assessed by attendance and one graded written report.

Teacher Education

Teacher Education is here represented by three university-based secondary school teacher education programs. The educations include a five-year integrated program that leads to a master's degree and two one-year postgraduate programs for academic and vocational teaching. There are some variations among the programs, and they all include two seven- to eight weeks' periods of work placement. In the placements, teacher students most often have two supervisors selected by the school. Norwegian teacher education is regulated through a national framework. In work placements, there are no demands related to content or mentoring, except a fixed duration, and with a pass or no pass assessment. Work placements are mandatory components of the Teacher Education, and the students do not receive academic credit points for this part of the program.

Methods

The students' appraisals of knowing, practices, and learning were captured through focus group discussions. Brinkmann (2007) has advanced that interviews can increase focus on epistemic content to garner more information about learning from participants. Thus, asking students to narrate an activity is not necessarily sufficient to grasp the information they have to offer. Rather, the discussions enable students to discern knowing as it relates to their experiences. By

facilitating the opportunity for student groups to narrate their personal epistemologies, they situate themselves in their work and how it affects their knowing. It also affords the participants a chance to contrast their own experiences with other students. Focus groups were selected because the students share a collective set of experiences which they can discuss in relation to each other. As pointed out by Wilkinson (2016), it is possible to draw findings from the way in which students present themselves to each other. For instance, one student might contrast their work placement learning with campus-based learning. Other students might find merit in these sentiments, but also feel the need to highlight the ways in which their learning at campus prepared them for their work placements, thus providing increased nuance to their accounts of their learning.

Following recommendations given by Barbour and Kitzinger (1999), the group discussions were centered on core themes with supporting questions aimed to foster students' independent discussions. The focal discussion themes were common for all three education programs and were constructed through meetings between the authors, and also within a larger project group. The themes were constructed to ensure discussions about personal epistemologies, and the students' engagement with workplace practices. Three principal discussion themes were selected: (i) the characteristics of learning at a workplace, as opposed to a campus setting; (ii) a characterization of activity during the work placements; and (iii) learning outcomes in the work placements in general terms (i.e., the students gave accounts of concrete learning experiences and how they manifested).

The themes were divided into sub-questions. Probing questions were asked to clarify and further pursue themes that were raised by the students (e.g., "Tell me more about holding fish, how do you do that?"). To ensure that the correct meaning was captured, the students' utterances were repeated for validation (e.g., "So you think learning in the workplace is

different because you encounter weather?"; "Just to make sure that we have the correct meaning, you think that learning in workplaces are different from learning at campus?").

Selection and procedure

The participants consisted of nine Music Performance students (one orchestra interview and one multi-activity project interview), six fish health students (one interview) and 21 teacher students (one integrated teacher education-, and two post graduate student interviews). The participants were recruited through self-selection by approaching students in each study program and inviting participants who had completed their work placements. The students were asked to collaborate in a project about learning in work placements. The students were informed that the discussions would be anonymized at the outset. The discussions consisted of one moderator in each group (three moderators) in the Teacher Education program and two moderators in Music Performance and Aqua Medicine programs interviews. When two moderators were present, one had the principal role of facilitating the discussion, while the second moderator observed and ensured that all items of the discussion themes were covered. Each interview took approximately one hour and was transcribed verbatim for analysis. In cases where individual moderators conducted interviews, the disciplinary group performed the initial analysis in concert, before disseminating the results to the larger cross-disciplinary group.

Analysis

The students' discussions were initially disseminated through presentations among the authors to discern the students' accounts of their learning. We then employed a variant of constant comparison analysis, in which themes relevant across all interviews were selected iteratively. This method is recommended for focus group research that focuses on specific themes and the shared experience among several participants (Onwuegbuzie et al. 2009). The relevant themes

emerged as we selected the following instances of expressions of knowing: (i) knowing that is developed in-situ, and sequential sets of knowing, which is procedural, (ii) knowing that is propositional or conceptual, and concerned with overarching principles, and (iii) students' dispositions (e.g., values and subjectivity) as students relate them to work placements.

These three instances are inspired by Billett's (2001) outline of workplace learning. For example, the students' accounts of a particular situation could express procedural knowing through students' account of their enactment of a particular task, and dispositions when students discuss their motivations to engage in the particular task.

