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Teacher Perceptions on Student Motivation

Melanie J. Snow & Donald J. Wink
University of Illinois-Chicago
msnow@uic.edu; dwink@uic.edu

Keywords: motivation, teachers, noticing

Abstract: Choices teachers make to motivate students are critical to designing and managing learning environments. While the supports and benefits teachers provide to students have been studied, the work on how teachers notice and respond to motivation is minimal. We know that motivation is important for student achievement and that intrinsic and extrinsic incentives can support learning (Pintrich 2003; Ryan, 2000). The greatest benefit however to the student lies with intrinsic motivation. One key to understanding the intrinsic motivation of the student is looking at what the student needs to be motivated. How the individual supports intrinsic motivation can be seen in the Self Determination Theory (SDT) work of Edward Deci and Richard Ryan (Deci & Ryan, 2011). SDT uses three motivational needs that foster the student's ability to be intrinsically motivated; *autonomy*, the learner feels some locus of control over their situation, *competency*, the learner has the skill necessary to have agency in their learning and *relatedness*, the learner feels connected to their learning environment through peers and teachers (Deci & Ryan, 2011).

Previous observations of teachers noticing motivation indicate that once teachers identify a motivation problem they may choose to implement an intervention to "increase motivation." Teachers then use their own beliefs, rather than understanding student needs, to determine the "why" behind the lack of motivation and to select an intervention (Hardré, 2013). In fact, when asked, teachers admitted to not fully understanding motivation or how to increase motivation (Hardré, 2013). This is important since the right intervention supports the motivational needs of the student and can create observed increases in intrinsic motivation as well as academic achievement (Neimic and Ryan, 2009).

For this study a focus group of urban high school science teachers was convened to understand how teachers identify and understand motivation as well as how implemented interventions do or do not reflect the psychological needs of the student. Conversations were transcribed and coded using an a priori set of codes based on the motivational needs defined by SDT. Coding was conducted by placing dialogue into a category matching a motivational need and subsequently re-analyzed to determine if the dialogue referenced a student. If so, the dialogue was coded for what motivational need might have been supported for the student based on student behavior, interaction, or outcomes as identified by the teacher.

Findings revealed instances where the intent to support a specific need with an intervention used by a teacher might not have been the need the student was seeking to have supported. In one instance a teacher revealed how the motivation of a difficult student changed based on helping the student get an "A." According to the teacher this change happened by assigning extra coursework, an intervention the teacher saw as relationship building. However, looking at this from a student's perspective one could argue that the student was gaining motivation by means of competency or autonomy. This could imply evidence of an ineffective classroom that lacks appropriate motivational supports for students.

References

Deci, E. L., & Ryan, R. M. (2011). Self-determination theory. *Handbook of theories of social psychology*, *1*, 416-433.

Hardré, P. L., & Hennessey, M. N. (2013). What they think, what they know, what they do: Rural secondary teachers' motivational beliefs and strategies. *Learning Environments Research*, *16*(3), 411-436**.**

Hattie, J. (2003). *Teachers make a difference: what is the research evidence?* (p. 4). Camberwell: Australian Council for Educational Research.

Niemiec, C. P., & Ryan, R. M. (2009). Autonomy, competence, and relatedness in the classroom Applying self-determination theory to educational practice. Theory and Research in Education, 7(2), 133-144.

Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of educational Psychology*, *95*(4), 667.

Beyond the Leaky Pipeline: What Learning Experiences Drive Students to Join STEM?

Jue Wu & David Uttal
Northwestern University
juewu2015@u.northwestern.edu; duttal@northwestern.edu

Keywords: STEM learning, Motivation/interest, Adult learning

Abstract: This poster will present a detailed, qualitative analysis of the structural, psychological, and sociological factors related to students' decisions to join STEM from non-STEM fields.

Motivation and theoretical background: Researchers often address the deficit of U.S. STEM workers using the "leaky pipeline" metaphor (Alper, 1993). This metaphor implies that the number of STEM workers shrinks at various educational levels (Anderson & Kim, 2006; Astin & Astin, 1992; Hall, Dickerson, Batts, Kasuffmann, & Bosse, 2011; Wang, 2013). However, by focusing on "leaks" in the pipeline, this metaphor leaves out a key group of students: those who enter STEM fields at various points along the pipeline. This overlooked group (hereafter, *STEM joiners*) could play an important role in addressing national shortages of STEM workers and increasing gender diversity in STEM.

Research question: What Learning Experiences Drive Students to Join STEM?

Summary of methods: Using a grounded theory approach, we conducted semi-structured interviews with 15 STEM joiners at an elite private Midwest university and coded and analyzed transcripts using NVivo 10.

Analyses, results, and discussion: The decision to join STEM is a developmental process that often involves overcoming anxiety about students' perceived preparation for STEM.

- Many joiners had been interested in STEM in high school and had thought about majoring in STEM in college. However, when in college, many decided, after comparing with peers, that their high school STEM preparation was not good enough to major in STEM.
- Nevertheless, these students did take some STEM courses, usually as part of the college distribution requirements. These classes proved to be critical to students' decision to enter STEM. Contrary to their initial perception of poor preparation, the future STEM joiners found that they actually did well in early STEM courses. This experience helped them overcome their earlier belief that they were not well prepared to become STEM majors.
- Individual and small-group mentoring opportunities were also critical to students' decision making. These opportunities included (a) spending time in office hours with a professor who encouraged the student to join STEM or (b) participating in advocacy groups, such as "Women in Computing", that supported both their interest in a STEM field and their growing belief that they were both competent and prepared.
- Career considerations were also important. Students found out by themselves or were often told that STEM fields offer lucrative jobs.

