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# How do signature pedagogies get their signatures? The role of assessment and professional artefacts in preparing students for their professions

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## ABSTRACT

Signature pedagogies are widely used in professional education to prepare students for the complex and unpredictable nature of professional work. We argue that assessment moments involving professional artefacts contribute to the evaluation and formation of professional knowledge, skills and moral understandings – and thus to the signature of the pedagogy. The ‘authenticity’ these professional artefacts add to assessment is of particular relevance for understanding the pedagogic signature. Drawing on interviews from a professional study programme in dental hygiene, we employ sociocultural theories to analyse how different assessment moments are used to evaluate and develop students’ competences of working with professional artefacts: dental radiographs. The findings show how the use of professional artefacts in three different assessment moments requires students to engage deeply with the epistemic, practical and moral dimensions of their profession. Our study contributes both empirical and conceptual insights to the field’s understanding of the inner workings of signature pedagogies.

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## Introduction

Professionals need to be able to respond competently and efficiently to often irreversible and high-stakes work situations. This need poses a great challenge to professional education, which must prepare students for the complex and unpredictable nature of professional work (Squires, 2005). The preparation for such situations cannot take place in isolation and out of context. Instead, students need to develop good professional habits that will allow them to later make professional decisions based on appropriate knowledge, practical skills and moral reasoning in an integrative manner (De Lange et al., 2018, 2020).

In response to these challenges, professional study programmes typically develop distinct ‘signature pedagogies’ through which students learn the ‘three fundamental dimensions of professional work – to *think*, to *perform*, and to *act with integrity*’ (Shulman, 2005, p. 52, original emphasis). As Shulman notes, most signature pedagogies involve educational settings where students need to publicly perform as practitioners.

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Such settings are typically ‘assessment moments’, where students must demonstrate their professional knowledge and skills while performing a professional task. From an assessment *for* learning perspective (Wiliam, 2011), such performative assessment moments always serve both formative and summative purposes. They provide students with opportunities to develop and practice relevant professional skills, while at the same time allowing teachers to assess and certify the students’ competencies. To understand how signature pedagogies are used to prepare students for professional work, one relevant avenue of study is to examine how these assessment *for* learning practices as core features of signature pedagogies contribute to students’ development of professional knowledge and skills.

Previous research has shown that the way in which assessment is designed and implemented in any study programme is influenced by often taken-for-granted knowledge, norms and practices of the respective discipline (Buchy & Quinlan, 2000; Cowie & Moreland, 2015; Esterhazy, 2018; Havnes, 2004). While assessment designs are sometimes inherited from previous course leaders and seemingly influenced by mainly pragmatic considerations, we argue that even in such cases the assessment designs have originally developed in response to the implicit expectations and norms around what is considered appropriate assessment in the given discipline. The same applies to signature pedagogies, where the format, timing and content of the assessment are often implicitly shaped by the underlying professional knowledge, norms and values.

Disciplinary practices also influence which *artefacts* from the professional context are used in the assessment of professional education (Esterhazy, 2018; Havnes, 2004). Such artefacts might include specific equipment, knowledge resources, or procedures that are often unique to the profession and require a deep understanding of professional norms, conventions and standards (Wertsch, 1994). Assessment moments that are used to evaluate students’ competence in using professional artefacts are therefore interesting study objects, as such moments constitute a link between professional and educational settings and can provide deeper insights into the workings of signature pedagogies.

Based on these considerations, this study aims to investigate the role that assessment moments play in the context of signature pedagogies and how the use of professional artefacts in these assessment moments contributes to the ‘signature’ of the pedagogy. To this end, we draw on student and teacher interviews in a professional study programme in dental hygiene to study how teachers use different assessment moments to assess and support students’ competences in using professional artefacts, and how students develop their professional skills and knowledge through these assessment moments. Among the core professional artefacts in the dental hygiene programme are dental radiographs, which are used to evaluate the oral health of patients during clinical examinations. With a focus on these radiographs, we address the following research questions:

- How do the course teachers use assessment moments to evaluate and develop students’ professional skills, knowledge and moral understanding related to radiographs?
- How do students make sense of relevant professional skills, knowledge and moral understanding through their engagement with radiographs in the different assessment moments?

In the remainder of the article, we review the empirical literature on signature pedagogies and assessment before elaborating on the conceptual notions of professional artefacts and their mediational role in professional learning. This review prepares the foundation for addressing our research questions based on the findings from our empirical study.