The strength of this analytical approach is the emphasis and legitimization of diverse expressions of knowing, and how these expressions are continuously enacted through work and individuals' life histories. The approach also attends to criticism of sociocultural and cognitive theory to overly focus on either individuals or the social context in which individuals act (Hodkinson et al. 2008). By examining individuals' accounts of knowing as they come to engage in workplace practices, we aim to capture the intersection between individuals' thinking and their development in particular contexts (i.e., work placements). The instances were selected using NVivo qualitative data analysis software (Version 12.1.2.256), and the instances were then reviewed and discussed among the authors to ensure that they represent the findings.

Findings

Our analysis revealed three prominent themes in the students' epistemological accounts: (i) the engagement with risk and failure; (ii) enacting routines; and (iii) identity and dispositions. All three derive from individuals' engagement (or willingness to engage with) these experiences. The themes are presented below. All excerpts are our translation from Norwegian to English.

The epistemology of risk and a real chance of failure

Being afforded access to tasks with a real chance of failure has long been held to be a prominent feature of work placements, and is often portrayed as a stark contrast to campus-based activities that may seem contrived (e.g. Costley 2011; Grossman et al. 2009). The students in all three programs mirror this sentiment. However, it is offered here not merely as an experience, but as an experience that inform students' personal epistemologies. Thus, being afforded the potential to fail accords the students with a sense of the value of failure for their own learning, and a sense of actions needed to mitigate and handle difficult situations appropriately in the future.

Musicians striking the right (and sometimes wrong) note

The multi-activity project was perceived by the Music Performance students as a project consisting of several varied activities, in which they are given a great deal of freedom and responsibility. They were involved in many artistic productions within a short period and aimed at the same time at high artistic quality. The students perceive this particular combination as highly relevant to their development as musicians, because they believe this is how reality (i.e., performances for an audience) works.

I have gathered that the concert is about the music and playing together. Especially the times you play with the locals, and they were really happy that we were there. [It's about] making a good show. And it wasn't about [me], but about the band's performance for the audience. The entire scene is connected. You forget that it is theater, it is sound, lights. Everything is supposed to work to make a good show. If I play the wrong notes I can't go around being disgruntled.

As illustrated in the excerpt, participating in a variety of unfamiliar practices in the multi-activity project, such as teaching, collaborating with children, and amateurs or

improvising, is experienced as a high-risk endeavor. The multi-activity project constitutes a distinct practice context in that it includes the complex and high-risk features of professional practice. Yet, it is embedded in an educational setting, as students have lower expectations than employed musicians.

Alone in the fjords

The Aqua Medicine students seem to have encountered specific challenges pertaining to their location in Norwegian fjords as a sole professional far away from the University and fellow professionals. The students also gave accounts that indicated a novel enactment of procedures related to diagnosis of fish diseases and injuries. For instance, some symptoms might not be as clear in the field as it was during lectures or demonstrations at campus.

Much of what is presented during teaching sessions is the ideal portrait. A professor can present on a blackboard and, in a way optimize all factors. It is something completely different when you're standing out there and it is blowing 22 m/s and it is snowing sideways.

Engagement with work placement complexities expanded the students' conceptions about sickness and symptoms. Further, as these experiences pertained to enterprises' success, the activities became more important. One student explained these issues in the following way:

[They] are responsible if it goes to hell, it was twenty against one. So, you need to have some balls too, you have to be able to put people in their place, for this is a company that is contracted to perform a specific job. They are assessed on how much time they use. On a treatment for example. Because time is money.

Here, the student emphasized the monetary pressures in enacting Aqua Medicine, a pressure that is perceived to increase by the prospect of making decisions alone and quickly.

Teacher students and authority

It was great to just be able to be alone in the classroom. To try to do exactly what I wanted, I had the authority. The other authority [supervisor] wasn't in the classroom. I was responsible for everything, everything I put forward

As the above quote suggests, the teacher students emphasized the importance of being autonomously responsible for a class. In being left alone with no external supervision, students were afforded a sense of freedom to conduct themselves as they saw fit. Other students interjected with the apprehension they experienced at the prospect of exercising authority to discipline students, or otherwise behaving as a teacher.

I got to experience situations where I got some exercise in talking with people in the hallway. And that was things I was very nervous about, taking the step to point at a guy: "YOU are coming out into the hallway", or something like that. I thought that was really great, at least that I was allowed to test out such things.

The situation above indicates that the student found coming to grips with confrontational situations valuable. "Talking in the hallway" refers to removing the students from regular lectures to discuss their behavior. Being nervous about implementing the steps also underscores the level of risk the student perceived in the situation. That is, the potential of failing to exercise authority in the classroom.