Implications: The results shed light on how educators and policy-makers can help broadening participation in STEM. First, professors, advisors, and peers need to be aware of the potential negative consequences of social comparison. Both formal and informal mentoring opportunities need to be targeted to students who may be wondering whether they are qualified for STEM majors; the mentor can help address decreases in self-esteem or motivation that occur from negative social comparison. Second, college officials should be aware of the potential benefits of early STEM courses and should point out that doing well in early classes is a good sign that students will succeed in later courses.

The effects of local vs. non local place-based learning in virtual environmental education

Amanda Siebert-Evenstone, Golnaz Arastoopour, & David Williamson Shaffer
University of Wisconsin - Madison
alevenstone@wisc.edu, arastoopour@wisc.edu, dws@education.wisc.edu

Keywords: place-based learning, science practices, civic engagement, virtual internships

Abstract: Most environmental education is context-based, meaning content learning is situated within a specific application (Lieberman & Hoody, 1998). Gruenewald (2003) claims that the most effective form of environmental education is a type of context-based environmental science learning where the context is local called place-based learning. This type of learning emphasizes a close connection between where students live and what students learn. Research on place-based learning has shown that curricula that incorporate such a concept improve science learning, community engagement, and interest in science topics (Powers, 2004; Ardoin, 2006). Many educators have studied various sociological and psychological effects of place-based learning (Semken et al., 2009; Ardoin et al., 2012), however, no studies have directly compared the effects of place-based vs. non place-based learning. One potential reason for the lack of comparative experiments is that by definition, place-based learning is based on a local physical environment, and thus once a student leaves the local environment, then it is no longer place-based learning. One solution to this paradox is to create immersive, context-based, virtual environments that simulate problem-solving in a specific place. Virtual internships, like LandScience, have the potential to address this issue by having students in various physical locations engage in an authentic learning experience about a specific place, which may be local to some students and non-local to other students.

In LandScience, students role-play as urban planners who develop a new land-use plan for Lowell, Massachusetts. After learning about the history of Lowell, indicators, and stakeholders, students create and test land-use plans and evaluate stakeholder needs. LandScience fosters interaction with realistic but accessible urban planning models that simulate the effects of land use decisions on social, economic, and environmental indicators. By working to understand these relationships, students learn to understand the dependencies and tradeoffs in complex eco-social systems.

We collected pre- and posttest responses from 10 implementations of students who engaged in LandScience when participating in either Massachusetts (n=68) or a different state (n=26). To be included in the analyses students must have answered all three sets of questions. Because of the importance of place in fostering engagement in one's community, we questioned how and if the "place" represented in LandScience affected student learning during the virtual internship. We compared student scores based on their location when engaging in the internship by conducting multiple regression analyses to predict the change in outcome for civic engagement, examples of science modeling, and interest in cities and the environment. Students located in Massachusetts and developing a plan for Lowell, had significantly higher changes in civic engagement, ability to identify science models, and interest in cities and the environment than students who developed a land-use plan for Lowell but did not live in that state. Because our internship is based in a specific place, students that lived in that city and state may have connected with the local context as a more meaningful experience. This study suggests that

students may learn more from online experiences set in their location in contrast to non-local places.

References

1. Ardoin, NM. (2006). Toward an Interdisciplinary Understanding of Place: Lessons for Environmental Education. *Can J Environ Educ*., *11*(1):112-126.
2. Ardoin, NM, Schuh, JS, Gould, RK. (2012). Exploring the dimensions of place: a confirmatory factor analysis of data from three ecoregional sites. *Environ Educ Res*., *18*(5):583-607.
3. Gruenewald, DA. (2003). The best of both worlds: A critical pedagogy of place. *Educ Res*., *32*(4):3-12.
4. Lieberman, GA, Hoody, LL. *Closing the Achievement Gap: Using the Environment as an Integrating Context for Learning*. Poway, CA: Science Wizards; 1998.
5. Powers, AL. An evaluation of four place-based education programs. *J Environ Educ*., *35*(4):17-32.
6. Semken, S, Freeman, CB, Watts, NB, Neakrase, JJ, Dial, RE, & Baker, DR. (2009). Factors that influence sense of place as a learning outcome and assessment measure of place-based geoscience teaching. *Electron J Sci Educ.*, *13*(2):136-159.

Using a Text Mining Approach to Rapid Prototype a Formative Assessment in Online Problem-Based Learning

Chris Georgen & Alejandro Andrade
Indiana University
cgeorgen@indiana.edu; laandrad@indiana.edu

Keywords: problem-based learning, CSCL, text mining, learning analytics

Abstract: We make a preliminary case for a computational method intended to facilitate real-time formative assessment in a problem-based and computer-supported collaborative learning environment. With a focus on the development of disciplinary discourse, we aim to address how learning analytics, in this case text mining, can capture learning and provide learners and instructors with meaningful information that supports learning, engagement, and trajectories toward mastery (Siemens & Baker, 2012). To do so, we explored a computational approach to automatically capture text-based data, resulting in measures of learners' discursive alignment to each other and expert benchmarks (i.e., similarity values) as participants progressed through a problem-based learning (Hmelo-Silver, Duncan, & Chinn, 2007) unit in an undergraduate introductory sound engineering course that focused on mathematical and engineering principles of analog electronics.

The preliminary results of our analysis are two-fold. First, student-expert similarity values significantly increased as students progressed through individual work, group hypothesis forming and testing, and final proven group answers. This provides evidence for problem-based learning's potential to encourage and develop expert-like discourses and disciplinary literacies. Moreover, we posit that similarity values or representations of similarity values (e.g., word clouds) may enhance PBL as formative assessments. Second, our results indicate that text mining and similarity values can quickly capture student work and are suggestive of orientations toward local and broader disciplinary practices. This affords a working and contextual model of knowledge and expertise situated in technologically enhanced pedagogy. We see this as "rapid prototyping" of student-expert performance that can be modeled and iterated concurrent to learning and instruction. We believe that when provided access to similarity values, students and instructors can correlate their practices with other forms of evidence (e.g., grades or lab experiments) and work toward alignment and shared understanding within peer groups and with experts.

