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► To cite this version:

Lisa Björklund Boistrup, John Keogh. The context of workplaces as part of mathematics education in vocational studies: Institutional norms and (lack of) authenticity. CERME 10, Feb 2017, Dublin, Ireland. hal-01937431

HAL Id: hal-01937431

<https://hal.science/hal-01937431>

Submitted on 28 Nov 2018

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The context of workplaces as part of mathematics education in vocational studies: Institutional norms and (lack of) authenticity

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This paper presents an analysis of institutional norms and the authenticity of out-of-school contexts that are reflected in a film about mathematics teaching in a comprehensive in-service vocational studies programme. The analysis was performed through the lenses of a theoretical framework of learning in different contexts and an empirically derived framework of mathematics as part of workplace complexity. The comprehensive in-service programme, which is available on internet, aims to improve mathematics teaching and learning, nationwide in Sweden. Through our analysis, we highlight a dissonance between the pedagogical approach displayed in the film, and how its authenticity may be compromised from the perspectives of our analytical frameworks.

Keywords: Workplace mathematics, vocational studies, institutional norms, authenticity.

Introduction

A key assumption in this paper is that school, as an institution, has much to learn from workplaces. We adopt the view where mathematical notions are not only applied *at* workplaces but also are developed *in* workplaces (Wedeg, 2013). One argument presented is that the context of any workplace stands in stark contrast to a formal mathematics classroom, where calling on authentic everyday experience may inhibit school mathematical sense-making (Gellert & Jablonka, 2009). Simultaneously, the performance of different jobs may be underpinned by the similar mathematics concepts as in the school context, but often interwoven in complex activities. The difference is not only in the type of work done, but in the sophistication of their contexts, such that unproblematic transfer of knowledge and skills may be highly unlikely. From an educational perspective it is rather about recontextualisation (Bernstein, 2000, see also FitzSimons & Boistrup, 2017). Through recontextualisation, a practice (for example mathematics) is transformed, rather than transferred, to an education context. In support of professional development for mathematics teachers in vocational programs in upper secondary school, Skolverket (Sweden's Education Authority), produced, among articles and the like, a number of short films, each demonstrating ways of teaching and, in the case of this paper, taking relations between contexts of school mathematics and workplaces into account. Our contribution is concerned with how the institutional norms present in one such film may restrict authentic meeting points between workplace mathematics and school mathematics, and the possible implications for such a film. Our research question was: "What institutional norms may be construed through analysis of such a film, and what are the implications for vocational students of mathematics as part of their future work?" Through a description of our analysis, we highlight the dissonance between the pedagogical approach displayed in the film and how its authenticity may be compromised from the perspectives of our analytical frameworks.

Literature on mathematics: In work and in school

That the mathematics knowledge, skills and competence that underpin work may be denied, or dismissed as common sense may be a testament to its invisibility rather than its absence from the workplace (Boistrup & Gustafsson, 2014; Keogh, Maguire, & O'Donoghue, 2014; Williams & Wake, 2007). Mathematics may be something that workers use to solve problems or manage mathematics-containing situations, and may be observable as numerate behaviour (e.g. Gal, van Groenesteijn, Manly, Schmitt, & Tout, 2003). In contrast, school mathematics is topic-specific, determined by curriculum, shaped by prescribed text, built on layers of escalating complicatedness, taught to the rhythm of the semester, and formally assessed as a *passepourtout* to the next level of complicatedness. Whether its transferability is enabled by the context in which it is learned or contained by it, is disputed (Evans, 2000; FitzSimons & Wedege, 2007). The introduction of 'real-world' mathematics to the classroom offers the prospect of easing the transformation from formal mathematics learning to its application in work situations. Nevertheless, it is often constrained and reduced to mathematics word-problems surrounded by 'real world' conceits, that may be "inauthentic... fragmented, static bits of tasks.. that are neither contextualized nor intellectually challenging" (Wiggins, 1989, p. 711).

In Keogh, Maguire, and O'Donoghue (2016), a Workplace Context Complexity Protocol (WCCP) is presented. It identifies workplace competence, in relation to mathematics, as being shaped by strands such as familiarity and stressors. The ability to capture and calibrate the features of many workplaces, informed by the students, may enable teachers to build a platform to establish authentic, credible and familiar workplace contexts in which to set and explain mathematics as part of workplace complexity. In Boistrup (2016), a case of a nursing aide is presented drawing on different sociological frameworks, indicating connected notions as in Keogh et al. (2016). In the analysis of the study presented in this paper, we drew on findings from these two studies.