The epistemology of enacting routines

Routines can encompass the procedures by which work is enacted. However, routines refer to tasks that are encountered by students, and can take procedural, conceptual and dispositional dimensions. Routines can be continuously repeated every day or only intermittently. Ryle (2009) emphasized how the enactment of procedures (knowing how), such as routines, emerges

in concert with conceptual knowing (knowing what). Thus, procedures are analytical, and routines can encompass various elements of knowing as they are enacted by students. As the students have taken part in practices in work they have come to develop and appreciate knowing (i.e., their personal epistemology) related to various routines (Hole et al. 2018). Additionally, the students detail in length the relationship between these routines to their conceptualizations of learning. This is particularly true when students engage in routines in the context of supervision and discussions regarding their own knowing (Gherardi 2009b).

Performing music

I would like to learn more about how to act in an orchestra or how I better can attach myself to other instruments. And when am I supposed to listen to the second oboe? And how in the world am I supposed to listen to the second oboe, which sits all the way over there? There is no focus on that in a school orchestra.

As illustrated in the above excerpt, rehearsing and performing a repertoire in a professional orchestra setting constitutes the core procedural knowing the students encounter in the orchestra placement program. The students describe how they learn ways of listening, ways of watching, and of acting in the orchestra. In the orchestra, the students receive less direct feedback from supervisors, and is according to the students more a matter of learning by doing by having to “pick up things” according to the students. This entails identifying and listening to specific instruments in order to play on time, learning to count, experiencing the need for clear musical communication, and “how to *be* in the orchestra”. These ways of learning are a result of students engaging with practices, and as being enculturated in a specific professional orchestra circumstance. The orchestra offers the students a range of tools to understand orchestra playing and acting. According to the students, a main difference between

the professional- and school orchestras is the higher musical level of the former. This level demands serious and focused practicing of the orchestra repertoire.

Measuring fish

The Aqua Medicine profession students described their engagement with procedural knowing initially to consist of fish-handling skills. This was particularly salient when working with fish farmers, as opposed to their work with fully trained Aqua Medicine professionals. Their engagement included being able to hold the fish, where the hands needed careful placement to prevent the fish from slipping. As one student iterated:

Coming out on a facility as an Aqua Medicine Biologist, and never having handled trout, then you make a fool out of yourself.

The students also worked on the routine maintenance of the fish farm. This routine was performed in cooperation with an aquaculture farmer and consisted of weighing, cleaning, and transferring fish. These routine tasks consisted of different procedures from the ones the students had engaged with prior to their work placement. The students also described fish farmers' extensive knowing when observing fish movements in the fish pen and other tacit knowing, which enabled them to detect diseases and injuries quicker than the students. The students emphasized how these routine tasks were equally important to master as the more specialized knowing used by Aqua Medicine Biologists.

Enacting and maintaining lessons

The teacher students are learning a profession that they have observed for years in the classroom. They have several conceptions concerning what teachers do in a classroom. However, the teacher students describe that while they as pupils witnessed what took place at "the stage", they were as teacher students allowed backstage and became aware of teachers'

responsibilities outside the classroom. They furthermore encountered a bodily and emotional experience of teaching and understood how complex and time consuming it can be.

I was really surprised over how much time we used. Both for preparations, to conduct the lessons, but not least on conversations after lessons, which, in a way, I benefited most from.

The student teacher student also discussed the varying degrees of participation offered to them by the schools they attended during the work placement. They appreciated having supervisors that gave them some advice, and who also encouraged them to try out their own ideas. Moreover, they enjoyed being included in the staff and engage in knowing embedded in the professional community in an informal way. The teacher students' access to procedural knowing varied. Some were left to their own trial and error. Others were invited into a dialogue or told more specifically what to do.

The epistemology of values

Dispositions have come to take a more prominent role in understanding workplace settings and learning (Hodkinson and Hodkinson 2004). This is also reflected in the students' accounts of their learning in workplace settings. Rogoff's (1995) emphasis of participatory appropriation, meaning individuals' willingness to change to accommodate new routines and willingness to engage with the work presented to them, further describes the importance of dispositions to workplace learning. Identity permeates all the students' accounts, both in terms of their backgrounds when engaging with new settings (i.e., practices), or willingness to solve challenges and use effort in their work (Billett 2004).