While real-time feedback by means of learning analytics is not novel, automating similarity values, as an approach to identify the distance between students and expert benchmarks, may help students learn and instructors correlate assessments and design instruction. This preliminary case serves as a fruitful proof-of-concept that learning analytics can be used to provide real-time formative assessments in support of computer-supported and problem-based learning environments. Furthermore, that over time students made alignments toward expert discourses provides evidence for problem-based learning as a valuable method of inquiry and instruction. Practically, this work may have important implications for educators and researchers alike, as it provides an entry point into learning analytics and data mining as a valuable and reliable approach to formative assessment in a variety of learning environments. This work points toward new avenues for meaningful and practical real-time assessment practices during collaborative inquiry, computer-supported or otherwise.

References:

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). Educational psychologist, 42(2), 99-107

Siemens, G., & Baker, R. (2012). Learning analytics and educational data mining: towards communication and collaboration. Paper presented at the Proceedings of the 2nd international conference on learning analytics and knowledge.

Fostering a Holistic Conceptualization of Science Practices: A Framework to Support Teachers' Understanding and to Transform Classroom Practice for Student Learning

Nicole D. Martin & Sadhana Puntambekar
University of Wisconsin - Madison
ndmartin@wisc.edu; puntambekar@education.wisc.edu

Keywords: science practices, science education, teacher learning

Abstract: Recent reforms in science education center on teaching science as a practice by which we understand, evaluate, and represent the world (Lehrer & Schauble, 2015). Understanding science as interdependent practices to construct scientific knowledge has become a prominent perspective, emphasized in the recent Next Generation Science Standards (NGSS, 2013). Helping students learn science practices requires significant changes from traditional science education that frequently presents science as a linear, procedural method; we must provide teachers with the appropriate support to successfully implement these changes (Reiser, 2013). Previous research has predominately focused on supporting science practices through instructional materials, but these materials must be complemented by *teachers'* understanding how to support students. Tabak and Radinsky (2015) acknowledge that research on teaching is less frequent in learning sciences, and our research importantly addresses this gap by viewing teachers as learners and investigating how to foster teachers' learning of science practices.

We aim to answer the following research question: how can we support teachers to develop holistic conceptualizations of science practices that transform their teaching and help students understand science practices? The first step in this pursuit, which we focus on here, is refining a conceptual framework for supporting a holistic understanding of science practices. This framework will then be used to support teachers' understanding of science practices and help improve their teaching of these practices. We propose a framework that consists of four ways for *teachers* to support science practices that will offer new contributions by explicitly addressing the importance of understanding the interdependencies and epistemic purposes of science practices. The framework outlines four support mechanisms for teachers to help students learn science practices: i. opportunities to engage in practices (e.g. Driver, Newton, & Osborne, 2000); ii. guidance for participating in practices (e.g. McNeill, Lizotte, Krajcik, & Marx, 2006); iii. guidance for why practices are important in science (Sandoval & Millwood, 2005); and iv. guidance for how practices are interconnected (Erduran, 2014). Previous research has found these supports to be beneficial for students, but supports have predominately been material-based tools, not guidance from *teachers*. These supports have also typically been investigated separately and not synthesized into a cohesive framework for supporting a holistic understanding of science practices. We used this framework to preliminarily investigate teachers' approaches to supporting science practices in the classroom, through analyses of classroom observations, and teachers' understanding of science practices, through analyses of semi-structured interviews. Our initial findings suggest that teachers may need additional guidance to 1) understand science practices as interconnected and 2) develop concrete teaching strategies that support students' leaning of science practices. These initial findings provide the basis for refining and further developing the framework in order to guide teachers' learning of science practices as interdependent. We anticipate that this work will help provide concrete ways that teachers can support students' understanding of science practices and develop professional training programs

for teachers. This work will have important implications for helping teachers learn how to implement a comprehensive focus on science practices in their classrooms that aids students' holistic understanding.

References

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education*, *84*, 287.

Erduran, S. (2014). Revisiting the nature of science in science education: Towards a holistic account of science in science teaching and learning. In *Proceedings of the Frontiers in Mathematics and Science Education Research Conference* (pp. 14–25). Famagusta, North Cyprus.

Lehrer, R., & Schauble, L. (2015). The development of scientific thinking. In L. S. Liben, U. Muller, & R. M. Lerner (Eds.), *Handbook of Child Psychology and Developmental Science* (Seventh., pp. 671–714). Wiley.

McNeill, K. L., Lizotte, D. J., Krajcik, J., & Marx, R. W. (2006). Supporting students' construction of scientific explanations by fading scaffolds in instructional materials. *The Journal of the Learning Sciences*, *15*(2), 153–191.

NGSS Lead States. (2013). Next Generation Science Standards: For states, by states. Washington, DC: The National Academies Press.

Reiser, B. J. (2013). What professional development strategies are needed for successful implementation of the Next Generation Science Standards?, (September). Paper prepared for K12 center at ETS invitational symposium on science assessment. Washington, DC. http://www.k12center.org/rsc/pdf/reiser.pdf

Sandoval, W. A., & Millwood, K. A. (2005). The quality of students' use of evidence in written scientific explanations. *Cognition and Instruction*, *23*(1), 23–55.

Tabak, I., & Radinsky, J. (2015). Educators' coaches, peers, and practices: Revisiting how teachers learn. *Journal of the Learning Sciences*, *24*(3), 343–346.