## Signature pedagogies and assessment

Scholars have studied signature pedagogies in various professions, including law (Sullivan et al., 2007), medicine (Bryant & Milstein, 2007), nursing (Benner et al., 2009), social work (Wayne et al., 2010) and design (Crowther, 2013; Motley, 2016). What these signature pedagogies have in common is that they all aim to develop professional knowledge and skills in an integrated manner (Shulman, 2005). Doing so involves learning across different educational settings such as seminars, clinical trainings, or internships. In these different settings, students are expected to develop the integrated knowledge, skills and morals of their profession, which Shulman calls the ‘habits of the mind, hand and heart’ (2005, p. 59). While Shulman does not explicitly mention artefacts, becoming a professional also involves the development of skills and knowledge related to the competent use of the equipment, resources and procedures central to professional work. The ambition to develop competent professionals thus implies that signature pedagogies need to involve assessment moments where students must demonstrate and develop their ability to use professional artefacts in a competent and integrative manner. This scenario poses a specific challenge for the design of assessment in professional education.

Indeed, research on assessment across different disciplines has generated evidence that assessment in professional education generally differs from that in non-professional education. A large-scale mapping of assessment forms in the UK revealed that professional students received more than twice as much oral feedback as non-professional students did (Jessop & Malekar, 2016). Further studies have shown differences between professional and non-professional disciplines in assessment and feedback (Nesi & Gardner, 2006; Neumann, 2001). In this regard, the notion of ‘authentic assessment’ is noteworthy. ‘Authentic assessment’ concerns the introduction of realistic tasks into assessment situations (Osborne et al., 2013), with the intention to bridge the theory-practice gap students commonly experience in professional education. To overcome this gap, ‘authentic assessment’ is introduced in many professional disciplines as practical tasks in concrete assessment situations that challenge students to identify and discriminate knowledge-aspects and ethical issues during practical decision-making (De Lange et al., 2020; Tennant et al., 2010). Thus, ‘authentic assessment’ closely resembles the idea of habits of the mind, hand and heart being engrained in assessment moments.

The question of how assessment moments involved in a signature pedagogy relate to the development of professional skills and knowledge has only received limited attention in the literature so far. Some exceptions include studies on design education that have shown how the assessment moments found in ‘crits’ (i.e. public presentations and assessments of design models) ‘encourage students to adopt the habits, mind-sets, and ways of performing that will be required of them in the workplace’, thereby making them central to these professions’ signature pedagogy (Motley, 2016, p. 239). Another study on crits included a survey that found that students perceived the feedback they received during crits as more engaging and relevant for their learning than more

traditional feedback on written assignments in other subjects (Schrand & Eliason, 2012). Similarly, Heinert, 2017, p. 293) suggests that assessment moments in the form of peer critique are a central part of the signature pedagogy in writing studies, through which students learn to use ‘their heads, hearts, and hands to try on the role of experts’. She argues that these assessment moments help students understand that sharing their texts and providing feedback to each other is a central skill that must be mastered in order to become a proficient writer. The design models, text drafts and procedures of critique commonly used in these different assessment moments are all examples of professional artefacts that students need to learn to use on their way to becoming competent professionals.

The above-referenced studies suggest that signature pedagogies entail various assessment moments involving professional artefacts that serve the integrated development of relevant professional skills and knowledge. While professional artefacts have remained implicit in much of the empirical work on signature pedagogies so far, we argue that the role of such artefacts in these assessment moments in particular deserves further attention. In this study, we therefore focus on those assessment moments that involve professional artefacts to understand how the use of these artefacts supports students in their development as professionals along their educational paths.

## Conceptual background

We take our point of departure in the sociocultural perspective on human development and learning (Vygotsky, 1978). In this tradition, learning is seen as the transformation of individuals into sociocultural beings that are equipped with the cultural and intellectual skills relevant for participating in the social practices of their society. Central to this idea is that all human action, including reasoning and learning, is mediated by cultural artefacts that have developed over time and are embedded in the meaning systems of the given social context (Wertsch, 1994). Such artefacts may be either of intellectual (e.g. concepts, symbols) or material (e.g. pens, paper) nature. Mediation means that the use of artefacts transforms the ways in which humans reason, think or carry out activities. In order to become sociocultural beings that are full member of society, they need to learn to use the cultural artefacts that have developed as part of social practices.