Integrating audiences in performances

In the multi-activity project and in the professional orchestra placement program, the students enacted conceptual knowing by stimulating discursive understanding of Music Performance in professional settings. Both groups believed that this is not taken sufficiently care of in campus settings. Both groups also find supervision and feedback (from teachers, peers, or experienced musicians) the most important factor stimulating learning in work placements. The high degree of collaboration and reflection in the multi-activity project is a central part of the students' positive experience. Central learning experiences, such as the shift of focus from individual students to the music, audience, and other issues, seem to emanate from to the network of social relations at play in the multi-activity project.

I've been there a whole week, and everything was focused towards including, talking, trying to convey. So, I will take that with me into other projects. Not taking people on stage with me or take people with me home, but the focus from now on, after this project, will be directed towards those listening to me.

Thus, social practices seem to be central to students' learning in the project, not least from their peers and from "new audiences". The collaborative and reflective approaches seem to be a key factor in making these learning experiences explicit. The orchestra program students also find supervision and feedback important, and they describe a context in which this happens both in less formal ways and less frequently. For instance, the students identify feedback from experienced fellow musicians (mainly individual feedback from the person 'next to me') as a highly valuable way of learning in orchestra practices. These statements give a hint of the strengths of the social mechanisms at play in these rather different social contexts of the multi-activity project and the professional orchestra.

The multi-activity project seems to have brought on a range of questions about the role and tasks of the students as future musicians, about music itself, of working as a portfolio musician, and of “expanding the frames”. Since the students start to question reasons for becoming a musician and what kind of musician they want to be, there is an epistemological shift in focus from simply gaining expertise in their respective instruments. In comparison, the orchestra students highlight the importance of having a chance to understand the orchestra culture of networking and of finding a “way into” the orchestra. The students even talk about “learning how to *be* in the orchestra”. In these learning experiences, the students are enculturated in a professional orchestra culture, with codes, procedures, musical, and bodily actions, and spoken statements and feedback.

Fish farming: a matter of geography

The Aqua Medicine students came to develop their sensibilities about how to approach their work as Aqua Medicine Biologists. First, in terms of the cultures the practices they encountered were perceived to derive from. Second, in terms of their individual subjectivity (i.e., values and assumptions) when they encountered work. One student described his engagement with the working practices in terms of backgrounds. According to this student, fish farming originates in Northern- and Western Norway, whereas as an Eastern Norwegian, he had no underpinning cultural framework to understanding the Aqua Medicine work. Another student iterated that “It is no secret that many of those who work as fish health professionals in Norway come from Northern- or Western Norway”.

The students also emphasized the relationship between their enactment of their knowing and their identity as Aqua Medicine Biologists. This was determined by the students’ emphasis on how they imagined the fish farm workers’ derision of Aqua Medicine Biologists who could not handle living fish:

How should they take me seriously if I cannot even handle the fish? Well, to be able to help them throw the net and to collect fish and feed the fish and do these sorts of things. Well, it is a bit stupid to just stand and look like some idiot, you have to contribute.

These are the students' expressions of values they perceive in the Aqua Medicine profession, and as they have encountered them in their work placements. The students at some level negotiated how they would act in contentious situations. One student gave an account of a supervisor Aqua Medicine Biologist being confronted by several fish farmers who disagreed strongly against their pharmaceutical recommendations. The Aqua Medicine Biologist was confronted with farmers who could potentially lose large profits. This illustrates the effort sometimes required to act appropriately as an Aqua Medicine Biologist despite local pressures. It also intersects with interests of the local community (i.e., the workplace), professional standings of fish farmers in general, and students' sensibilities about the role of values and willingness to actively maintain their own values.

Moving from student to teacher

The teacher students seemed to develop an initial understanding of themselves as teachers through the work placement. They emphasized that it was important to access the professional community and learn more about teachers' overall responsibilities. Further, they engaged in a broader understanding of what it implies to be a teacher, such as the complexities of the work and the many roles that teachers simultaneously have to assume when encountering students, colleagues, or supervisors. Thus, teacher students in work placements seemed to consider the extent to which they are suited for teaching and what kind of teachers they want to become. The teacher students had different preferences related to freedom and responsibilities. Still, they shared the wish for some kind of autonomy to enact teaching practices and thereby evolve their understandings of themselves as teachers.

