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þý D a m a , C r i n a

ISLS International Society of the Learning Sciences
2014

þý D a m a , C , Muukkonen , H , Ludvigsen , S , Nerland , M , Lakkala , M , K O A , Ilomäki , L , Markauskaite , L , Goodyear , P & Bachfischer , A 2014 , Enrollment of higher education students in professional knowledge and practices . in J L Polman , E A Kyza , D K O'Neill , I Tabak , W R Penuel , A S Jurow , K O'Connor , T Lee & L D'Amico (eds) , Learning and becoming in practice : The International Conference of the Learning Sciences (ICLS) 2014 Proceedings . vol. Volume 3 , ISLS International Society of the Learning Sciences , Boulder, CO , pp. 1283-1292 , International conference on learning sciences , Boulder, CO , United States , 23/06/2014 . < <http://www.isls.org/icls2014/Proceedings.html> >

<http://hdl.handle.net/10138/153048>

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Enrollment of Higher Education Students in Professional Knowledge and Practices

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Abstract: In this symposium, we discuss students becoming “enrolled” and appropriate the knowledge and practices of their prospective profession. This discussion and the related research are anchored in the acknowledgement that education programs should provide opportunities for learning and development of competencies required for knowledge-based work. We present empirical studies that examine learning in higher education courses in three different countries. These studies focus on student engagement, participation, and experiences in learning activities emphasizing knowledge practices that resemble professional work, and analyze how enrollment takes place and is facilitated by curriculum design and instruction. The findings show the nature and complexity of the knowledge practices embedded in the curriculum and how students become involved in these activities. The symposium delineates challenges for designing learning scenarios that support such enrollment. Ultimately, the symposium contributes to the ongoing discussion on how enrollment and curriculum design can stimulate and support knowledge-driven learning.

Introduction

This symposium addresses the processes through which higher education students become enrolled in learning activities that resemble knowledge structures and practices that are characteristic of their prospective professions. Furthermore, it examines the way the education programs assist and support students in this process.

In recent years, the expansion and increasing complexity of each domain’s body of knowledge, and the use of state-of-the-art technologies that bridge geographically dispersed knowledge and resources have also profoundly influenced higher education. It is already widely acknowledged that profession-oriented higher education programs should provide opportunities for learning that match the professional knowledge practices and the competencies required to deal with knowledge-based work in general (Nerland, 2012). Workplace settings expect future employees to be proactive and capable to generate knowledge and collaborate with others, to use advanced tools, and to adopt epistemic modes of practice (Goodyear & Zenios, 2005). Accordingly, higher education is challenged to design dynamic and open learning environments with an emphasis on knowledge-driven activities (Healey & Jenkins, 2009). While there is agreement that such activities are beneficial, they remain complex and challenging for students. This highlights the necessity for facilitating the way students conceive knowledge-driven activities and their enrollment in the epistemic practices specific to each profession.

The main focus of this symposium is two-fold. *First*, it aims to unveil what characterizes *students becoming enrolled* in the knowledge culture and practices of their prospective profession, through the corresponding higher education programs. *Second*, it attempts to provide insights into how instruction and curriculum design in higher education supports such enrollment in education programs in three countries. Ultimately, the symposium aims at contributing to the ongoing discussion on how various knowledge practices characteristic to professional domains can be stimulated and facilitated.

Empirical and Theoretical Background

Research on knowledge practices has examined how professionals devise and develop epistemic strategies for addressing open-ended problems, arguing that they need to conceive new knowledge, capitalize on collective expertise, and demonstrate inquiring skills and proactive behavior (Kerosuo & Engeström, 2003). This epistemification process (Knorr Cetina, 1999) that characterizes the dynamic changes in knowledge stems from modes of practice associated with those of science communities, in which knowledge production is one of the

core values and skills. Simultaneously, research on other professional practices, such as new product development or cross-functional units (e.g., Hyysalo, 2005), has shown that work is similarly artifact and technology-mediated. From a sociocultural perspective, human actions, including learning and interaction with others and their environment, are mediated by various means and tools (Wertsch, 1991). Knowledge objects are mediational means that can accumulate collective knowledge and experience and can represent resources for learning and activity. Objects are important because they represent and embody past learning and knowledge and, due to their functional complexity, are addressed to externalize existing understanding, but also to negotiate, design or test new ideas and solutions (Miettinen & Virkkunen, 2005).

