THE EPISTEMOGRAPHY OF URBAN AND REGIONAL PLANNING 912: APPROPRIATION IN THE FACE OF RESISTANCE

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Abstract: Preparing citizens to address the complex problems inherent in cities requires our changing society to embrace a new kind of education. One way to train people to think about complex problems is to identify and study how professionals who think in those ways develop their *epistemic frame*. In this paper, we examine one of the ways urban planners master and appropriate relevant expertise through an ethnographic study of an urban planning practicum. Specifically, we use a new method called *epistemic network analysis* to look at presentation feedback sessions during two weeks of the practicum to explore emergent relationships between the teacher's planning expertise and the students' expertise. The results of this study indicate that epistemic network analysis offers a technique for analyzing the kinds of situated understanding that result from sociocultural learning and for observing the translation of pedagogy into practice in various types of learning environments.

Major issue(s) addressed

Measuring learning in a practicum environment can be challenging, and a growing body of research suggests that a new method called epistemic network analysis (Shaffer et al., 2009) can inform our understanding of how professionals-in-training learn in a practicum environment. According to Donald Schön (1983; 1987), a practicum environment is explicitly designed to forge the links between knowing and doing that are central to the reflective practice of a profession. In a practicum, novices are initiated into a professional community of practice and extend their knowledge through tackling complex problems.

John Friedmann (1973) argues that our changing society requires a new kind of education where knowledge is extended and people are trained to think about and address the complex problems inherent in cities. One group of professionals tasked with addressing several of these challenges is urban planners, and studying how professional urban planners learn in a practicum environment can help us better understand how to train people to address complex problems.

In this paper, we examine one of the ways urban planners develop expertise through an ethnographic study of Urban and Regional Planning (URPL) 912, a graduate level practicum at a large Midwestern university. The main goal of the study was to explore the learning processes experienced by the 20 graduate students in the practicum. The students were guided in the production of a site plan for a developing area by a planner with 34 years of planning experience. In the study, we used epistemic network analysis to examine the presentation feedback sessions during weeks four and five and to explore emergent relationships between the teacher's planning expertise and the students' expertise.

Potential significance of the work

The results of this study have the potential to influence the future design of professional practicum environments as well as the broader landscape of education.

Theory

A major goal for educators is creating instructional contexts in which skills are both mastered and appropriated (Herrenkohl & Wertsch, 1999). Mastery and appropriation, according to Wertsch and Polman (2001), are part of mediated action—human action that is fundamentally characterized by a tension between active agents and the cultural tools they use to carry out action. Wertsch and Polman (2001) define mediated action as forms of action such as speaking, reasoning, and calculating that inherently involve agents actively using cultural tools. Herrenkohl and Wertsch (1999) stress that mastery of a cultural tool involves having the skill to use a cultural tool effectively, "knowing how" as opposed to "knowing that," or in other words, procedural versus declarative knowledge. In contrast, appropriation focuses on an agent's tendency to use a cultural tool, which can be distinct from the level of mastery involved. Using Bakhtin (1981), Herrenkohl and Wertsch (1999) claim that appropriation means to adopt, imitate, or pick up someone else's accent. Thus, appropriation is a process of making something, such as a historical narrative, one's own.

High levels of mastery are frequently associated with appropriation; however, some forms of mediated action are characterized by mastery but not appropriation of a cultural tool. Bakhtin argues that cultural tools are often not easily and smoothly appropriated, and that an agent may use a cultural tool but with a feeling of resistance or even outright rejection. When such resistance grows sufficiently strong, the agent may refuse to

use the cultural tool altogether (Wertsch, 1998). However, Wertsch (1998) writes, "it has become increasingly clear that interactional contexts involving resistance and rhetorical opposition may provide some of the most productive settings for developing mastery and appropriation of cultural tools" (p. 182).

Herrenkohl and Wertsch (1999) believe that one of the most effective ways to foster the appropriation, and not just the mastery of cultural tools is to coordinate these cultural tools with sociocognitive roles. They claim that sociocognitive roles can be understood in terms of rights and responsibilities, where people have opportunities to exercise their rights as a way of being responsible to their community. Herrenkohl and Wertsch (1999) offer the example wherein a building inspector exercises her right to stop construction on a building because the contractor is suspected of using sub-par materials. In this example, the inspector is exercising a right in the context of her responsibility to protect public safety. Or, put simply, she is performing her job.