Teacher students have a preconception of teaching based on curriculum literature, lectures, and observations. In work placements, they develop an emotional- and experience-based conception of their role. Literature and scientific concepts also became more meaningful and they saw how it might contribute with a critical view of their own practices. Some teacher students iterated that their workplace experiences made them more interested in reading scholarly literature or made them to shed light upon previous experiences. When it comes to curriculum literature, the students indicated that their work placement experience was not aimed at connecting learning at campus with learning during work placements. Several students indicated that work placements and the university coursework emerged as two separate epistemologies. For instance, one student iterated that:

It was weird having a university teacher who said: “don’t just read the syllabus, there is so much more out there”. And then I had a school [workplace] supervisor who says: “stick to the curriculum, that’s what the students learn, and that’s what they use”.

The excerpt illustrates conflicting views offered by university teachers and workplace teachers. In this instance, the student did not reach a conclusion as to what view she preferred. However, the participation in teaching practices offered the student an insight into the thinking of teachers in the workplace and those found at campus.

Discussion

All students gave epistemological accounts concerning their engagement with knowing (i.e., procedures and conceptions) and dispositions in their work placements. They had previously encountered these dimensions in some form at campus and otherwise in their lives. Additionally, they come into contact with practices (i.e., knowing) not previously encountered at campus. These experiences constitute subjectivity in construing learning as it arises in

workplace situations, and thus development of students' personal epistemologies in work settings. Table 1 sums up our findings and the various expressions related to the three prevalent themes in the students' accounts.

Table 1. Enacting personal epistemologies in work placement practices

Personal epistemologies	Expressions as derived from students' accounts
Risk	Students being afforded with independent decision-making and with tasks that require independent measures to solve. Independence provides valuable opportunities for learning.
Routines	Various tasks prove context-sensitive. Enacting practices continuously provide unforeseen obstacles and challenges.
Values	Encountering various work-related situations can make students consider new approaches to problems. These encounters also engender students' consideration of individuals' subjective role in work and worthwhile work to pursue in future situations. Subjectivity in terms of students' life histories can be negotiated continuously in enacting work.

Music Performance students have engaged with musicianship procedures for several years when playing instruments. During their workplace experiences, however, students were afforded engagements with concert performances that had an influence on the local community. The planning had to consider several contextual factors. The performance itself became less prominent in the face of the integration of performances with the local community. This corresponds to the fish health profession students who have advanced their laboratory capabilities during their campus-based experiences. In work settings, this knowing was challenged because multiple confounding factors had to be accounted for (e.g., weather, limited time, and the opinion of the local farmers). The teacher students experienced similar developments where some found that keeping their pupils focused was less important than

anticipated. Instead, their principal challenges were unanticipated instances, such as hallway encounters or one-to-one counseling.

Expressions of knowing and working experiences

The workplace practices with which the students engaged, made the students consider expressions of dispositions, and conceptual and procedural knowing across all participants and programs. However, the findings reveal that there was increased emphasis on particular expressions in different programs. The Aqua Medicine students gave accounts of a dichotomy between their schooling at campus, which provides extensive conceptual knowing, and procedural knowing provided in their work placements. This was evident in accounts such as how the students found they could not really count the lice on fish. According to one student, counting lice was something they had learned at campus, but was unable to complete in the work placement. In contrast, the Music Performance students revealed that aspects of their procedural knowing were extensively engaged through their overall experience as musicians, and at campus. They engaged with other domains of knowing in their work placements, namely how communities and musicians interact in the enactment of concerts and other performances. Thus, the understanding of concepts was developed for Aqua Medicine and Music Performance students, where lice counting and performance encapsulated aspects they had not considered prior to the work placement.

This dichotomy between affordances of knowing at campus and through work was highly problematic among some Aqua Medicine students. The enactment of their occupation was seen to more legitimately take place in work placements than at campus. This tension between occupational- and campus training has been documented in several education programs, such as in teacher education (e.g., Korthagen 2010). Across all participants and work placements, the tension emerged as: (i) conflicting recommendations for literature as experienced by teacher students, (ii) as complexities in sampling and laboratory work among

Aqua Medicine students, and (iii) as ways to follow fellow musicians in participating in an orchestra, or the enactment of a successful performance with a variety of communities to attend to among the Music Performance students. In these cases, students seemed to convey that they had been misled on campus at some point or given an inaccurate representation of enacting work.

Aqua Medicine Education is aimed towards a specific occupation, as opposed to other biology students, with whom they share a substantial amount of coursework. It is therefore interesting to note that a perception of misleading content at campus exists in the Aqua Medicine program. The shared coursework raises questions as to the extent to which this tension is promoted by work placements or is also prevalent in disciplinary educations. Given this, it is important to emphasize that the students' expositions still indicate that their engagement with complexities through work further developed their critical sense as to what constitutes valuable learning at campus. That is, to what degree it is valuable to implement concepts, procedures and values as disseminated by teachers in their understanding of their work as Aqua Medicine Biologists.