Historical Reasoning While Writing in History: A case study

Michael J. Bolz
University of Illinois at Chicago, Learning Sciences Research Institute
Mbolz2@uic.edu

Keywords: historical reasoning, writing, think-alouds

Purpose

This case study examines the nature of a student's historical reasoning as they read historical sources and composed a text-based historical essay. It extends the current tradition of research on writing in history through an investigation of both the historical writing a student produces and the historical reasoning the student engaged in to create that product. This study addresses the question: In what ways does a student's historical reasoning come to be represented in their historical writing?

Theoretical Framework

Recent initiatives to reform history education have advocated for an inquiry-based approach to the teaching and learning of history (Shanahan & Shanahan, 2008; Wineburg 2001) that calls for students to engage with sources and think historically. Research examining students' historical reasoning regularly rely on evidence in students' written essays to make claims around the types and complexity of the historical reasoning students engage in to generate those products (De La Paz, 2005; Monte-Sano, 2010; Monte-Sano & De La Paz, 2012, Young & Leinhardt, 1998). However, it is still unclear whether and to what extent the written historical essay is an accurate or representative window into students' historical reasoning.

Methods and Data Sources

This study is situated within the context of a year-long intervention designed to promote students' historical reasoning and inquiry in an 11th grade high school Advanced Placement U.S. History course. Think-alouds were conducted with 9 participants as they read multiple sources and composed an argumentative source-based history essay. One student's protocol was purposefully identified for use in this illustrative case study.

Video data of the think-aloud sessions were transcribed verbatim, and these protocols were parsed into idea units. These units were then coded for dimensions and degrees of historical reasoning (sourcing, corroboration, contextualization) and elements of argument (e.g. generation of claims, use of evidence). The student's essay was similarly coded for evidence of historical reasoning and argument structure, followed by a comparative analysis across the coded essay and protocol data.

Results

Analysis demonstrates that the written essay only provided partial insight into the student's reasoning. Although the essay provided some accurate traces of the student's historical reasoning, the protocol analysis indicated that the student not only engaged in more historical reasoning than was evidenced in the essay, but that the historical reasoning the student engaged in was more complex and varied than what was demonstrated in the essay. Additional analysis indicated that the task prompt and text set also drove the nature of the historical reasoning the student engaged in.

Implications

Few studies have attempted to examine students' historical reasoning during the writing process. While students' written products show some traces of their historical reasoning, written products do not necessarily demonstrate the range or complexity of reasoning students' engage in to create those products. This holds critical implications for both the ways in which researchers make claims about student reasoning from essays, as well as the ways in which teacher's assess students historical reasoning in assessment settings.

References

De La Paz, S. (2005). Effects of Historical Reasoning Instruction and Writing Strategy Mastery in Culturally and Academically Diverse Middle School Classrooms. Journal of Educational Psychology, 97(2), 139.

Monte-Sano, C. (2010). Disciplinary literacy in history: An exploration of the historical nature of adolescents' writing. The Journal of the Learning Sciences, 19(4), 539-568.

Monte-Sano, C., & De La Paz, S. (2012). Using Writing Tasks to Elicit Adolescents' Historical Reasoning. Journal of Literacy Research, 273-299.

Shanahan, T., & Shanahan, C. (2008). Teaching disciplinary literacy to adolescents: Rethinking content-area literacy. Harvard Education Review. 78(1), 40-61.

Wineburg, S. (2001). Historical Thinking and Other Unnatural Acts: Charting the future of teaching the past. Philadelphia, PA: Temple University Press.

Young, K. M., & Leinhardt, G. (1998). Writing from Primary Documents: A Way of Knowing in History. Written communication, 15(1), 25-68.

The Role of an Authentic Audience in Computational Modeling: Designing Models of Tides for Younger Children

Ashlyn Karan
Vanderbilt University
ashlyn.e.karan@vanderbilt.edu

Keywords: science education, modeling, computational thinking, audience, and constructionism

Abstract: Constructionism proposes that learning is particularly effective when "the learner is consciously engaged in constructing a public entity" (Papert & Harel, 1991, p. 1). Existing research suggests that constructionist activities, such as building computational models for an audience, support conceptual growth because designing for an audience (a) positions students as authors of content, increasing the utility and importance of their task (Kafai, Ching, & Marshall, 1997; Lehrer, 1993), and (b) facilitates shifts in students' perspectives, supporting them in building coherent knowledge frameworks as they negotiate their understandings with their audience (Greeno & van de Sande, 2007, 2012; Thagard & Verbeurgt, 1998). While these arguments are theoretically compelling, they have not been directly tested by comparing the conceptual growth of students designing models for an authentic audience to the conceptual growth of students designing models without an audience.

To contribute to this line of research, I compared two groups of 6th grade classrooms as they created computational models of tides: classrooms designing models for an audience of younger students and classrooms designing models as an assignment for their teacher.
I asked how considering an audience of younger children:
1. affects students' learning about the mechanisms that cause tides,
2. influences students' design choices in models and artifacts,
3. shapes students' priorities, and
4. supports domain-specific reasoning during discourse.

I analyzed students' assessments, models, artifacts, and discourse to explore how designing for an audience shaped students' participation and learning. I used a mixed-method approach to analyze data (Chi, 1997). Grounded coding (Charmaz, 2006) allowed me to systematically identify and compare themes, and quantifying data allowed me to interpret patterns within the coded data (Chi, 1997).

I found that students in the audience condition demonstrated greater knowledge about the mechanisms that cause tides than students in the no-audience condition (Table 1). My analysis suggests that designing for an audience of younger children facilitated goals such as showing mechanisms responsible for tides (Table 2), and that these goals supported domain-specific reasoning (Table 3).