In the context of professional education, becoming a professional entails that students need to learn using the intellectual concepts, processes and material objects that are central to their profession. We define these specifically as ‘professional artefacts’ that mediate human action in the context of professional practice. Such artefacts have primarily emerged from the existing meaning system of the professional practice over time and are instilled with the collective knowledge, norms and conventions of the profession from which they are derived. Based on these derivatives, when artefacts are activated during the flow of professional work, they also mediate individual perceptions in the way the practitioners act and make meaning of their work.

Among the professional artefacts used in the dental hygiene profession are dental radiographs. Working with these artefacts requires professional dental hygienists to recognise patterns, discriminate normal from abnormal features, formulate diagnoses and decide on further treatment (Van Der Gijp et al., 2014). These proficiencies require knowledge about anatomy, radiological imaging techniques and an acquaintance with

the clinical context (Van Der Gijp et al., 2014). In order to prepare students for these requirements, the signature pedagogy of the dental hygiene profession includes sequences of action that manifest as assessment moments whose purpose is to develop and judge the students' ability to generate and interpret radiographs within the accepted knowledge base of the profession.

In the context of our study, we define 'assessment moments' as situations where students need to demonstrate and are assessed on professional knowledge, skills and norms related to radiographs. These moments entail both situations that serve purely formative purposes as well as situations that lead to the generation of summative grades. Such assessment moments might be embedded in various educational settings such as seminars, final exams, or clinical training. Based on our conceptual ideas outlined above, we argue that assessment moments give students opportunities to practice and receive feedback on their evolving competences in using radiographs. These opportunities in turn help students make sense of the practical, epistemic and moral dimensions of their profession. On the practical dimension, students learn which concrete actions to perform when working with radiographs, which in Shulman's (2005) words refers to developing the 'habits of the hand'. On the epistemic dimension, students develop the relevant knowledge, theories and concepts necessary to gain deeper insights when working with radiographs, linking to Shulman's 'habits of the mind'. Finally, on the moral dimension, students develop an understanding of professional norms and standards involved in working with radiographs, which accounts for Shulman's 'habits of the heart'. While these dimensions are closely intertwined in practice, their distinction has value for analytical purposes.

Based on the above conceptual basis, we will analyse how different assessment moments involving radiographs contribute to students' development of the three habits. In accordance with the sociocultural perspective, we term these three habitual elements *practical*, *epistemic* and *moral dimensions* of the profession. In this way, we aim to illuminate the significance of using professional artefacts in assessment moments and to understand what role these artefacts play in constituting a signature pedagogy that supports students' development of integrated knowledge in their profession.

## **Empirical setting of dental hygiene education in Norway**

Our empirical setting is a dental hygienist bachelor programme situated at a large university in Norway. The dental hygienist profession focusses on examining and caring for the patient's teeth and providing guidance on good oral hygiene. Dental hygienists can open their own practices but typically work in teams with dentists and other dental specialists in larger clinical settings.

As with other professional education, the study programme in dental hygiene is characterised by a signature pedagogy that entails distinct teaching, assessment and feedback practices. Studies from the US and the UK (Albino et al., 2008; Hay et al., 2010) have shown that dental health study programmes typically include assessment methods such as multiple-choice tests, evaluations of student-patient interactions and standardised examinations in which students rotate among a series of stations. Similarly, the study programme in our case of oral radiology contains a variety of assessments linked to different educational settings. These settings include seminar teaching and clinical training, both of which are integrated throughout the first and second year, ending in a written exam in oral radiology

**Table 1.** Structure of the dental hygienist bachelor programme with emphasis on oral radiology.

Semester	Lectures/seminars/demonstrations	Clinical training	Internship
1	General introduction to ethics, history of philosophy and science, public health	Pre-clinic	N/A
2	Odontological disciplines, public health, pathology, oral radiology	Adult/children/oral radiology clinic	6 weeks
3	Public health, societal dentistry, pharmacology, pathology, oral radiology	Adult/children/oral radiology clinic	6 weeks
4	Public health, odontological disciplines, oral radiology	Adult/children/oral radiology clinic	6 weeks
5	Public health and clinical specialisation, thematic weeks, odontological disciplines, project work	Intra-oral examinations in adult/children clinic	6 weeks
6	Public health and clinical specialisation II, final theory and clinic, bachelor thesis	Intra-oral examinations in adult/children clinic	N/A

at the end of the fourth semester and an integrated practical examination (including oral radiology) at the end of the sixth semester. In addition, teachers formatively assess and provide feedback on practical competencies during teaching and clinical trainings throughout the four semesters (De Lange et al., 2018). See Table 1 for an overview of the study programme's structure.