According to the students' utterances from all three programs, we suggest that the students have developed their independent understanding of their education. They better understand how to enact their knowledge and what knowledge to pursue further. In other words, we have documented instances of procedural and conceptual learning, which is superseded by the students' accounts of their subjectivity in engagements with practices. These findings align with diverse approaches to learning in higher education (Billett 2009b; Eraut 2004). Baillie, Bowden, & Meyer (2013) criticize the strong emphasis on singular iterations of knowledge (i.e., procedures and concepts) in higher education, and call for a new focus on individuals' dispositions to act at a later stage. That is, what procedures and concepts the students will pursue, and the extent to which they will put effort into their learning. Indeed,

several authors have found that dispositions have a close relationship with learning (Hodkinson et al. 2008; Prawat 1989). In our study, this is also illustrated by the teacher students' emphasis on being provided with an appropriate level of freedom to experience risk and to autonomously plan and execute lessons.

[Please insert Figure 1 about here]

Conceptual model

We have employed a wide conceptualization of students' engagement with work placement epistemologies by including concepts, procedures, and dispositions. The purpose of this wide approach was to make use of developments in practice-oriented research that conceives of learning through practice by analyzing knowing in diverse expressions (Billett 2001; Duguid 2005) and to capture their relevance to investigate three different work placement schemes.

An important finding concerns the differentiating dimensions of conceptual and procedural knowing enacted by the students. A second finding concerns students' dispositions, which is based on an emphasis on students' volition to engage with the knowing that develops in working practices. This volition is based on individuals' dispositions as they are formed through individuals' life histories, and further developed as students engage with work in the context of their studies.

The workplace practices were enacted in communities, such as those encountered by setting up a show in a small town (Music Performance students), in the rural culture of Western Norway (Aqua Medicine students), and the school community (Teacher Education students). The communities initiate practices that accommodate students' learning through their engagement, and shape students' propensities to further engage in the practices. These engagements shape students' development trajectories and an understanding of their present and future work.

Magolda, Abes, and Torres (2008) hold that students' encounters with diverging knowledge claims, including those underpinned by various social settings (e.g., campus and workplaces) are crucial for the development of subjectivity in their knowledge claims. Thus, the extent to which procedures and concepts are developed can hardly be separated from their personal epistemologies. Our findings support the notion that crucial learning within work placements is not necessarily connected to the access students are given to specific iterations of knowing. Instead, the learning is connected to the development of personal epistemologies that are born from encounters within the work placement. We propose the following model (Figure 1) to conceptualize the relationships between workplace practices, the knowing found in enacting these practices, and personal epistemologies engendered by engaging and discussing knowing.

The three instances proposed in Figure 1 (practices, knowing, and personal epistemologies) should not be construed to be causal. Rather, all three instances coexist and develop concurrently as individuals engage in working practices. As argued by Rogoff (1995) and other sociocultural learning researchers, discerning learning as continuous implies concurrent rather than intermittent development in individuals.

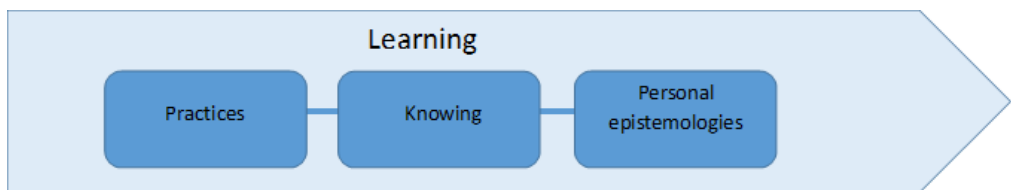


Figure 1. Theoretical conceptualization of work placement learning and personal epistemologies as drawn from our analysis.

Conclusion

By documenting how knowing and dispositions intermingle in the students' accounts of personal epistemologies, we have aimed to provide a new lens through which educators and

researchers can understand learning through work placements. In pedagogical terms, the inclusion of dispositions can be a valuable asset to traditional focus on conceptual knowing in relation to students' education. Further study is required to gauge the extent to which students' perception of highly crucial learning occurs solely in work placements, which should indicate change in teachers' approaches to students' learning in campus. Nevertheless, simply acknowledging the complexities of practice in regular teaching can aid students to adjust expectations and enactment of their knowing as in work placements.

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