Because they prioritized communicating the mechanisms that caused tides to their audience, students in the audience condition were more likely to take on users' perspectives. This shift in perspective helped them build more coherent understandings of tides as they negotiated between conceptions. The students in the no-audience condition were less likely to negotiate between

their own and users' perspectives. Instead, they often guessed or recalled the answer that the teacher valued without engaging in domain-specific reasoning.

Additionally, students in the audience condition were motivated by the perceived utility of their task. They were more likely to describe their models as useful to others, work on models outside of class, consider issues beyond the requirements of the assignment, and design and share solutions to class problems. These forms of engagement led to an increase in model quality and participation, contributing to the relatively higher conceptual growth in the audience condition compared to the no-audience condition. These findings suggest that incorporating an authentic audience into classroom modeling projects promotes engagement and conceptual growth.

References:

Charmaz, K. (2006). Constructing grounded theory: A practical guide through qualitative research. *SagePublications Ltd, London.*

Chi, M. T. (1997). Quantifying qualitative analyses of verbal data: A practical guide. *Journal of the Learning Sciences*, *6*(3), 271-315.

Greeno, J. G., & van de Sande, C. (2007). Perspectival understanding of conceptions and conceptual growth in interaction. *Educational Psychologist*, *42*(1), 9-23.

Greeno, J. G., & van de Sande, C. C. (2012). Achieving alignment of perspectival framings in problem-solving discourse. *Journal of the Learning Sciences*, *21*(1), 1-44.

Kafai, Y. B., Ching, C. C., & Marshall, S. (1997). Children as designers of educational multimedia software. *Computers & Education*, *29*(2), 117-126.

Lehrer, R. (1993). 7 authors of knowledge: Patterns of hypermedia design. In S. P. Lajoie & S. J. Derry (Eds.), *Computers as cognitive tools.* Hillsdale, New Jersey: Lawrence Erlbaum Associates, Inc.

Papert, S., & Harel, I. (1991). Situating constructionism. In I. Harel and S. Papert (Eds.) *Constructionism* (pp. 1-14). Ablex Publishing: Norwood, NJ. Accessed from http://papert.org in January 2016.

Thagard, P., & Verbeurgt, K. (1998). Coherence as constraint satisfaction. *Cognitive Science*, *22*(1), 1-24.

Tables:

Table 1

Pre-Assessment, Post-Assessment, and Pre-Post Gains in Audience and No-Audience Conditions

	Audience (n = 42)		*No-Audience* (n = 39)			
	M	SD	M	SD	t-test	p
Pre-Assessment	2.95	1.98	2.97	2.37	-.05	.96
Post-Assessment	5.17	2.64	4.13	2.22	1.91	.06
Pre-Post Gains	2.21	2.32	1.15	2.31	2.06	.04

Table 2

Goals and Priorities in Class Discussions

	Audience	*No-Audience*
Aesthetics	7	21
Right Answers	48	77
Show Mechanisms (General)	32	19
Show Mechanisms to a Specific Audience	37	2
Total	124	119

Table 3

Relationship of Goals and Priorities to Domain-Specific Reasoning

	Not domain-specific; limited reasoning	*Domain-specific; limited reasoning*	*Domain-specific with reasoning*
Aesthetics	**24**	5	3
Right Answers	**52**	**61**	6
Show Mechanisms (General)	5	**26**	**22**
Show Mechanisms to a Specific Audience	4	8	**13**

Quantitative Ethnography

Brendan Eagan, Wesley Collier, Golnaz Arastoopour, Andrew Ruis, Amanda Evenstone, Zachari Swiecki, David Williamson Shaffer
University of Wisconsin-Madison, Department of Educational Psychology – Learning Sciences
beagan@wisc.edu; wcollier@wisc.edu; arastoopour@wisc.edu; arruis@wisc.edu; alevenstone@wisc.edu; swiecki@wisc.edu; dws@education.wisc.edu

Keywords: educational research methods, educational data mining/learning analytics, complex thinking, ethnography

Abstract:

21st century educational research depends on the ability to teach and assess the development of complex thinking skills. In the age of educational games, MOOCs, and learning environments that provide easy access to large quantities of educational data, we have more information than ever about what students are doing and how they are thinking. Education has Big Data. However, the sheer volume of available data can overwhelm traditional qualitative and quantitative research methods.

This poster will provide an overview of the science of Quantitative Ethnography and a preview of recent developments of three key tools that researchers can use to assess complex thinking in educational Big Data: Epistemic Network Analysis (ENA), nCoder, and rho. The development of these tools is all in the service of one methodological framework, Quantitative Ethnography.

Quantitative Ethnography is a set of research methods that weave the study of culture together with statistical tools to understand learning. It is a process of using statistical tools to warrant claims about theoretical saturation in qualitative data, allowing Learning Sciences researchers to make meaning about the cultures of different communities of practice. It offers a way to tell textured stories at scale, going beyond searching for arbitrary patterns in mountains of data generated by MOOCs, LMS, games and simulations.

Epistemic Network Analysis (ENA) is a network modeling technique for modeling learning in Big Datasets. ENA was recently shown to find meaningful patterns in discourse that methods like Principal Components Analysis (PCA) miss (Collier et. al. 2016). Methods like PCA model correlations between concepts that students reference over a whole dataset – a semester in a class, or a whole game, for example. This can show how one group of students might use a cluster of concepts more than another overall – what can be thought of as *global connections*. In contrast, ENA models connections students make at a *local level*: that is, the way they link ideas within a single activity. It then looks for patterns in these connections over time. This "local" approach can reveal patterns that a global approach does not. Additionally, ENA can now model *individual* contributions to *collaborative work* using a new technique called *moving stanza windows* (Siebert-Evenstone et. al. 2016). Moving stanza windows create a network for each line of talk showing the connections it contributes to the group's recent discourse.