## Methods

The conceptual considerations above call for a qualitative methodology that allows us to gain rich insights into the underlying reasons for how radiographs are used in assessment moments and how students associate these moments with the development of their professional habits. For this reason, the main data draws on semi-structured focus-group interviews and plenary discussions from four distinct student cohorts (2015, 2016, 2017 and 2018) in the dental hygiene study programme. The populations in these student cohorts were respectively  $n = 16$ ,  $n = 32$ ,  $n = 18$  and  $n = 22$ . The aim of the student interviews – which were originally conducted as part of another research project focussed on the digitisation of the written exam for the oral-radiology course – was to investigate how students in the current study programme experienced the conversion from analogue to digital exams (De Lange et al., 2018) and video-based assignments (De Lange et al., 2020). Students were interviewed at the end of the fifth semester, which occurs around six months after the summative written exam in oral radiology is administered. The data collections in 2015 and 2016 were based on focus groups with four informants each, while the 2017 and 2018 data collections included eight informants each (total of  $n = 24$ ). All the informants signed up voluntarily for the interviews with informed consent, which allowed the informants to withdraw from the study at any point without further explanation. All interviews were conducted in Norwegian and transcribed verbatim; the English translations have been edited lightly for this paper. In this process, the informants' identities were fully anonymised.

Repeated readings of the data material from the original project (a total of 132 pages of transcripts) revealed that the interviews also provided rich insights into the students' experiences of working with radiographic images during other assessment moments in the study programme. For this reason, no further student interviews were conducted for the present study. In addition, we conducted an in-depth interview with the main teacher

in oral radiology (who is also the third author), in which we focussed on the reasons and intentions behind the different assessment moments related to dental radiographs in the study programme (a 15-page transcript).

We acknowledge that the third author's role as lecturer in the dental hygiene study programme has potential influence on the findings of this study. For this reason, we maintained a strict division of labour where the first two authors were solely responsible for analysing and reporting the findings. The third author remained in a participatory role during the data collection and analysis phase and only later contributed to this article with further elaborations and insider knowledge on the study programme. In light of our qualitative research design, we considered the ability to check interpretations and data readings with one of the main informants well familiar with the empirical setting as an advantage.

We analysed the interviews following a thematic analysis method (Braun & Clarke, 2006) with a deductive focus. Choosing this theory-driven method allowed us to target our analysis specifically to those themes that we had identified as relevant through our previous conceptual considerations and literature review. In a first step, we read through the teacher transcript with the aim of identifying patterned responses, in which the teacher referred to assessment moments involving radiographs. These assessment moments were operationalised as situations, in which students had to perform certain tasks related to radiographs (such as *generate*, *interpret*, or *discuss*) that were either assessed with a grade or included formative feedback. For each response, we identified which assessment moment it referred to and which professional habits the teacher highlighted as important (see Table 2 for example, excerpts). The resulting codes were summarised into rich descriptions of three main assessment moments in the study programme, thus addressing the first research question of how the course teachers use assessment moments to evaluate and develop students' professional skills, knowledge and moral understanding related to radiographs.

Second, we identified all student responses relating to the three previously identified assessment moments and coded for themes of how students reported on their development on the *practical*, *epistemic* and *moral dimensions* of the profession (see Table 3 for example, excerpts). The results were used to address the second research question of how the students make sense of relevant professional skills, knowledge and moral understanding through their engagement with radiographs in the different assessment moments.