Few studies have focused on the challenges students encounter when entering professions and the corresponding knowledge practices. Research examining practices of inquiry in higher education by Muukkonen and Lakkala (2009), and Stankovic (2009), and Damşa, Andriessen, Kirschner, Erkens and Sins (2010) pursued research that conceived learning as an activity that involves addressing complex knowledge-based problems, which requires collaborative inquiry and knowledge construction to reach appropriate solutions. Such complex processes involve a focus on shared understanding, joint actions at the epistemic level, and a good balance between work with knowledge and the management of the process. In addition, the research-based learning model brings aspects of the scientific knowledge culture and practice into educational settings, in an effort to organize learning that supports students in developing “epistemic fluency” (Goodyear & Zenios, 2007). Studies with this focus have provided some insights into how research-like activities have the potential to transform (undergraduate) students from course-takers to producers of knowledge (Shaw, Holbrooke, & Burke, 2011), or on the acceptance within disciplines that students can contribute to research and knowledge production (Brint, Cantwell, & Sazena, 2012). Lambert’s (2009) study showed how this type of learning has the potential to reconfigure students as intellectual producers through their active engagement and participation in the research cultures of their departments and disciplines.

Relevance and Contribution to the Conference

In this symposium, we build on the aforementioned insights to better understand the knowledge culture and practices relevant to learning in higher education. Two aspects are of importance here: *how students’ engagement* in knowledge practices emerges and *what* is used and constructed, in terms of *knowledge and knowledge objects*. We use the notion of *enrollment* (Nespor, 1994), as an overarching concept depicting how knowledge structures and practices are mobilized, but go beyond the original conceptualization, by assigning students an active, participative, and sense-making position in this process.

The contributions in this symposium report on research that examines learning activities of undergraduate students in three different countries, highlighting the epistemic dimensions of the process. Common denominators for the three studies are the higher education settings, methodologies that attempt in-depth exploration of rich sets of data, and shared notion that students learn knowledge practices through active engagement and participation.

The *first study* examined how students from two Norwegian undergraduate programs, teacher education and computer engineering, respectively, become enrolled in and adopt the knowledge practices of their future profession through collaborative projects. The analyses of discursive interaction and of the use and construction of knowledge objects by student groups show that students’ knowledge practices reflect valued practices in their prospective profession, respectively, the sharing of personal knowledge in teaching and distributed problem solving, mediated by procedural standards in computer engineering. The *second study* explored how three Finnish undergraduate courses, i.e., development of business ideas and multimedia products, advanced themes in project management within the financial domain, and customer projects in the field of biosciences, were set up to engage student teams in the processes that simulate workplace practices in knowledge intensive organizations. It specifically investigated the participating students’ expectations of and learning experiences, and the assessment of collaborative outcomes and processes. The findings suggest that the students were eager to explore work-life and the knowledge of expert practices for customer projects by engaging in initiating and sustaining multidisciplinary collaboration, and by advancing the shared objects. The *third study* explored functional epistemic games for knowledgeable action and learning in professional education, with a focus on the nature of epistemic games embedded in tasks that aim to prepare students for externships in workplace settings. The participants were enrolled in professional practice courses in pharmacy, nursing, social work, school counseling, and education at an Australian university. The analyses focused on collected artifacts and interviews and depicted the characteristic patterns of situated inquiry that students were expected to learn. The findings suggest that learning for knowledgeable action is underscored by ways of knowing that weave traditional epistemic games with situated problem-solving actions and discourse into embodied assemblages of functional epistemic games.

The findings of these three studies shed light on the domain-specificity of practice and led to a better understanding of the processes students undergo to “become professionals”. From the perspective of learning through interaction and mediated by knowledge objects, students’ activities in the collaborative projects

demonstrate that knowledge work can be designed in higher education contexts. But, while students find ways to navigate through the complex knowledge of the various domain and practices, as shown in Study 1, they report discrepancies between their initial expectations and the actual experiences during the projects, as pointed out in Study 2. The in-depth look by Study 3 into the mechanisms of functional games that characterize the complexity of professional epistemic practices, underscores the general conclusion that facilitating the enrollment of students into knowledge practices is not necessarily a straightforward endeavor. It requires a subtle understanding of the nature of knowledge practices and strategies that are expected to be learned and taught, and a sophisticated array of pedagogical design alternatives and instructional strategies that have sufficient potential to address the challenges encountered in this context both by students and by those facilitating their learning.