Analytical framework

Selander (2008) presents a design theoretical perspective of learning when he explains how learning may take place in relation to its communicative constituents and associated processes, and where the design of a setting affects possible learning. This perspective is underpinned by Institutional Theory (e.g. Douglas, 1986), which emphasizes how society is surrounded by institutions which condition the actions that are possible to take. The perspective is similarly influenced by multimodal social semiotics as described by Van Leeuwen (2005) and others, where emphasis is put on the ways in which communicative resources are used, such as speech, artefacts, gestures displays and the like, and the roles they might occupy in the setting. From this perspective, learning is considered to take place in all kinds of settings, for example, the situation as reflected by the learning required to buy a bus ticket in an unfamiliar city. It could also encapsulate a workplace, where, typically, the main institutional norm is to "get the job done", part of which includes some learning.

Selander (2008) also specifies this theory in terms of a formal setting of learning, such as a mathematics lesson. In this paper we draw on the following selection of facets of this theory, highlighted in italics:

- We analysed the *institutional framing* of the lesson of the film, and the purpose of the chosen *curriculum*. We also paid attention to the *learning resources* that were present.
- We analysed the *social interaction* between teacher and students in terms of displayed *interest* in the communication, informal *assessment acts* and *teacher interventions*.
- We analysed how, and through which communicational resources (e.g. speech and hand gestures), teacher and students *presented* the *processes* undertaken during a problem solving activity. In addition, we analysed how, and with what focus, students were *meta-reflecting*, i.e. reflecting on their own actions.

In the analysis, we adopted the WCCP protocol by Keogh et al. (2016), using attributes from the strands comprising the model, e. g., *accountability*, *clarity*, *familiarity*, *stressors* and *volatility*, to capture the matrix of factors that are thought to define, enable and constrain performance in work.

Methodology: Case study and analysis

This is a case study (Yin, 1984) wherein the primary data source is a film that is part of a ‘module’ on mathematics in vocational studies, upper secondary level, within a larger nationwide in-service program. The vocation of the students participating in the film is not made clear. However, as the context is introduced by the teacher as being concerned with a patient and her medication, we found it reasonable to infer that the students in the film are prospective nursing aides. We do not seek to analyse what the teacher is saying and doing *per se*, but rather to examine the messages being projected by the Swedish Agency for Education to teachers, albeit through the medium of an abridged video provided for teachers in the agency’s official website. Secondary data, analysed for interpreting the film’s message from its institutional context, stem from a discussion template to guide teachers’ in discussing the film, an interview with a home-caring nurse, potential parts of the module where the vocation of home-caring nursing aides are described, and the national syllabus for mathematics in upper secondary school, vocational studies (Skolverket, 2013).

The design theoretical perspective of learning was used in the analysis of the different processes in the film, which helped both in describing the lesson, and in the construal of institutional norms as reflected through the filmed lesson. The theory offers a framework with which to analyse learning with a particular focus on instances of institutional norms that are ‘there’ from the ‘beginning’, shaping, and perhaps containing the possible setting and learning activity. The perspective does not focus, specifically, on the content being taught and learnt. In our analysis we coordinated the design theoretical perspective with the framework by Keogh et al. (2016) in order to address how the teaching objective being illustrated, e.g. relations between workplace mathematics and general mathematics, is presented.

We transcribed the film multi-modally (Van Leeuwen, 2005), documenting what was being said and done, by whom, and identifying the artefacts that were being used and how. In the first step of analysis we both analysed the data through the two different frameworks i.e. Selander’s perspective and Keogh’s WCCP (Selander, 2008; and Keogh et al., 2016) separately. In this analysis, we

compared the transcript of the film with the concepts of the frameworks and with the secondary set of data. In a second step of analysis, we focused specifically on institutional norms while building on the findings from the previous analysis. The kind of institutional norms that we construed concerned relations between school mathematics and workplace mathematics. In this paper, we account for our analysis of the teacher's introduction and our analysis of the first student's contribution and whole class discussion.

Analysis and findings: A mathematics lesson claiming to draw on workplace 'reality'

This section describes our first step (description and analysis) and second step (construal of institutional norms) of analysis while indicating elements in the analytical frameworks using italics.