**Table 2.** Example excerpts – teacher interview.

Excerpt	Themes
"In the seminars, students learn to investigate the images. The teacher tells the students 'You should know all structures. Whenever I point to any part of the image, you should know what it is. No matter where it is. Because this is what you need to learn, so that you know what is the normal anatomy no matter where I point at any dental radiograph'. (teacher)	Assessment moment: Analysis of radiographs during seminar Professional habits: Ability to identify normal anatomy on radiographs
"They have two 'semester tests' with practice exercises about normal anatomy and legal frameworks that they need to pass in order to continue. These tests are there to ensure that students know these topics very well." (teacher)	Assessment moment: Radiology semester tests Professional habits: Knowledge about legal frameworks and normal anatomy



**Table 3.** Example excerpts – student interviews.

Excerpt	Themes
'This analysing of images during our radiographic practice [ <i>author's note: during the clinical training</i> ] really made our learning curve [ <i>author's note: in the oral-radiology course</i> ] much more intensive. And afterwards, I think I got much better in the radiographic practice as well' (student/2015)	Assessment moments: Analysis of radiographs during clinical training & oral radiology seminars Development of professional habits: Improvement of knowledge about anatomical structures (epistemic) and practical approaches of how to describe normal anatomy on radiographs (practical)
'I think anyway that the exam in this form [ <i>author's note: refers to exam questions that require naming of anatomical structures on radiographs</i> ] has been completely relevant and exactly what we do. And it has been a very practical approach. I agree that it was exactly as if the clinical work got easier.' (student/2015)	Assessment moments: Written oral radiology exam Development of professional habits: Increased knowledge about anatomical structures on radiographs facilitates work with radiographs in practice (epistemic)

## Findings

The interviews showed that the dental hygiene study programme involved various assessment moments, in which students were evaluated and received feedback on their performance of professional tasks related to radiographs. Students and teachers alike highlighted the radiographs as central parts of the dental hygiene profession and the study programme. The following student quote illustrates this view clearly: 'We use [radiographs] every day in the clinic. We use them every time we have a patient. So oral radiology is really an incredibly important subject and one we use all the time' (student/2015). This statement was echoed by the teacher, who acknowledged that she 'couldn't have a single teaching session, nothing, without showing [the students] radiographs' (teacher). The interviews also revealed that students' engagement with radiographs revolved around assessment moments that were embedded in different educational settings that fulfilled different purposes.

In the following sections we present three different assessment moments involving radiographs that took place in three different settings: seminars, exams and clinical training. We selected these moments for deeper analysis because they are particularly illustrative of the signature pedagogy in the dental hygiene programme observed in this study. For each assessment moment, we present the teachers' reasoning of how these assessment moments were intended to help the students, followed by how the students made sense of how these assessment moments had contributed to their professional formation as dental hygienists.

### **Assessment moments in seminars**

During the first two study years, students participate in seminars in oral radiology on topics such as normal dental anatomy, caries and bone structure. The seminars involve frequent assessment moments that typically involve wall projections of radiographs, upon which students need to identify normal anatomic structures and discuss their observations in groups and with the teacher. In these formative assessment moments, the teacher asked the students 'to come up to the screen [and point at and describe what they see on the images] . . . so that they can discover for themselves, and I can discover what they see and can help them' (teacher). In this process, the students were challenged to describe and explain what they observed on the radiographs, which gave the teacher

the opportunity to identify any difficulties and knowledge gaps in the way the students perceived these images. In this way, the teacher could assess and help students to develop self-awareness, both on the practical and epistemic dimension of looking at radiographs through the eyes of an experienced oral radiologist.

According to the teacher, 'the first time a student sees a radiograph, they don't have the cognitive possibility to see what I see' (teacher). For this reason, she always pointed out very explicitly what she saw on an image during these assessment moments in order to help students see the same; she also ensured that the students could draw connections to the theoretical knowledge presented in the seminars. In this regard, the teacher also emphasised feedback as an important part of these assessment moments. In the group discussions of radiographs, students learned to self-assess which anatomical structures they felt confident identifying on their own and for which parts they needed to ask the teacher for clarification. These assessment moments 'get the students to discuss things with each other first, so then they can be much more precise about what they're wondering about when they come and ask questions, because they've excluded many options on their own beforehand' (teacher). Doing so allowed students to make sense of what kind of epistemic knowledge was required to later make competent judgements on their own.

Another aspect of these assessment moments was that the students developed practical skills in writing down what they saw in the radiographs. These exercises prepared students for the final exam but also for their clinical training, where they need to be able to write reports about the anatomical structures visible in a radiograph. To support students' development on the practical and epistemic dimension, the teacher repeatedly challenged students in these point-and-tell assessment moments. She explained that 'whenever I point to any part of the image, [the students] should know what it is. No matter where it is. Because this is what they need to learn so that they'll know what the normal anatomy is' (teacher).