Herrenkohl and Wertsch (1999) propose that by promoting the idea of "doing one's job" and emphasizing the responsibilities to one's community and the set of rights that accompany those responsibilities, students will practice skills important to the sociocognitive role and begin to master and appropriate them. Unfortunately for educators hoping to introduce sociocognitive roles into their classrooms, Herrenkohl and Wertsch do not outline a specific process for creating the sociocognitive roles or offer suggestions about the types of skills that could be mastered or appropriated through students assuming roles.

Schön (1983; 1987) argues that, in most professions, people begin to master and appropriate skills in professional practicum experiences. In a professional practicum, novices engage in simulations of professional work. Their work is guided by repeatedly taking action and explicitly reflecting on that action with peers and mentors, what Schön refers to as reflection-on-action. The process of explicit reflection-on-action allows one to look back on a completed task or process to consider the implications and consequences of actions. Schön (1983; 1987) argues that the goal of the professional practicum is to bind action and reflection together to produce professional expertise particular to each profession.

Extending Schön, Shaffer (2004a; 2004b; 2006) argues that a professional practicum is a key step to developing the epistemic frame—or the ways of knowing, of deciding what is worth knowing, and of adding to the collective body of knowledge and understanding—of a particular community of practice. In a practicum environment, experienced mentors explicitly reflect-on-action as a way to model the epistemic frame of a profession. For novices, iterative cycles of action and explicit reflection-on-action with peers and mentors bind together the elements of the epistemic frame—the skills, knowledge, values, identity, and epistemology—that an individual takes on as a member of a community of practice. This collection of cultural tools forms the epistemic frame of the community, which, once appropriated, can be used when an individual approaches a situation from the point of view (or in the role) of a member of the community (Shaffer 2004a; 2004b; 2005; 2006).

Thus, Schön (1983; 1987) and Shaffer (2006) have a model of learning in a professional practicum that involves iterative cycles of action, explicit reflection-on-action, and the construction of a profession-specific epistemic frame. Their model extends Herrenkohl and Wertsch's (1999) assertion that coordinating cultural tools with sociocognitive roles can lead to both mastery and appropriation. Specifically, Schön and Shaffer move beyond a conversation about rights and responsibilities and into a discussion about designing professional practica and building epistemic frames. However, Schön and Shaffer's model does not address the role resistance plays in the mastery and appropriation of an epistemic frame.

While it is possible, and often quite important, to analyze how well students and others have mastered a cultural tool, such analyses can be quite limited in that they do not consider all of the complexities in the relationship between agents and the cultural tools they use (Wertsch, 1998). Thus, measuring appropriation in a practicum setting requires analysis of the process over time to see if there are instances of resistance that are inhibiting the appropriation of the epistemic frame. One way to analyze those components is through an epistemography, an analysis of the structure of a professional practicum through the lens of epistemic frames where one can examine the kinds of action and reflection-on-action that develop the epistemic frame of a profession (Shaffer, 2005; Svarovsky, 2006; Hatfield, 2008). An epistemography allows one to see learning principles at work and recognize some features of the practicum as being more essential than others in developing the professional epistemic frame. However, as Wertsch (1998) noted, the relationships between agents and their use of cultural tools are complex, and traditional statistical methods do not account for the complexities.

The kinds of professional understanding that a practicum develops are complex because they are not merely a collection of disconnected skills and knowledge. Rather, the power of an epistemic frame is in the connections among its parts, a network which consists of relationships among conceptual, practical, moral, personal, and epistemological parts (Shaffer et al., 2009). Thus, analytical methods such as social network analysis provide a robust set of tools for representing networks of relationships, including complex and dynamic relationships of the kind that characterize epistemic frames (Shaffer et al., 2009). In social networks, individuals are considered nodes in the network and relationships between individuals are represented as arcs or links between nodes (Haythornthwaite, 1996). For example, a social network analysis of an urban planning practicum

might examine the relationships among students and the teacher throughout class meetings. Within each class session, different configurations might emerge as old friends connected, new friendships emerged, and different team projects occurred. The amount of time individuals spend with each other could be taken as a proxy for the strength of their relationship by analyzing the different connections among and between nodes and links. That type of analysis would provide a quantifiable way of comparing social relationships across time and a means for better understanding the informal information flows that supplement the formal practicum curriculum.