The nCoder tool supports the development and validation of codes—both automated codes and inter-rater reliability in traditional hand coding procedures. Currently it is being redesigned to use natural language processing techniques, such as nearest neighbor, using latent semantic analysis and topic modeling to support theory driven automated coding. A crucial aspect of these efforts is to establish the reliability and validity of these automated approaches.

Rho is a new statistical approach developed to establish the reliability of automated coding schemes. Rho is built into nCoder and will be available soon as a stand-alone r package.

References:

Collier, W., Ruis, A.R., & Shaffer, D.W. (2016). Local versus global connection making in discourse. Paper presented at the *12th International Conference of the Learning Sciences*, Singapore.

Siebert-Evenstone, A. L., Arastoopour, G., Collier, W., Swiecki, Z., Ruis, A. R., & Shaffer, D.W. (2016). In search of conversational grain size: Modeling semantic structure using moving stanza windows. Paper presented at the *12th International Conference of the Learning Sciences*, Singapore.

Drawing Prompts Enhance Students' Learning with Conventional Visual Representations in STEM

Sally P. W. Wu
University of Wisconsin – Madison
pwwu@wisc.edu

Keywords: drawing, STEM education, visual representations, educational technology

Abstract: In science, technology, engineering, and mathematics (STEM) fields, students must often learn by integrating concepts depicted in conventional visual representations with their own mental models. However, students face difficulties when learning with conventional representations and require instructional support to effectively integrate concepts with mental models. To this end, prompting students to draw their own representations may be particularly beneficial to support students in processes of mental model development (Ainsworth, Prain, & Tytler, 2011; Cheng & Gilbert, 2009; Schmeck, Mayer, Opfermann, Pfeiffer, & Leutner, 2014).

Drawing may be effective because it helps students externalize their mental models through generating and revising their own representations (Leopold & Leutner, 2012; Valanides, Efthymiou, & Angeli, 2013). Prompts to draw are often provided with other instructional activities in STEM learning settings to help students integrate domain-relevant concepts with students' own mental models (Bobek & Tversky, 2014; Zhang & Linn, 2011). Because students only require pen and paper, drawing prompts are practical because they are low-cost and easy to incorporate into instruction., However, there is little research on the conditions in which drawing is effective (Van Meter & Garner, 2005).

Many open questions remain regarding how drawing supports learning when combined with other instructional activities and how to best implement drawing activities in STEM instructional settings (Cheng & Gilbert, 2009; Quillin & Thomas, 2015). For instance, prior research has not investigated how drawing prompts can support mental model development when combined with other instructional activities. Moreover, no previous study has investigated the efficiency of providing drawing prompts compared to other effective instructional strategies by replacing existing instructional activities with drawing prompts to account for instructional time. Understanding how and when drawing prompts may be effective and efficient can provide insight into whether drawing prompts are beneficial and how prompts can be integrated with instructional activities to help students learn with conventional representations.

To address these open questions, I investigated the effectiveness and efficiency of drawing prompts in the context of an educational technology in which undergraduate students learned chemistry concepts with conventional visual representations. Two laboratory experiments provide evidence that drawing prompts enhanced students' learning on immediate and delayed post-tests. Experiment 1 tested the timing of drawing prompts, while Experiment 2 tested the different types of prompts targeting specific cognitive processes. Quantitative test scores show that drawing prompts are an effective and efficient instructional activity that complements an educational technology and enhances learning of domain knowledge. Preliminary qualitative think-aloud, interview, and drawing data showed that drawing prompts can support students'

mental model development. Results extend theory about how drawing may complement existing instructional activities to support students when learning with conventional visual representations. Furthermore, I demonstrate that drawing with paper and pen is an effective strategy for learning without adding instructional time, and hence drawing can be implemented at low-cost and low-effort. This research addresses open questions regarding how drawing prompts can be effectively and efficiently incorporated into other instructional activities and thereby support students' learning with conventional visual representations in STEM learning settings.

Reference

Ainsworth, S. E., Prain, V., & Tytler, R. (2011). Drawing to learn in science. Science, 333(6046), 1096–1097.

Bobek, E., & Tversky, B. (2014). Creating visual explanations improves learning. In Proceedings of the 36th annual conference of the cognitive science society (pp. 206–211). Austin, TX.: Cognitive Science Society.

Cheng, M., & Gilbert, J. K. (2009). Towards a better utilization of diagrams in research into the use of representative levels in chemical education. In J. K. Gilbert & D. Treagust (Eds.), Multiple representations in chemical education (pp. 55–73). http://doi.org/10.1007/978-1-4020-8872-8_4

Leopold, C., & Leutner, D. (2012). Science text comprehension: Drawing, main idea selection, and summarizing as learning strategies. Learning and Instruction, 22(1), 16–26. http://doi.org/10.1016/j.learninstruc.2011.05.005

Quillin, K., & Thomas, S. (2015). Drawing-to-Learn : A framework for using drawings to promote model-based reasoning in biology. CBE Life Sciences Education, 14(1), 1–16. http://doi.org/10.1187/cbe.14-08-0128

Schmeck, A., Mayer, R. E., Opfermann, M., Pfeiffer, V., & Leutner, D. (2014). Drawing pictures during learning from scientific text: Testing the generative drawing effect and the prognostic drawing effect. Contemporary Educational Psychology, 39(4), 275–286. http://doi.org/10.1016/j.cedpsych.2014.07.003

Valanides, N., Efthymiou, I., & Angeli, C. (2013). Interplay of internal and external representations: Students' drawings and textual explanations about shadow phenomena. Journal of Visual Literacy, 32(2), 67–84.