This symposium's contribution to the conference is two-fold. *First*, the symposium attends to issues of relevance to the conference theme in the context of learning in higher education. *Second*, the symposium setup aims to stimulate interaction between the presenters and the audience by: 1) presenting the theoretical and practical frameworks of each of the three studies; 2) depicting the methodology and, especially, the analytic approaches that support the understanding of the examined practices; and 3) by inviting a focused discussion that addresses these three themes and the theoretical, methodological, and practical implications of the presented studies. We intend to engage the audience in the discussion of the contributions, using the three themes to structure the interaction.

Collaborative Knowledge Practices in Higher Education: A Comparative Analysis of Student Learning in Two Undergraduate Programs

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Introduction

This paper examines how students from two higher education programs, teacher education and computer engineering, respectively, become enrolled in and adopt the knowledge practices of their prospective profession through collaborative projects. The study focuses on understanding how students engage in these knowledge structures and practices and how the study programs facilitate the students' participation in these processes.

In recent years, learning in professional domains has been profoundly influenced by developments taking place in a rapidly evolving knowledge society. An essential aspect hereof is the movement to make professional practices more knowledge-based. While a more dynamic relationship between professional fields and higher education brings to the latter the emerging developments of the former, it also brings accompanying challenges. Following the dynamic developments in the work field, characterized by ongoing knowledge production, sharing, and assessment, learning environments are becoming increasingly complex (Nerland, 2012). In the higher education context, this brings about the necessity of introducing students to the knowledge practices of their prospective profession and of supporting them in this process. Students are expected to adopt epistemic strategies and to become actively engaged in profession-specific, knowledge-driven activities. Specifically, students are expected to display active engagement, collaborate with each other, and develop the ability to generate knowledge.

While it is important to understand both the mechanisms by which professional knowledge domains are translated into curriculum and instruction and how students understand and enroll in these practices, few studies have addressed these aspects. This empirical study examines how computer engineering and pre-service teacher students learn and engage in complex learning situations that resemble the knowledge practices of their professional domain. As part of a larger research project, the analyses in this explorative study focus on: a) how students understand and appropriate knowledge structures and strategies specific to their prospective profession; b) how they use and co-construct the knowledge objects that are characteristic to the domains, and c) how they mobilize knowledge resources to inform their projects.

Empirical and Theoretical Background

Recent developments in the knowledge field and new requirements that graduates must fulfill when entering professions have emphasized the need to prepare students for the challenges of knowledge-driven professional work (Healey & Jenkins, 2009; Nerland, 2012). Toward this end, a number of empirical studies (Damşa et al., 2010; Muukkonen & Lakkala, 2009; Zimbardi & Myatt, 2012) have pursued research that conceives of learning as an activity focused on complex problems and distributed project work that resembles professional settings. While these studies provided valuable insights, further research is needed to develop a better understanding of students' immersion and active involvement as participants in processes of knowledge production.

The theoretical framework we build upon follows sociocultural and sociomaterial perspectives on practice and learning. The former emphasizes the social, constructive nature of learning and the fact that activities are mediated by various tools (Valsiner & Van der Veer, 2000; Wertsch, 1991). The latter depicts the

mechanisms and arrangements through which knowledge is produced and circulated within expert communities, comprising material aspects (i.e., tools, artifacts, resources), but also procedures, ideas, and attitudes (Knorr Cetina, 1999). In Knorr Cetina's terms, these form the machineries of knowledge construction, which 'make up how we know what we know' (1999, p. 9) within a given domain of expertise and serve to construct knowledge. Emerging from these perspectives, two concepts inform our theoretical and analytic framework. *Epistemic practices* and *action* emerge in this social context in which interaction is paramount. Hence, discursive interaction facilitates the sharing of knowledge and the transformation of meaning potential (Linell, 2009) into "frozen" meaning and traceable knowledge in the context of the collective process. It also allows one to identify the way professional culture is conceived by the participants through their talk. The notion of *epistemic* (or *knowledge*) *objects* is linked to the content of the knowledge practice. These objects can be "material entities or processes" (Knorr Cetina, 1999), which are question-generating and complex entities that have the potential to open lines for inquiry and research. According to Nerland (2012), such objects embody the knowledge of the domains and represent points that students and novice practitioners can use to access the relevant expert cultures and collective knowledge structures. Examining the knowledge objects students engage with or create in collaboration permits the identification of the emerging knowledge; it also allows for the identification of how knowledge within a particular domain is explored and enacted in different contexts.