However, as Shaffer (2009) argues, social network analysis was developed to provide insight into relationships among and between individuals and groups, rather than relationships within the conceptual, practical, moral, and epistemological world of an individual. Therefore, building on social network analysis, Shaffer (2009) has developed epistemic network analysis, a computational modeling technique for the development of epistemic frames.

Epistemic network analysis is based on two key concepts: (1) that thinking can be characterized by the application of an epistemic frame composed of the linkages between professional skills, knowledge, identity, values, and epistemology; and (2) that the development of professional thinking can be quantified, analyzed, and visualized with a dynamic network model of the developing epistemic frame (Shaffer et al., 2009). Epistemic network analysis has been used to trace frame development in elementary and middle school students during epistemic games based on engineering and urban planning (Nulty & Shaffer, 2008; Nash & Shaffer, 2008). A preliminary re-analysis of qualitative data collected on a science journalism practicum suggests that epistemic network analysis will be a useful tool for analyzing epistemic frame development in professional practica (Hatfield, 2008).

This study extends the ideas of Wertsch, Schön, and Shaffer by examining the relationships between appropriation, resistance, reflection-on-action, and epistemic frames in a professional planning practicum. The aim of this study—the epistemography of URPL 912—is to uncover the learning process within a graduate urban planning practicum. In particular, we investigate how one teacher communicated his urban planning epistemic frame in the face of resistance by describing the students' initial resistance to the teacher's frame, the teacher's explicit reflection-on-action, and the students' appropriation of the teacher's frame. We then use epistemic network analysis to examine the teacher's role in the students' epistemic frame development by tracking how specific features and events in the practicum led to significant changes in frame development. We argue that epistemic network analysis can provide a computational model of the extent to which participants appropriated the ways of knowing, being, talking, and acting that characterize a particular community of practice. Finally, we discuss how the results of this study may contribute to the design of reflective learning environments and experiences that promote the development of the next generation of urban citizens.

Methods

Urban and Regional Planning (URPL) 912 was a three credit course that met once a week for 14 weeks for approximately three hours. We chose to study URPL 912 because the course gives graduate students an opportunity to work in a practicum setting and is a prerequisite to entering the professional field of planning. The teacher was a professional planner with 34 years of planning experience across the United States.

In the course, 20 graduate students from the URPL masters program prepared a site plan for a developing area of approximately 3,000 acres on the northeast edge of Madison, Wisconsin. In the syllabus, the teacher wrote that he expected the students to "read the landscape" and expand upon the City's draft neighborhood plan for the area. Most of the class sessions began with the teacher's lecture, class discussion, or a professional planner guest speaker for the first hour and team work time for the remaining two hours.

Classroom data were collected in digital audio recordings and supplemented with field notes. Recordings were transcribed to provide a detailed record of interactions, and field notes were used to capture meaningful non-verbal aspects of the context and to supplement the transcripts. No information on specific career plans was collected; however, several students mentioned plans to pursue planning in city departments, non-profit groups, and state agencies. No other demographic information was collected about the students.

The data were segmented into interactive units which were defined as strips of activity with a consistent interactional structure and topical focus. For example, if the class started discussing the capacity of a proposed wastewater treatment plant and then switched to discussing the location of bike and pedestrian paths, the switch in discourse topic would indicate two separate interactive units. If an interactive unit represented more than one category, it was coded for all applicable codes. Within each interactive unit, the students' comments were coded cumulatively instead of individually in order to compare the students' cumulative frame to the teacher's frame.