Van Meter, P., & Garner, J. (2005). The promise and practice of learner-generated drawing: Literature review and synthesis. Educational Psychology Review, 17(4), 285–325. http://doi.org/10.1007/s10648-005-8136-3

Zhang, Z. H., & Linn, M. C. (2011). Can generating representations enhance learning with dynamic visualizations? Journal of Research in Science Teaching, 48(10), 1177–1198. http://doi.org/10.1002/tea.20443

Text and Task Complexity in Reading Literary Texts

Allison H. Hall
University of Illinois at Chicago
ahall33@uic.edu

Keywords: literary reasoning, text complexity, instructional design

Abstract:

Recent changes in educational standards require students to engage in more complex tasks with more complex texts, which in the study of literature suggests moving beyond simply understanding the plot, setting, and characters to interpreting literary texts for deeper meaning. Therefore, in designing instruction, the potential sources of complexity of literary texts used in classrooms need to be considered and understood. However, there is as yet little empirical work that looks at complexity in literary texts in actual classroom contexts. This work attempts to address that gap by examining sources of text complexity in the study of two novels, with particular attention to the demands of the tasks.

Sources of difficulty in literary texts stretch beyond simple measures of word count and vocabulary level, as other aspects of text may also interfere with interpretation (e.g., theme, genre, rhetorical devices). Goldman and Lee (2014) argue that understanding sources of text complexity also requires analysis of the task and context of readers. Furthermore, Lee, Goldman, Levine, and Magliano point out that “knowing” in literary reasoning requires a focus on how authors use language and structure to convey meaning and create effects, considered by Hillocks and Ludlow (1984) the highest level of literary reasoning in their taxonomy of skills. The question for educators becomes how to support students in using higher level skills in reading complex literary texts. This study examines sources of difficulty for students in studying two different novels in the context of instruction designed to support students in learning literary reasoning.

Data for this study come from 20 students in an 11th grade English classroom in a small racially diverse urban high school (87% low income). Data sources include lesson artifacts, field notes, and video recordings of classroom observations across an academic year. Data also include audio of meetings and debriefings with the teacher, written lesson plans, student written work, and audio of interviews with individual students.

To investigate the sources of complexity in reading the two novels, data were examined for indications of student struggle in relation to reading and interpreting the texts. These points of struggle were identified from teacher comments and from student work not matching expectations based on instructional objectives. Class discussions and written work related to the area of difficulty were then analyzed for sources of complexity (e.g., language and structure of the text, knowledge of rhetorical devices, knowledge of theme, demands of task).

Preliminary analyses suggest varying sources of complexity for students in reading these novels, heavily dependent on the nature of the particular tasks as well as the types of knowledge required by those tasks. Also, tasks became more difficult if there was confusion at the sentence level or with understanding literal events in the novels.

Research on how students engage in complex tasks while reading complex literary texts can help us better understand issues around teaching and learning literary reasoning. In

particular, understanding sources of complexity can help teachers and educators design instruction to support students in engaging in these practices.

References

Goldman, S. R., & Lee, C. D. (2014). Text Complexity. *The Elementary School Journal, 115*(2), 290-300.

Hillocks, G., & Ludlow, L. H. (1984). A taxonomy of skills in reading and interpreting fiction. *American Educational Research Journal, 21*, 7-24.

Lee, C. D., Goldman, S. R., Levine, S., & Magliano, J. (2016). Epistemic cognition in literary reasoning. *Handbook of epistemic cognition*, 165-183.

Taking a Critical Stance in English Education: Defining Literary Argumentation in Problem-based Professional Learning

Angela Joy Fortune
University of Illinois at Chicago
angelajoyfortune@gmail.com

Abstract: Foregrounded in current policy (e.g., CCSS, 2010) is a focus on higher-level critical thinking instantiated through disciplinary literacy practices characterized by engaging in argumentation (Graff, 2003; Hillocks, 2010). For secondary teachers, the shift to disciplinary literacy instruction emphasizing argumentation repurposes tools of English Language Arts (ELA) to increase students' disciplinary expertise (Moje, 2007). English teachers are uniquely positioned to adopt disciplinary literacy pedagogy as their responsibility of teaching students to read and write across disciplines is now shared in concert with other disciplinary teachers. This creates an authentic "problem" space for English teachers to re-evaluate their disciplinary focus and make sense of argumentation as they interpret standards and develop the capacity to support students' achievement of disciplinary literacy goals. Shifting to new standards and concepts requires professional learning opportunities that are situated to address problems of practice (Raphael, Vasquez, Fortune, Gavelek, & Au, 2014) and engage teachers in addressing both conceptual understandings and practical application (Zech, Gause-Vega, Bray, Secules, & Goldman, 2000).

This work is grounded in constructivist theories that view learning as interactive cultural events situated within social practices (Rogoff, 1994; Vygotsky, 1978; Wenger, 1998). Teachers construct understandings through social participation in collaborative discussions around common goals (Shulman & Shulman, 2004). In problem-based professional learning, teachers engage collaboratively with learner-centered tasks around authentic problems of practice and dialogically construct how the problem at hand should be defined as instructional leaders facilitate the process by setting up the problem and serving as a "guide on the side" rather than the "sage on the stage" (Bridges & Hallinger, 1995; 1997). Guided by the question, "How do English teachers make sense of disciplinary argumentation in problem-based professional learning?," this study examines how English teachers who participated in a problem-based professional learning network constructed a conceptual definition of disciplinary argumentation.

This study is situated in a larger Reading for Understanding research project, Project READI (Reading, Evidence, and Argumentation in Disciplinary Instruction), which is a national research project aimed at supporting 6th through 12th grade students' argumentation using multiple texts in history, science, and literature (Goldman, Lee, Britt, Greenleaf, & Brown, 2009). For this study, data draws on 10 English teachers participating in PD at an urban university in the Midwest. Using constant comparative methods (Glaser, 1965), a hybrid coding approach (Fereday & Muir-Cochrane, 2008) was applied to video data of teacher discourse and written artifacts collected during their six rounds of work constructing a conceptual definition of argumentation in order to conduct a thematic analysis.