Methods

The study was conducted at two bachelor's degree programs in Norway, Teacher Education (TE) at a large university and Computer Engineering (CE) at a university of applied sciences, respectively. These study programs were selected because of their orientation to specific professions and because, at the moment, the programs are undergoing a reform to strengthen knowledge-oriented and research-based learning (Healey & Jenkins, 2009). The TE program is a five-year teacher education program that offers a master's degree and teaching qualification, and it recently introduced curriculum elements aimed at strengthening students' scientific reasoning and analytic competencies. The CE program offers bachelor's degree and master's degree programs in the engineering and information technology field, and it has recently implemented a research-based learning curriculum.

In this research project, the strategy for the empirical investigation considers the gradual immersion of students into the knowledge and practice of the domain. Following this idea, the project started by observing and documenting the instructional and learning practices in a first year bachelor's degree introductory course within each of the two programs: the "Expaed" (TE) and "Web project" (CE). Both are introductory courses and contain varied activities (e.g., lectures, assignments, and individual and group work). The six participating student groups from the Expaed course were required to analyze a case of a pupil displaying learning difficulties by applying the knowledge about learning theories they had gained during the course and by writing a case report. The four participating student groups from the Web Project course were required to design and develop a website, using the programming languages learned during the course (i.e., HTML, CSS, PHP, Java), and to write a project report. Through comparative case studies (Yin, 2003), this first explorative iteration examined learning activities with a focus on existing processes and practices, which will feed into the research design of subsequent iterations.

The dataset reflects the nature and distribution of the activities across the length of the study units and supports an understanding of the interconnections that exist across levels (individual, group, and institutional). The following *data categories* were collected: a) interaction data (video recordings of group meetings, online discussions and correspondence, and field notes); b) knowledge objects (documents, comments, and meeting notes); and c) course documents and lecture materials. The data analysis attempted to capture the complexity of the knowledge work, and it examined the resources and strategies in various contexts. To understand *how* students engage with and act towards appropriating the knowledge practices of their domain, and the way they mobilize and use various resources, we analyzed the groups' discursive interactions within the collaborative work. We employed a technique building on the interaction analysis method, which focused on identifying epistemic actions and object-oriented interaction (Damşa et al., 2010). A document analysis of the groups' knowledge objects and knowledge resources was performed to examine *what* the groups used and constructed in terms of disciplinary knowledge.

Preliminary Findings and Discussion

The analyses revealed different ways of organizing the collaborative activities at the program level and at the group level. While the TE groups were organized within the context of larger seminar groups and were provided with some incidental guidelines for the collaborative process, the CE groups were organized by the course leader based on their expressed interest, and they were provided with more detailed project work procedures. The TE groups organized their work mainly as face-to-face discussions with some support from online discussions. Their discussions were more explorative, based on experience-based knowledge and local knowledge sources (exclusively course material and teachers' feedback), and they tended to divide the tasks and

the writing responsibilities among the members. The CE groups followed more structured procedures for collaboration and their knowledge construction took place through a series of iterations by way of trial-and-error strategies; they used a validation tool recommended by the teacher to check their produced scripts. These groups accessed and mobilized a range of programming resources available online, and they used online spaces actively to share and discuss their work.

These analyses only allow for preliminary conclusions, but they provide an insight into the specificity of each domain's knowledge and strategies, with differences concerning both the content-related joint work and the procedural aspects of the collaboration. The TE students used rather explorative strategies in approaching the group assignment and they worked towards defining and clarifying the knowledge needed to address the case. The discussions were often focused on how to frame the analysis and report according to the academic standards. Their collaboration appeared to be rather loosely organized and the resources they accessed were domestic to the program. The CE students worked through their collaborative task by employing a structured set of steps and phases, which built on strategies used by software development project teams. In a sense, their work was more organized and thorough, but the use of these prescribed procedures and of the validating tool had a restrictive effect on the exploration potential of the collaboration. In the use of resources, these groups exceeded institutional boundaries and accessed external sources of information. The way TE the students' knowledge objects were developed showed a prevailing strategy of division of labor, while the CE students' objects were, in most cases, developed iteratively, in close collaboration and in an incremental fashion.