Students appreciated these formative assessment moments during their oral-radiology seminars, where they could practice analysing different radiographs and point out anatomic structures. They expressed that these moments prepared them well for the final exam, which was reflected in the fact that they were not surprised about the questions they received. The students also perceived that the assessment moments in the seminars had a positive learning synergy with the moments in the clinical training. One student explained that 'this analysing of images during our radiographic practice [during the clinical training] really made our learning curve [in the oral-radiology course] much more intensive. And afterwards, I think I got much better in the radiographic practice as well' (student/2016).

In summary, the assessment moments in the seminars supported the students in developing primarily on the practical and epistemic dimensions of their profession. Students learned practical skills by performing point-and-tell demonstrations in front of an audience, formulating precise descriptions of what they saw on radiographs and asking relevant questions to clarify what they had seen. On the epistemic dimension, students developed knowledge of normal anatomy and pathology and how to explain the structures they had observed based on disciplinary conceptions.

Our findings also illustrate the two-fold sociocultural notion of artefacts in these assessment situations. The teacher presented pre-selected radiographs as professional

artefacts derived from and instilled with the generalised knowledge, norms and conventions of the profession. At the same time, the students took these artefacts into use during concrete sequences of action performed through their point-and-tell demonstrations, which then contributed to the students' unique learning experiences and professional formation.

### ***Assessment moments in exams***

At the end of the fourth semester, the students take a summative written exam in oral radiology that requires them to identify and explain anatomical structures on high-quality static radiographs. Until this exam, the only summative assessments in oral radiology they receive are two shorter tests with questions about normal dental anatomy and legal frameworks that students need to pass in order to continue. These tests are intended to ensure that students have a good knowledge foundation of relevant topics for their work with radiographs in clinical settings. Students highlighted the exam and the tests as important preparation for their professional practice. In this regard, they mentioned various epistemic, practical and moral aspects related to radiographs that they needed to master to do well on the exam. These aspects included (1) theoretical knowledge about anatomy, pathology and radiographic techniques; (2) skills of identifying and describing normal dental anatomy and distinguishing normal from deviating structures that might be pathological; and (3) knowledge about legal regulations that determine when exposing patients to radiation is ethically appropriate.

Generally, the students thought of these summative assessment moments as certifications of their professional competence and stated that passing the exam 'helped make the clinical part easier' (student/2015). They especially considered those exam questions useful that related to topics they were often asked about in formative assessment moments during clinical training. In describing such a situation, one student explained that 'the [clinical] examiner pointed at a structure and asked, "Can you explain what this is?" And, because of this written exam, I feel that most of us are now fairly confident in describing normal anatomy' (student/2015).

Other students explained that the exam did not prepare them sufficiently for some aspects of clinical practice. One informant pointed out that she had encountered radiographs during her clinical training in a children's clinic, which they 'did not have anything about in our oral-radiology exam' (student/2015), because the radiographs used in the exam were only from adult patients. This situation indicates that the students treated the exam questions in the oral-radiology exam as a knowledge repository for their future practice. As mentioned by one student, students would sometimes use memorised answers from exam questions in their clinical practice 'so that you actually have something to say when you get this question from a patient' (student/2017).

In summary, the written exams and tests in oral radiology were generally considered to be formal milestones in the study programme used to certify and approve necessary practical, epistemic and moral understanding of how to operate, interpret and work with radiographs. At the same time, the exams also had a formative function, as they influenced how the students would work further with radiographs in other assessment moments and in future practice. In tests and exams, radiographic artefacts therefore appeared as more than just generalised knowledge sources, as the students used their

experiences from summative assessment moments in making sense of using radiographs in other educational settings, such as in the clinic and in professional practice.

### ***Assessment moments in clinical training***

A third setting with frequent assessment moments involving radiographs is the clinical training. The clinical part is divided into training in the radiology clinic and in the interdisciplinary adult and children dental clinic at the university campus. At the radiology clinic, students work exclusively with radiographs to become familiar with specialised radiological equipment. In the adult and children dental clinic, the work with radiographs is part of a wider set of tasks related to the general treatment of patients.