This study's goal was to observe students learning to become planners through participation in a practicum. To capture interactions between the expert teacher and the novice students, we decided to focus on the communication between the teacher and the students during presentation feedback sessions. Presentation feedback sessions were occasions for the teacher and the students to offer feedback on information teams collected and for the teacher to explicitly reflect-on-action. Those sessions occurred in four classes throughout

the semester: weeks 4, 5, 11, and 13. We chose to analyze data from the presentation feedback in weeks four and five because the feedback given during those weeks focused on the information needed to create successful site plans whereas the feedback given in weeks 11 and 13 was more focused on the logistics of preparing for the final presentations. The specific activities in weeks four and five are outlined in more detail in the results section.

We used the teacher's epistemic frame in week four as the comparative model for the students' cumulative epistemic frame in both week four and week five because we were interested in seeing if the epistemic frame the teacher used during week four influenced the students' epistemic frame in week five. Additionally, after giving his initial lecture in week five, the teacher did not contribute as much as in week four. To measure the teacher's contribution in weeks four and five, interactive units were coded for the presence of the teacher's comments.

Table 1: Analytic codes applied to segmented interactive units for qualitative data analysis.

Code	Description	Example
Resistance	Student references to their conception of how the planning process should progress in a way that was contrary to the teacher's conception of how the process should move forward	…I sort of got the sense that they [the City] want us to deliver to them a set of policy recommendations and other higher level stuff to help them move this process along rather than our own design.
Reflection-on-action	References where the teacher looked back on a completed task or process to consider the implications and consequences of actions	…I'm just saying that when you look at the land use pattern, based on uses like that quarry, there's real limitations on residential in a large part of the area...Maybe this needs to be a place with a real employment center instead of just a bedroom community. I'm not saying that you don't have residential, and I'm not even saying you necessarily start in one place or the other, but I'm saying that it's gotta be in the thought process here.
Skill of reading a landscape (S/L)	Ability to use the landscape to inform the planning process	…I that it's very important that we step back and say, "How does this landscape speak to us?" Rather than letting someone else give it to us.
Skill of suggesting alternatives (S/A)	Ability to use a specific strategy or an alternative way to approach creating a plan	Shoehorning residential onto the North end won't work. Let's see if we can put some jobs up there so that the people who live further south, where it's easier to do residential development have a place to go that's a mile away or a mile and a half away instead of coming down to Madison. With that, make it a more sustainable community.
Skill of questioning assumptions (S/QA)	Ability to identify the assumptions the students made in their analyses	You guys all have to make some recommendations, but I don't want us to go into this without making sure that we are comfortable with the assumptions they [the City] are operating under…I'm not comfortable with all of the assumptions they are operating under and I think that their assumptions are no longer evidence-based…
Knowledge of additional information (K/AI)	References to specific information that might be useful for creating the site plan.	This is what we think is important to identify: Property values and who owns it to see if there's any correlation there. Target areas for potential development areas etc... Changes in zoning with different incentives for developers, transfer of development rights. Existing viewshed protection…
Knowledge of past process (K/P)	References to the process used by the City of Madison to create a plan for the same redevelopment area.	We saw a map of what they [the City] have in mind, and they already have land uses plotted out. They are presenting that to the mayor in the next few weeks. In that land use map, they have mixed use housing and TODs [transit oriented developments] and lower density housing, and the majority of it is also going to be lower density acreage.

Value of serving the public interest (V/PI)	Stating that the needs of people affected by the planning process are important to urban planning practice	The developer has to be involved in this association. It's not optional. They have to be part of the deal, and you are going to have to figure out what the City of Madison would say to one or more private land owners.
Epistemic statement about stakeholders' desires (E/SD)	Justifying decisions based on how participants thought a particular stakeholder group would respond.	…Businesses that might be developing through the university or incubator or something. They are going to need production and assembly facilities. They are going to need distribution facilities. And that might not be stuff they can get either on campus or in that incubator. This might be an ideal spot for them…
Epistemic statement about principles of good urban form (E/UF)	Justifying decisions based on the principles of good urban form	The city is planning the East Wash. build out in terms of employment…which means that it would have to put itself on the periphery because of the land loss. They could have an office near their production facilities. We see that as a potential benefit.