To conclude, we consider that these results open up a line of investigation that provides a better understanding of how students enroll in the knowledge structures, practices, and culture of the domain, but with a clear focus on the details that allow them to undergo the process of "becoming professionals". It is interesting to note how the students' knowledge practices resemble characteristics of the two professional cultures, highlighting local embeddedness and the sharing of personal knowledge in teaching and distributed problem solving mediated by procedural standards in computer engineering (Nerland, 2012). The findings show that it is important to capitalize on the domain procedures and structures, but also to find a balance between what a novice student can and must know. Furthermore, the way students participate in the process is influenced by the program that facilitates their interaction with the strategies and objects that are considered to be essential for becoming a knowledgeable professional.

Simulating Epistemic Practices of Knowledge Work in Higher Education: Students' Expectations and Experiences

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Introduction

Current university education faces new challenges in answering the requirements of society to provide students with the competencies that are necessary in the changing work life, such as solving open-ended problems, networking, collaborative creativity, epistemic agency, and digital competencies (Broussard, La Lopa, & Ross-Davis, 2007; Klusek & Bernstein, 2006; Muukkonen & Lakkala, 2009). The present study explored how three courses in university education were set up to engage student teams in the processes of new application and concept development that simulate the workplace practices they would encounter in knowledge intensive companies and organizations. We investigated the kinds of expectations that students have about such courses and how they evaluated their learning experiences. Furthermore, the research contributes by presenting example cases of how teachers assessed the epistemic practices of teams working on open-ended tasks.

Learning as Collaborative Knowledge Creation

A key characteristic present in various models that describe knowledge creation appears to be that collaboration is organized around long-term efforts for developing shared objects, such as articles, models, and practices; for instance in Engeström's (1987) expansive learning, Nonaka and Takeuchi's (1995) organizational knowledge creation, and Bereiter's (2002) knowledge building. Building on previous theories, the triological learning approach (TLA; Paavola & Hakkarainen, 2005) combined three metaphors of learning: the acquisition and the participation metaphors put forward by Sfard (1998) and the knowledge creation metaphor introduced in Paavola, Lipponen, and Hakkarainen (2004). *The acquisition metaphor* of learning addresses the assimilation of prevailing knowledge and an individual's mental models and strategies of learning. Such practices are familiar to anyone taking part in traditional higher education courses, i.e., attending lectures, working on individual tasks, and reading for exams. *The participation metaphor* highlights the adaptation to existing dialogue and to cultural and communal practices. These may be exemplified by a field-training period, where students become familiar with the practices, tools, and cultural knowledge of a particular working community. *The knowledge creation metaphor* and the TLA highlight the object-centered aspect as being central in collaborative learning. The presence of knowledge artifacts, practices, and products—objects—is the rationale for the term "triologic".

This approach emphasizes the interaction between collective and individual efforts in working on shared objects as well as on the iterative and sustained character of this process, similar to epistemic objects in professional practices (Knorr Cetina, 2001).

For higher education, this presents the need to promote particular types of competencies, specifically by emphasizing the shared knowledge objects and their iterative development resulting from the interplay between epistemic and regulative efforts during collaboration. In general, teachers have expressed a concern about how the assessment of an individual student's performance can be conducted while the coursework is carried out in teams. This concern stems from a framework of assessment in which the individual is expected to master all the aspects of the assignments, i.e., necessary knowledge and skills as a solo performance. In knowledge creation practices, the process necessitates intensive collaboration, because the participants are required to have complementary skills and knowledge or expertise from different disciplines.

Aims of the Study

We investigated three higher education courses organized as project work in which multidisciplinary teams of students were assigned to work on open-ended and complex tasks for customers. Such settings are novel to most undergraduate and master's degree students. We examined how students perceived these educational settings and how they described their experiences of collaborating with members of their teams and with the customers. Furthermore, the paper addresses questions about how to evaluate collaborative outcomes and processes. Specifically, the research examined the following questions: 1) What kinds of expectations did the students express for the course and its learning outcomes? 2) What kinds of experiences did the students report after the course? and 3) How did the teachers set up the assessment of the collaboration efforts and the outcomes?