Description and analysis of film title and the teacher's introduction

The purpose of *curriculum*, in this case the topic claimed by the title of the film, is to go from the particular workplace mathematics to general mathematics. One central *learning resource* in the lesson is a screen at the front of the classroom where the teacher's computer is mirrored. In the beginning there is a picture of, and a short text about, a patient, called "an Irma" by the teacher. The problem is presented in writing as follows:

Irma who is 90 years old has high blood pressure. In order to lower the blood pressure, Irma takes medicine with the active substance bendroflumetiazide. She has been prescribed 15 mg, which she should take each morning.

Each morning, she should take 9 pills in total. Help Irma to fill the 'dosett' [a dosage unit]:
HOW MANY PILLS OF EACH KIND SHOULD SHE TAKE?

The teacher checks with the students whether they are familiar with the active substance (*social interaction*). The students do not respond to this, and there is no sign of communicated *interest* in the topic from the students. There is more evidence of engagement when the teacher asks them to say the name of the dosage unit. There is not much *assessment* communicated to the students in this first part.

When we analysed the data with the WCCP framework (Keogh et al., 2016) one main point to consider was *familiarity*. The familiarity strand of the framework refers to how *specific* an activity is and to what extent the activity is a *regular* or irregular *occurrence*. In our interpretation, the context in which the problem is set is totally *unfamiliar* with regard to the students' future vocation, especially in connection to potential *accountability*. Firstly, it is not a nursing aide's *responsibility* to distribute pills into dosage units. Secondly, it is not feasible to restrict the patient to an exact number of different types of pills. This kind of *decision making* is not authentic. Thirdly, the way the teacher in the film begins his introductions, by referring to the picture of the patient as "an Irma", is not interpreted as reflecting any *familiarity*. This way of objectifying patients is not authentic from the perspective of a nursing and caring workplace (see also Boistrup, 2016).

Institutional norms construed from the title of the film and the teacher's introduction

The *institutional norms* that frame the setting of the lesson are construed from the title of the film and from how the teacher introduces the work. One institutional norm is construed as (1) "It is

important to introduce general mathematical methods based on particular workplace problems”. The basis for this construal is the title of the film, which is presented at the agency’s website where teachers are invited to find and use the film. A second institutional norm is construed as (2) “It is important to find mathematics in the context of the students’ future vocations and build on that”. This norm is construed from the teacher’s way of starting the lesson with the patient, Irma, where he describes the problem with her pills. This norm is part of the institutional framing also, since it is stated in the national syllabus that mathematics in vocational upper secondary school should be strongly influenced by the future vocations of the students (Skolverket, 2013). A third institutional norm is construed as (3) “It is not really important to secure the authenticity of contextualized tasks”. The basis for this is described above in relation to Keogh et al. (2016) and Boistrup (2016), where it is clear that this is an example of un-familiarity with a workplace context, rather than a lesson where the mathematics teacher is making an effort to acknowledge the context of future workplaces of the students.

Description and analysis of first student and whole class discussion

After the introduction the teacher starts a new sequence (*teacher intervention*), where he invites the students to discuss, in pairs (*social interaction*), possible solutions to the problem. At this point, the teacher is still standing at the front of the classroom, looking at the students. The students are looking to their front. The teacher repeats the problem and tells the students to discuss it for 30 seconds. The *resources* the students are offered to use are speech, writing, and calculators etc.

The teacher *intervenes* and initiates a whole class session. The teacher asks a student to *present* how she solved the problem. The student *represents* her previous solving of the problem with *resources* as speech and gaze when *presenting* her solution to the teacher and the class. Her first *meta-reflection* occurs when she says that her answer may not be correct. She then *presents* that she doubled the pill with 1.25 mg substance, to make 2.50 mg comprising 2 pills. She then added one of the 2.50 mg pills, to make 5 mg comprising 3 pills. She then took this times 3 which makes 15 mg and 9 pills, as required in the problem. In the film there is no further *discussion*. Instead the teacher *intervenes* telling the class, while pointing at the screen, “The method that Jasmine mentioned here is building on those numbers being easy”. He elaborates for 10 seconds on this and continues, “but there is a general method. And this we call a system of equations, i.e. to set up a system of equations.” This can be viewed as feedback, which constitutes an implicit *assessment*.

When analysing with the framework by Keogh et al. (2016) one point was again *familiarity*. The student in focus solves the problem in a way that could be the case for a nursing aide (Boistrup, 2016). (Here, briefly, we assume that the problem is authentic.) *Accountability* attributes are present in her reasoning, for example she takes the *initiative* and she uses the *concreteness* that suits this particular situation. The teacher stresses *theoretical concepts* and *abstract thinking* while stressing that the student’s method only works with “easy numbers”.