The result of the coded segments was a database of interactive units showing the presence of the teacher's comments, resistance, reflection-on-action, and epistemic frame elements. The relationships among these different components were then analyzed using epistemic network analysis to identify salient themes.

Epistemic network analysis adapts the framework of social network analysis for use with cognitive, rather than social, elements (Hatfield, 2008; Shaffer et al., 2009). As discussed in the background section, Shaffer (2009) has developed epistemic network analysis, a computational modeling technique for the development of epistemic frames. For details on the computations involved in epistemic network analysis, please see Shaffer (2009).

Once an epistemic frame is represented as a series of cumulative adjacency matrices showing the strength of association between each pair of frame elements for a given participant in the data set, the characteristics of the network can be quantified using concepts from social network analysis, such as network density and centrality of individual nodes (Shaffer et al., 2009). The overall structure of an epistemic frame can then be quantified by computing the relative centrality of each node: the square root of the sum of squares of its associations with its neighbors expressed as a percentage of the weight of the heaviest node in the network.

For this study, the relative centrality of each frame element and sub-element at the final time slice of the presentation feedback activity was calculated in order to compare the cumulative students' frame in weeks four and five to the teacher's modeled frame in week four. Calculating the relative centrality exposed which frame elements were further or closer to the center of the epistemic network (relative centrality values closer to 100) since epistemic frames consist of elements linked together with some elements more central than others. Using only the final time slice of relative centrality offered the most accurate picture of the students' cumulative frame development during weeks four and five since relative centrality is a cumulative measure of the changes in centrality to the epistemic network graph.

The frame similarity index (FSI) is an extension of epistemic network analysis. In this study, the FSI was calculated using the relative centrality which allowed comparisons between the students' frame development in weeks four and five and the frame modeled by the teacher in week four. The FSI was computed by using the difference between the cumulative students' final relative centrality calculations for each frame element in weeks four and five and the teacher's final relative centrality calculations for each frame element in week four. The absolute value of the difference of the values was then calculated. In order to make claims about skills, knowledge, values, and epistemology as a whole, the average of the frame sub-elements (e.g. E/SD and E/UF) was computed, and the results were graphed as cumulative frame elements (e.g. epistemology instead of E/SD and E/UF).

The FSI affords us the ability to use qualitative data to compare the development of complex thinking quantitatively. The FSI can be visualized using a radar plot where the optimal frame is represented as the origin and the developing frame is shown as something. This type of representation allows us to visualize the movement of novices' epistemic frame development in relation to the expert's epistemic frame. In the radar plot below, the teacher's frame is represented as the origin, and the closer the students' cumulative FSI is to zero, the more closely the students' frame resembles the frame the teacher modeled in week four.

Results

We describe our observations of URPL 912 in three parts below. First, we identify and describe the interactive units in which the students resisted the teacher during weeks four and five. Next, we identify and describe the interactive units in which the teacher reflected-on-action during weeks four and five. Finally, we describe the changes in the students' cumulative epistemic frame from week four to week five.

At the beginning of the semester, students in URPL 912 worked in teams to gather information about the redevelopment site. During the first class session, they learned that the City of Madison had been working on a plan for the site for three years, and the students were expected to "read the landscape" and expand upon the City's draft neighborhood plan for the area. The students continued to learn about the site through the teacher, guest speakers from the City of Madison planning department, out of class site visits and meetings with city officials, and targeted internet research. The teams were expected to present their initial findings during week four and their more specific findings during week five.

While presenting and giving feedback during week four, the students referred to the approach the City of Madison was using for the redevelopment site. When the teacher suggested alternative approaches that were contrary to the City's approach, the students began to resist his suggestions. Overall, in week four, 3 of the 11 segmented interactive units in the presentation feedback activity were coded for the students resisting the teacher's ideas, accounting for 54% of the time when both the students and the teacher were talking about the same topic. In contrast, in week five, the students did not resist the teacher's suggestions in any of the seven segmented interactive units in the presentation feedback activity when both the students and the teacher were talking about the same topic.