Methods

Three courses were designed by the teachers and their collaborators from professional organizations (course customers) to engage undergraduate students in complex knowledge creation processes in multi-disciplinary teams. *Case 1*, the "Application Development Project" (ADP) course was organized at the Metropolia University of Applied Sciences, Finland, and it ran from September 2009 to March 2010. The study participants were undergraduate students (n=50) and teachers (n=4) from three training programs: media engineering, industrial management, and media and communications. In addition, four customer organizations were involved. The course was purported to teach students about the development of business ideas and related services, and multimedia products. The students worked in 11 multidisciplinary teams of three-to-six members to develop business plans, user stories, marketing strategies, and software architecture in order to come up with operational business application. Teams' working documents, based on templates pre-structured with domain specific conceptualizations, were presented and discussed during weekly steering group sessions.

Case 2, the "Tax Office Exercise" (TAX), was a course on advanced themes in project management that ran from March 2010 to May 2010. It involved students in business and psychology domains (n=30) and academic staff (n=5) from the University of Helsinki and the Aalto University School of Economics. The students were asked to analyze the characteristics of different groups of taxpayers and to create, on the basis of this analysis, concepts for future research projects for the Finnish Tax Administration (the customer). The course aimed to be a practical way of learning virtual project management practices: managing a subcontracting network, team building, coordinating tasks and responsibilities, managing a complete project in a short timeframe, and using collaboration technology. The students worked in eight multidisciplinary teams (three-to-five students per team).

Case 3, the "Project Work Course" (BIO), was held at the Faculty of Biological and Environmental Sciences, University of Helsinki. Students (n=15) were divided into three teams, each of which worked on a customer project in the field of biosciences. The course, tutored by teachers (n=3) lasted from September to December 2012. The aim was to learn to plan, manage, and report on a project work for a customer. Initial project training provided models for organizing the process. During joint meetings the teams presented their work results and received feedback.

Data for the study consisted of the students' responses to open-ended reflective questions as well as the teachers' assessments of teams (and individuals). At the onset of the course (pre), the students were asked to answer the following questions: 1) What thoughts and expectations do you have about the course, its forms of studying, and its goals? and 2) What do you want to achieve by participating in the course? After the course, the students were asked to evaluate their experience by answering the following questions: 1) How would you characterize your overall experience(s) in the course? 2) How would you characterize your own participation and activity during the course? Please justify your answer. 3) What has been positive or impressive about the course? and 4) What has been challenging or disturbing in the course? The students were also prompted for other comments.

The qualitative data was analyzed inductively (Chi, 1997; Muukkonen, Lakkala, Kaistinen, & Nyman, 2010) by segmenting the responses into ideas. Several rounds of category development with the ATLAS.TI

software were carried out. A categorization of expectations and experiences was first data-grounded and then aligned with the TLA, when applicable.

Results and Conclusions

Students' pre-course reflections (f=303) indicated that the students expected to learn collaboration practices, independent teamwork and planning, new knowledge, and knowledge about the nature of work-life and expert-like practices. By taking the course, they hoped to gain contacts with employers and secure an employment advantage, and knowledge, practices, and skills for work-life; they also hoped to gain experience with project work and to strengthen their management competencies.

After the courses (f=401), *the students* reported that they had gained various kinds of knowledge and competencies. Further, they reflected to have learned how to take initiative, create new ideas and practices in teams, and project management and coordination. They especially valued that the courses included interesting assignments and outcomes, teamwork, projects, and real customers. Students critiqued the high complexity of the course assignments and the unclear initial goal framing and schedule; some of them criticized the virtual collaboration environment. Teamwork, in particular, generated numerous reflections. When teamwork had not advanced optimally in the team, the members reported frustration, problems with team coordination and scheduling, and uneven participation; when teamwork had advanced well, the students reported achieving creative outcomes.

We identified three foci in *teachers' assessment frameworks*: regulative documentation-based (e.g., team formation, management, participation), collective engagement-based (e.g., peer review entries, communication), and knowledge-based assessment (e.g., quality, innovativeness, and customer feedback).

A comparison of the expectations and experiences suggests that, before the course, the students wanted to gain knowledge of expert practices in real projects with customers. After the course, the students reported details about the dimensions of initiating and sustaining multidisciplinary collaboration and advancing the shared objects. Furthermore, several teams would have benefitted from more support for initial goal framing and team formation. The findings highlight that students valued the engagement in these types of learning practices, but the findings also call for more research on the ways to pedagogically design the complex assignments and to scaffold and assess the development of corresponding competencies.