The assessment moments during clinical training comprised the repeated performance and assessment of practical tasks related to radiology, including generating, interpreting and communicating about radiographs. The teacher explained that students 'need to take images and interpret the images while the patient sits in the chair' (teacher), and every time they took a new radiograph, the clinical teacher asked the students, 'What do you see here with this patient?' These assessment moments required that the students demonstrate relevant practical skills and epistemic knowledge as well as the ability to make moral decisions related to radiographs and handling patient relations. An example is the decision on when to disclose information about possibly malign structures on a radiograph to the patient, and when withholding information until the student has double-checked with a specialist might be best.

Both the teacher and students emphasised that what is assessed as appropriate radiology practice during these assessment moments is not always easy to coordinate between specialised radiology seminars and other educational settings where students work with radiographic images. As the oral-radiology teacher explained, this situation 'has been a challenge throughout. Because we in the specialist [radiology] department think, of course, that we're the ones who should define how things should be done and that the practitioners in [other settings] should do the same. But . . . we meet challenges when they don't work in exactly the same way as the oral-radiology specialists' (teacher). This scenario can lead to conflicts between the best practices that students are assessed on in their oral-radiology training at university and the practices they experience in clinical training, during their internships and later as professionals. For students, these conflicts meant that they had to learn to differentiate between these different settings and to make appropriate decisions that would safeguard professional standards while allowing them to adapt to local routines and procedures.

For example, formal regulations define 'panorama radiographs' as being outside the dental hygienists' competency domain and are therefore not addressed in the written exam. The students in our study were aware, however, that in many professional contexts, dental hygienists commonly work with such panorama radiographs on patients. This discrepancy between formal radiographic standards and practical conventions caused the students to feel a distance between the epistemic domains represented in the written exams compared to the practical dimensions found in dental clinics, thus illustrating a tension in operating with these artefacts. As one student noted, 'When we begin to work, we're going to take [panorama] radiographs like this, and of course we can't take such images without knowing what they actually contain' (student/2015).

Given this discrepancy, whenever students knew they were expected to provide a formally correct answer during a test or an exam that was different from professional realities, they referred to these assessment elements as ‘trick questions’ (student/2017).

This situation illustrates how professional norms and standards related to the practical, epistemic and moral dimensions of working with radiographs emerge differently in various educational and professional contexts. The summative assessment moments require students to demonstrate formal knowledge, skills and moral understanding, but the question of how radiographs are handled in professional life requires students to make sense of and reason about informal rules that evolve in slightly deviating directions over time.

In summary, assessment moments in clinical training rendered situations where students were challenged on epistemic practical knowledge dimensions in generating, interpreting and communicating about radiographs. In addition, the students were required to demonstrate professional ethical decisions about when to take radiographs and how much information to disclose to patients. In these formative assessment moments, the students’ active role in taking images and handling patients illustrate the tension between generalised features of the artefacts and their unique understanding in performing in the clinic in realistic situations. This scenario makes the patient exam one of the most integrated assessment moments, as it covers all professional dimensions (epistemic, practical and moral), and students can most clearly sense how general norms from the disciplinary domain migrate into specific individual experiences and meanings when handling radiographic artefacts.

## Discussion

Our analysis demonstrates how working with radiographic artefacts is deeply ingrained in the teaching and assessment of the dental hygiene programme. Radiographs are professional artefacts that exist in almost infinite variations. This variability means that dental hygienist students need to become familiar with a range of professional knowledge, skills and norms that equip them for working with radiographs. The fact that radiographs are complex artefacts requires different forms of assessment compared to static artefacts of less complex format. What all three assessment moments in our study have in common is that they require students to demonstrate their ability to differentiate between various types of radiographs and situations so that they can cope with any contingencies that might emerge during their professional work. This observation supports our sociocultural argument (Wertsch, 1994) that the characteristics of the professional artefacts mediate the ways in which assessment moments are organised in a signature pedagogy and what students need to demonstrate in these assessments.

The student interviews revealed that when students were assessed in their use of these professional artefacts, they reported a deep engagement with their profession, which then shaped their way of thinking as future professionals. Taking the assessment moments in the clinical setting as an example, students needed to make sense of a range of norms, standards and knowledge. They had to be familiar with the norms and standards related to patient care in order to decide how to communicate about the radiographs with their patients. In addition, these moments required students to understand how radiation works and how different types of equipment could help them achieve the desired result, which in general is part of the disciplinary knowledge that students need to learn.

Similarly, students needed to know Norway's Act on Radiation Protection and Use of Radiation, which defines the professional standards of when exposing patients to radiation is appropriate.