During the presentation feedback activities, the teacher often explicitly reflected on the students' findings, gave suggestions for additional information they could gather, and shared anecdotes about how the problems they were facing were similar to problems he had faced with previous projects. In week four, 11 of the 12 total segmented interactive units were coded for the presence of the teacher's comments, and 8 of the 11 segments during which the teacher spoke were coded for him reflecting-on-action. By reflecting-on-action, the teacher specifically pushed the students to question the City's assumptions and to consider how the population projections would affect traffic, jobs, and the overall development trajectory. By explicitly questioning the City's assumptions and offering suggestions about how to deal with multiple possibilities, the teacher spoke directly to the students' resistance in week four and strengthened the case for having the students' use his approach rather than the City's approach.

Unlike week four, in week five, the teacher started the class session by giving a lecture. During his lecture, the teacher reflected-on-action and explicitly addressed the students' resistance from week four. He reflected on the actions the students took in week four and referred to his experience as a planner in order to address the students' anxiety about using his approach instead of the more familiar City's approach. Specifically, the teacher suggested that taking time to gather information early in the process would have positive implications for the final site plan. To address their anxieties, he encouragingly reflected on the work the students completed in week four, told them he was expecting to be pleased in week five, and assured them that though they were at a slow part in the process, they were on course. To attend to the students' concern that his approach would not relate to the work the City had already accomplished, the teacher suggested that the students: "…Let this piece of land speak to us [because]…If we try to decide what it's going to look like before then, what you're going to end up with is exactly what you don't want to end up with which is something that doesn't relate."

Following the teacher's lecture, the students presented the information they gathered about the site and gave feedback on the information presented. During the presentation feedback, 8 of the 14 total segments were coded for the presence of the teacher's comments, and in one of the eight segments, the teacher was the only person speaking. Two of the seven segments wherein the teacher spoke were coded for the teacher reflecting on action. During the presentation feedback in week five, a student asked about the City's assumptions, and the teacher reflected-on-action by explicitly considering the implications and consequences that information would have for the recommendations they could make in their final site plans. By explicitly reflecting-on-action and addressing the student's resistance before they rejected his process outright, these data suggest that the teacher created a space where the students could begin to appropriate the epistemic frame he modeled in week four.

Using epistemic network analysis, Figure 1 provides a summary representation of the frame similarity index (FSI) of the difference between the students' cumulative epistemic frames in weeks four and five and the teacher's modeled epistemic frame in week four, which is represented by the origin of the radar plot. The total FSI was 165.8 in week four, but in week five, the FSI decreased to 90.3 suggesting that the students' frame became more similar to the frame the teacher modeled in week four. There was not a significant change in value development from week four to week five for the students; however, skills, knowledge, and epistemology frame elements began to look more like the teacher's modeled frame.

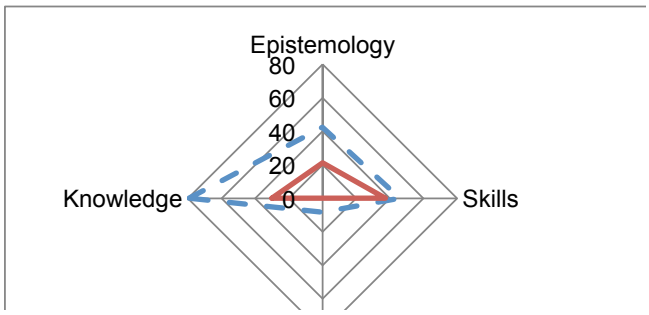

Figure 1. The origin of the radar plot represents the teacher's frame, and as the cumulative students' FSI moves closer to zero, their frame begins to look more like the frame the teacher modeled in week four.

By separating the epistemic frame elements into sub-elements, a more complete picture emerged about which specific sub-elements became more or less central to the students' epistemic frame from week four to week five (Table 2). As discussed above, for the teacher, V/PI, S/QA, S/Land, K/AI, and E/UF were the most central sub-elements in his epistemic frame in week four while the most central sub-elements in the students' epistemic frame were V/PI, E/SD, and K/P. In week five, instead of having a strong central core consisting of V/PI, E/SD, and K/P, the students exhibited a new configuration of their epistemic frame which looked more like the teacher's and included sub-elements such as S/Land, S/Alt, K/AI, and E/UF increasing in centrality. The order of centrality of frame elements also changed from week four to week five.