Institutional norms construed from first student and whole class discussion

The instance of the first norm regarding the high relevance of introducing general mathematical methods, is construed as present in the end of the sequence described. Implicitly, we regard the third norm, i.e. the lack of relevance to secure authenticity, to be apparent in the sequence. The teacher indicates that the student’s solution is not good enough since the method would not work well with

other numbers. However, it was taken for granted that a problem with a certain number of pills was relevant in the presumed context. We also construed a fourth institutional norm: (4) “All relevant power and knowledge resides with the teacher”. The basis for this construal derives from the way that the teacher assessed the student’s answer, seemingly dismissing her practical and correct solution to the problem as posed. In addition, the teacher did not allow much opportunity for the students to *meta-reflect* and discuss during the whole class session.

Conclusions and discussion

The findings derive from our analysis of a filmed lesson, which is part of a library of resource material for in-service training for mathematics teachers. Authenticity is key from the vocational mathematics learner’s point of view. In summary, we conclude that the workplace context presented in the instructional video is transparently contrived, dehumanised and shaped by an unrealistic aim, e.g. that a patient should be required to take exactly 9 pills. Furthermore, it is not the nursing aid’s job to decide medication. That this description of the setting is patently false to the students, risks discrediting the underlying content and, ultimately, may undermine the intended learning outcome.

In the film, a teacher introduces how vocational students can use a system of equations when solving problems in their future work as nursing aides. From our analysis and findings, we conclude that the film depicts a mathematics lesson where little time is spent on student interaction and student meta-reflection. The teacher is the most active person who intervenes most often. The overarching content promotes the benefits of solving workplace problems with formal school mathematics. Our analysis and findings reveal that the claimed workplace context, in fact, is not authentic to any significant extent. Nothing of the workplace complexity, shown in previous research (e.g. Keogh et al., 2016), is present and the teacher does not use the students’ knowledge about the work as nursing aide as a help to achieve authenticity.

We view the construed institutional norms as a series of essential messages (from the National agency to mathematics teachers), that can be interpreted from the film as:

1. It is important to introduce general mathematical methods based on particular workplace problems
2. It is important to find mathematics in the context of the students’ future vocations and build on that
3. It is not really important to secure the authenticity of contextualized tasks
4. All relevant power and knowledge resides with the teacher.

To a large extent the construed institutional norms coincide with a typical school mathematical discourse as described in Gellert and Jablonka (2009). Looking at the first norm, we argue that it is important not to exclude vocational students from general mathematical methods, but whether it is always important to build on workplace problems or not may be disputed. If it is essential to acknowledge the complexities of mathematics in work, as described in the first sections of the paper, it may be more suitable to introduce systems of equations intra-mathematically rather than drawing on inauthentic problems. The inherent risk of inauthentic contexts is it may serve to undermine rather than support the learning outcome. Regarding the second norm, there are a number of studies (e.g. FitzSimons & Wedege, 2007) revealing that in order to secure the authenticity of workplace mathematics, a way forward is enabled by cooperation between the stakeholders,

including mathematics teachers, vocational students, and workplaces. Such projects may create opportunities to find relevant pathways from workplace problems and ways to solve them with general mathematical methods.

The primary data source of our analysis was a filmed example for a module on mathematics in vocational studies within a larger nationwide in-service program. The film is used in this study as a starting point for a discussion. Our analysis acknowledges that there is not much in the module, as a whole, that reflects a balanced account of the work done by nursing aides. Hence, we find it hard to see that a teacher-discussion based on this film alone, without, for example, alternative films for comparison and contrast, would challenge a school mathematical discourse, where out-of-school contexts are not meant to be taken as ‘real’ (cf. Gellert & Jablonka, 2009). Rather, we see a risk that a film like this perpetuates existing institutional norms. We concur that much more work is needed in the future, both in terms of professional development and research, to enable and facilitate mutual learning opportunities between school practice and workplace practices. In such work, our use of the design theoretical perspective of learning (Selander, 2008) may be of use in the analytical description of mathematics lessons with an interest in institutional norms, teacher interventions, communication and roles of modes. In addition, the framework is useful for comparisons within and between workplaces since the perspective also includes informal and semiformal settings, such as workplaces. Additionally the WCCP framework (Keogh et al., 2016) may be useful for identifying authentic mathematics with reference to the complexities of workplaces with an interest in the factors that define, enable and constrain performance in work.

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