Epistemic Games for Knowledgeable Action in Professional Learning

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Introduction

This paper reports research in the field of professional education and professional expertise that combines epistemic practice and epistemic fluency perspectives (Goodyear & Zenios, 2007; Knorr-Cetina, 1999; Morrison & Collins, 1996) to uncover characteristic ways of knowing that future professionals learn to enact when they are performing complex knowledge-demanding professional tasks. We extend epistemic forms, frames and games theories (Collins & Ferguson, 1993; Perkins, 1997; Shaffer, 2006) into the area of *situated professional work*. We identify six categories of epistemic games for knowledgeable action and learning in professional education. These emerge from our investigation of the nature of epistemic games that are embedded in tasks that university students complete in professional practice courses. Our findings show that such tasks go beyond *formal epistemic games* and the construction of mono-professional knowledge. Rather, these tasks require students to engage in new kinds of inquiry that enhance their situated understanding and inform the actions of others. These situated and distributed ways of knowing weave traditional epistemic games with professional problem solving, various modes of discourse and socio-material practices - making embodied assemblages of *functional epistemic games*.

Background

Research in such diverse fields as sociology, anthropology, cultural studies, psychology and information technologies has acknowledged that some important aspects of human behavior can be characterized by certain structures and patterns that appear repeatedly in their discourse and actions, including human "ways to think". Collins and Ferguson (1993) and others (Perkins, 1997) have argued that almost every domain of human activity has a set of such characteristic forms of knowledge and ways of knowing, which guide skillful investigations in those domains. They refer to these schematized kinds of knowledge as "epistemic forms", and the ways of working with specific epistemic forms as "epistemic games". As an example, they showed that science and history have a set of epistemic forms and epistemic games for conducting structural, functional and process analyses, including such forms as diagrams for spatial decomposition, tables for comparing and contrasting, and flowcharts for identifying causal relationships. They argued that these specialized but shared ways of knowing

constitute important domains of expertise. People who are good at recognizing and participating in a range of epistemic games are said to possess “epistemic fluency”: they are flexible and adept with respect to different ways of knowing about the world (Morrison & Collins, 1996). As Collins and Ferguson (1993) suggested, “Systematic analyses of theories and inquiry strategies in the different disciplines are needed to build a detailed theory of the different epistemic forms and games <...> and to identify other forms and games that sophisticated inquirers use.” (40).

Epistemic games are rarely taught explicitly and little is known about the variations across disciplines. Professions are inherently *multidisciplinary* fields. They construct their epistemological foundations by adopting generative frameworks from multiple academic disciplines, and also by creating their own ways of representing knowledge, structuring inquiries and validating claims (Goodyear & Steeples, 1998).

In the learning sciences, analyses of epistemic forms and games have focused on *generic* structures and ways of knowing that are recognized in various disciplinary discourses as tools for generating the community’s knowledge. As Perkins (1997) argued, epistemic games must have explicit epistemological agendas of discovery, verification and knowledge sharing. In short, these games should lead to what Greeno (2012) called, “formal knowledge.” However, *formal knowledge* is not the same as the *functional knowledge* that professionals use to make sense of the world (Greeno, 2012) and *formal ways of knowing* do not necessarily correspond to *functional ways of knowing* that professionals use when they “read” an encountered situation and decide how to act (Hutchins, 2012). In fact, the nature of the functional epistemic games, which professionals play when they generate the situated knowledge that informs their actions, is little understood.

Method

Our study included two stages. In the first stage, we investigated 20 professional practice courses that aimed to prepare students for externships in workplace settings in five professional fields: pharmacy, nursing, social work, school counseling and education. The dataset included interviews with 16 academics (faculty) coordinating these courses (up to 3 interviews per course) and a comprehensive collection of course materials, including tutorial handouts, specifications of assignments, and samples of completed tasks. The interviews focused on course designs, with particular attention to the design of tasks in which students were expected to learn and demonstrate certain workplace-related capacities. In total, we analyzed 24 tasks. Most included enactments of professional knowledge and skills (e.g., medication-dispensing role plays, children’s behavioral assessments, and teaching various lessons) and the production of related artifacts (e.g., assessment reports and lesson plans). To elucidate the epistemic games that students were expected to master, we adopted a combination of cognitive task analysis (Crandall, Klein, & Hoffman, 2006) and epistemic interviewing techniques (Brinkmann, 2007). We used the course resources as prompts for interviewing the academics and, through detailed questioning of how and why various artifacts were used and produced, we aimed to depict generative frameworks that students were expected to use for completing the tasks. During the analysis, we simultaneously re-analyzed collected artifacts and interviews, and recreated the main features of characteristic patterns around which students were expected to structure their situated inquiries. In the second stage, we complemented and corroborated the outcomes from the first stage by conducting observations of tutorials in a pharmacy course (3 tutorial groups taught by 3 academics over a 6 week period) and observing students’ independent group work in a teacher education course (2 groups).