Our findings also show that in different assessment moments, students needed to relate to diverse practices and standards. For example, the knowledge and skills assessed in the written oral-radiology exam were generally considered to be highly standardised and formal. Students saw the exam as a certification that their competence to work with radiographs was in line with professional standards. Still, they perceived the knowledge and skills assessed in the clinical training to be more idiosyncratic and closer to the 'messy' nature of professional work situations. We argue that learning to navigate the various practices and standards of the different assessment moments is a complex but crucial part of becoming a competent professional. Students need to understand the role of their profession with regard to radiographs, including which areas of responsibilities they are expected to take on and what the limits of their competencies are in comparison to the other professions they will encounter in their working lives. This understanding also includes being aware of areas of tensions, disagreements and conflicts between different stakeholders in the discipline. These insights suggest that assessment moments involving professional artefacts are among the central mechanisms by which signature pedagogies prepare students for the complex and unpredictable nature of professional work (Squires, 2005).

In consideration of the limitations of our study, we acknowledge that our focus on a single study programme and on interview data as only data source limits our ability to make wider claims about the frequency and distribution of how professional artefacts are used in different professional education programmes. While this is an important question that could be followed up in larger scale research, our study aimed primarily for theoretical generalisation (Eisenhart, 2009). To this end, we selected the dental hygiene programme as an empirical case suitable to 'establish, refine or refute' (Eisenhart, 2009, p. 60) our theorisation of the role of assessment and professional artefacts in signature pedagogies. By providing transparent descriptions of our methodology, theoretical assumptions, and empirical context we seek to provide a basis for the reader to judge whether this theoretical approach might lead to similar findings in other empirical contexts.

In continuation of our theoretical considerations, our findings link to Shulman's (2005) argument that most signature pedagogies include educational settings where students have to perform publicly as practitioners. We add to this argument by specifying these public performances as assessment moments and illustrating how the use of professional artefacts in these assessment moments makes them defining elements of the related signature pedagogy. Our analysis shows that assessment moments, where students need to demonstrate their ability to work with professional artefacts, become access points to professional practices. Similar to previous studies by Heinert (2016) and Motley (2016), we found that students developed professional habits of the heart, mind and hand when engaging in assessment moments of their study programmes. We have further expanded these findings by illustrating how engagement with professional artefacts in particular contributes to the development of these habits. In addition, our findings resonate with Schrand and Eliason's work (Schrand & Eliason, 2012), in that students experienced assessment moments

involving professional artefacts as particularly engaging and relevant, largely due to the formative feedback they received but also due of the experienced ‘authenticity’ these professional artefacts added to their performances (Tennant et al., 2010).

Our findings have also helped us pinpoint more explicitly how the development of a deep conceptual understanding is related to performing with professional artefacts, and the important role that connectedness and authenticity play in signature pedagogy. Professional artefacts are knowledge-carriers that travel across multiple contexts, thereby creating links between professional practice and educational settings in ways that endow the latter with qualities of authenticity. In this sense, using professional artefacts in assessment moments contributes to the students’ experience of authentic assessment (Osborne et al., 2013). To demonstrate their ability to work with these artefacts in a competent way, students must become familiar with multifaceted knowledge aspects, norms and conventions, both in generalised form but also in a tactile and social-relational sense (Wertsch, 1994). The boundary-crossing quality of these professional artefacts thus creates learning opportunities for students to develop as professionals in an integrated and authentic manner, which we consider to be a core trait of any given signature pedagogy (Shulman, 2005).

## Conclusion

This study has shown that assessment moments involving professional artefacts play a central role in making signature pedagogies effective in preparing students for their professional working lives. We have thus contributed empirical insights into the inner workings of signature pedagogies and how they are defined by students’ public performances in the form of assessment moments. Using the case of dental hygiene education, we have shown that the signature of this pedagogy is largely defined by an array of assessment moments in which students need to demonstrate and develop their professional skills and knowledge related to radiographs. These insights suggest that in both professional and non-professional educational-study programmes, teachers should consider the use of professional artefacts in assessments to help their students engage with the central knowledge and skills of the given discipline. In conclusion, our study has illustrated the explanatory potential of the sociocultural perspective and has opened up future research avenues to understanding the role of the material foundations and assessment practices found in different signature pedagogies.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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