According to Shaffer (2009), the relative centrality of a node within a network represents the extent to which the node is or is not part of the dense central core of the network. Thus, though some of the sub-elements became more central to the students' epistemic frame, the relative centrality values of the sub-elements in the students' frame in week five were consistently lower than the teacher's values. Presumably, the teacher had higher relative centrality values for frame elements in week four because his 34 years of planning experience necessitated that his epistemic frame start out more richly interconnected than the students' epistemic frame. Therefore, the 'looseness' of the students' epistemic frame may be due to the students beginning to appropriate the sub-elements, and since the dense core is central to the strength of the epistemic frame, their epistemic frame will likely strengthen over time.

Table 2: Cumulative relative centrality calculations for eight epistemic frame sub-elements for the students in weeks four and five and the teacher in week four.

	V/PI	S/Alt	S/Land	S/QA	K/AI	K/P	E/SD	E/UF
Students Week Four	91.65	44.72	0	60	28.28	91.65	100	44.72
Students Week Five	100	73.38	55.47	55.47	83.21	48.04	55.47	55.47
Teacher Week Four	100	46.71	96.30	100	95.35	0	61.79	91.45

These results suggest that examining changes in epistemic frame development across time was a useful way of seeing the process of appropriation in the midst of student resistance in URPL 912. Through explicit reflection-on-action, it appears that the teacher addressed the students' resistance, enabling them to appropriate his epistemic frame.

Conclusions and implications

This study extends Wertsch's work on resistance and appropriation. Wertsch (1998) writes about the productive role of resistance in the process of appropriation, and in week four, there was student resistance. However, looking across weeks four and five shows that the students' resistance subsided, and the bridge between the students resisting and not resisting was the teacher's lecture. The teacher's lecture was essentially an explicit reflection on the different frames held by the teacher and the students and provided a map of the professional vision of the planning practice. However, it seems unlikely that his lecture immediately helped the students understand the epistemic frame of planners in a new light and enabled them to put their new knowledge into practice in their presentation feedback. Therefore, the students must have started appropriating aspects of the teacher's epistemic frame in week four despite their resistance.

Thus, these results also suggest that the kind of reflective mentoring that Schön and Shaffer describe in professional practicum settings accomplishes the task of helping students appropriate a new frame in the face of resistance. Specifically, the results of this study indicate that identifying practicum activities that evoke evidence about certain aspects of an epistemic frame will provide valuable information for designing effective practicum environments and learning in general. For example, practitioners thinking about ways to enhance their practice might consider including iterative cycles of action and reflection-on-action which may lead to appropriation and mastery.

This study demonstrates that epistemic network analysis can be a productive way of tracking how specific interactions within learning environments lead to significant changes in cognitive development. Building on initial work (Hatfield, 2008; Shaffer et al., 2009), this study adds frame similarity index to epistemic network analysis' set of techniques, in this case to compare the students' frame development in weeks four and five to the frame modeled by the teacher in week four. Specifically, the differences between the students' and the teacher's relative centrality values suggest that indices from epistemic network analysis can be useful for group comparisons and experimental studies of interventions. In other words, epistemic network analysis provides a computational model of the process and extent to which participants appropriated the ways of knowing, being, talking, and acting that characterize a particular community of practice. Thus, epistemic network analysis offers a technique for analyzing the kinds of situated understanding that result from sociocultural learning.

This study's findings can expand epistemic network analysis to provide a computational model of the extent to which participants appropriate a professional epistemic frame in the face of resistance with the help of a mentor's explicit reflection-on-action. Thus, epistemic network analysis points towards a promising new way of observing the translation of pedagogy into practice in various types of learning environments. These findings—and future studies investigating reflective practica and the development of epistemic frames—can shed light on how to better prepare citizens to think about and address the complex problems inherent in cities because as John Friedmann (1973) wrote, "the reconstruction of society must begin with man's re-education."

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