Results and Discussion

Our findings revealed six main classes of functional epistemic games that we call: *propositional games*, *situated problem-solving games*, *meta-professional* and *trans-professional discourse games*, *translational public discourse games* and *weaving games*. Propositional games are most like the epistemic games already documented in the literature, so we do not describe them here (see Markauskaite & Goodyear, forthcoming).

Situated problem-solving games are played during the investigation and solution of specific professional problems, such as conducting reviews of medications used by patients with multiple diseases in order to identify possible issues, with an aim of proposing better medication plans (pharmacy), or designing lessons for classroom teaching (education). Elaborated problem-solving games could combine different aspects or stages of problem solving or design, which by themselves could be quite complex epistemic games. For example, a typical medication review includes *investigation* of a situation; *processing* of coded information using various conceptual tools; *prioritization* of findings using various professional heuristics and *development* of a reasonable, knowledge informed, practical solution. Overall, problem-solving games resemble professional practices that Goodwin (1994) calls “professional vision”. The guiding epistemological purpose is to enhance situated understanding of the specific problematical situation by structuring things and events in a particular professional ways and, consequently, offering feasible solutions.

Meta-professional discourse games are usually played with other professionals within a broader professional field, in order to evaluate various professional products, actions or events. They involve various deconstructions, evaluations and reflections, such as analyses of new medications, evaluations of teaching

resources, and reflections on one's practices. In contrast, *trans-professional discourse* games are played when professionals from different fields jointly work on complex problems. These games range from simple sharing of relevant information, such as writing a referral for a specialist consultation, to engaging in joint problem-solving conversations, such as medical case conferences for discussing identified issues and deciding about possible interventions. The primary epistemological function of such multi- and trans- professional discourse games is to re-describe professional knowledge from the perspective of others who (epistemologically) are outside the game that produced this knowledge. These games do not always produce new knowledge, but enhance joint knowledgeable action by creating links between different professional knowledges and actions.

Translational public discourse games are played when professionals engage in interactions with people who broadly could be described as "clients". Such games involve common patterns of discourse that professionals find effective for collecting relevant information and communicating their reasoning to non-professional audiences. For example, these games are evident in pharmacists' communication strategies with clients – e.g. when they gather relevant information about health conditions before dispensing a new prescription and characteristic ways of writing instructions on a box with medications. Such games are informed by the epistemological agenda of extended knowledgeable action (Clark, 2011). They transverse the boundaries between professional and everyday ways of knowing and thereby extend professional knowledgeable actions to the actions of others in the everyday world.

Weaving games are played in dynamic action and involve continuous intertwining of meaning-making, social interaction and skilled performance. They range from very specialized games that can require fine-tuned physical skill - such as strategies for capturing all the spelling mistakes in a literacy test - to quite generic games that require complex coordination of various general and specialized strategies and skills - such as a teacher's weaving of various strategies for identifying students' learning challenges, choices of appropriate translational games, and continuous fine-tuning of voice pitch and movement in the classroom. Weaving games usually blend multiple epistemological goals, which are adjusted and remixed in response to the unfolding situation.

Conclusions

The findings show that *functional* epistemic games for knowledgeable action and enrolment extend beyond the standard epistemological agendas of *formal* epistemic games that generate propositional knowledge. These professional inquiries follow patterns of pragmatic problem-solving, sensible decision-making and embodied situated action. They weave various games into larger assemblages of characteristic epistemic practices. Such weaving games involve continuous adjustment of actions in response to emerging situations and require fluent coordination of professional perception, problem solving, bodily skill, and discourse. Further, intelligent professional behavior relies on ways of knowing that not only expand one's perception of the problematic situation and improve one's personal understanding, but also on ways of knowing that extend one's epistemic activity to the environment, including social others, and enhance overall micro system's capacities for knowledgeable action. Meta- and trans-professional discourse and translational games play important roles in such extended knowledge activity. These discourse games require re-articulation of professional knowledge in various professional and non-professional epistemological frameworks, the capacity to recognize and switch between various traditional kinds of discourse, and also a professional capacity to play skillfully special kinds of games for translating knowledge.

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