Analyses revealed that teachers negotiated meanings to determine “what counts” as argumentation in their discipline. They determined that literary texts, interpretive claims, and the purpose of cultivating understandings of self and world are “what counts” most in literary argumentation. Teachers grappled with defining their disciplinary practice before negotiating their literacy practices in defining argumentation. They concluded the purpose of literary argumentation extends beyond making claims and using evidence to connecting to students’ lives and the human condition. They determined that through literary argument, students develop a worldview grounded in a critical perspective or framework. Through problem-based learning, opportunities were provided for collaborative construction of new understandings through meaningful conversations with fellow educators (Johnston-Parsons, 2012), using dialogue as the means for inquiry into problems of practice. These opportunities supported English teachers in making sense of disciplinary argumentation.

References

Bridges, E. M., & Hallinger, P. (1995). *Implementing problem based learning in leadership development*. Eugene, OR: ERIC Clearinghouse on Educational Management, College of Education, University of Oregon.

Bridges, E. M., & Hallinger, P. (1997). Using problem-based learning to prepare educational leaders. *Peabody Journal of Education*, *72*(2), 131-146.

Council of Chief State School Officers. (2010). The common core standards for English language arts and literacy in history/social studies and science and technical subjects. Washington, DC: National Governors Association for Best Practices. Retrieved from http://www.corestandards.org

Fereday, J., & Muir-Cochrane, E. (2008). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International journal of qualitative methods*, *5*(1), 80-92.

Glaser, B.G. (1965). The constant comparative method of qualitative analysis. *Social Problems,* 12(4), 436-445.

Goldman, S. R., Lee, C. D., Britt, A., Greenleaf, C., & Brown, M. (2009). *Reading for understanding across grades 6–12: Evidence-based argumentation for disciplinary learning* (USDE Grant No. R305F100007). Washington, DC: U.S. Department of Education, Institute for Educational Sciences

Graff, G. (2003). Clueless in academe: How schooling obscures the life of the mind. New Haven, CT: Yale University Press.

Hillocks, G. (2010). Teaching Argument for Critical Thinking and Writing: An Introduction. *English Journal*, 24-32.

Johnston-Parsons, M. (2012). *Dialogue and difference in a teacher education program: A 16-year sociocultural study of a professional development school*. Charlotte, NC: Information Age.

Moje, E. B. (2007). Developing socially just subject-matter instruction: A review of the literature on disciplinary literacy teaching. *Review of research in education*, *31*(1), 1-44.

Raphael, T. E., Vasquez, J. M., Fortune, A. J., Gavelek, J. R., & Au, K. H. (2014). Sociocultural approaches to professional development: Supporting sustainable school change. In L. E. Martin, S. Kragler, D. J. Quatroche, & K. L. Bauserman (Eds.), The handbook of professional development: Successful models and practices, Pre-K-12 (pp.145–173). New York: Guilford.

Rogoff, B. (1994). Developing understanding of the idea of communities of learners. *Mind, Culture, and Activity, 1*(4), 209-229.

Shulman, L. S., & Shulman, J. H. (2004). How and what teachers learn: A shifting perspective. *Journal of curriculum studies*, *36*(2), 257-271.

Vygotsky, L. S. (1978). *Mind in society: The development of higher mental process*. Cambridge, MA: Harvard University Press.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, MA: Cambrige University Press.

Zech, L. K., Gause-Vega, C. L., Bray, M. H., Secules, T., & Goldman, S. R. (2000). Content-based collaborative inquiry: A professional development model for sustaining educational reform. *Educational Psychologist*, *35*(3), 207-217.

Lucy the Chipmunk Defender: Embodied Learning in Figured Worlds at Recess

Lauren Vogelstein
lauren.e.vogelstein@vanderbilt.edu
Vanderbilt University

Keywords: embodiment, mathematics learning, informal learning settings

Abstract:

Our bodies profoundly affect our experiences, perspectives, and understandings of the world. However, the notion that our bodies are separate from mathematics has permeated Western philosophy. This has translated to schools' neglecting the body as a resource for mathematical thinking, learning, and understanding. Recent work has put the body back into the equation (Stevens & Hall, 1998; Stevens, 2012), attending to the multiple affordances of gesture use (Alibali & Nathan, 2012; Cook et al., 2008; Goldin-Meadow, 2005; Nemirovsky et al., 2012). However, these investigations tend to look at mathematical embodiment in discrete, individual bodies. This paper investigates students' body interactions in relation to each other in the *figured worlds* (Holland, 2001) that they both inhabit and invoke.

In order to explore methods of support for children's learning through their own bodies, we first need to discover how children already use their bodies. The traditional classroom is not a great place to observe this because student movement is restricted. The playground, in contrast, is an environment where students engage in a wide range of purposeful everyday movement that shapes their social, physical, and cognitive development (Goodwin et al., 2002) and allows children to begin to formulate autonomy and to initiate independent actions (Hayward et al., 1974). Further, the problem solving skills and spatial geometric reasoning used there have the potential to contribute to mathematics learning. In order to begin to identify a repertoire of socially-influenced physical movements that occur in the playground setting, a descriptive study of 4th and 5th grade students was undertaken.

The study took place in a small (450 students) K-5 elementary school in a suburb of a large Midwestern city. About 150 4th and 5th grader students were observed during school recess 1-2 times per week over seven weeks. Following a participant observation model (Thorne, 1993), I observed peripherally and interacted casually with students. 4.5 hours of video data (9 sessions) were captured and then analyzed using in depth interaction analysis, allowing for nuanced examination of the multimodal interactions between students (Jordan & Henderson, 1995; Goodwin, 2000).

This paper focuses on the analysis of one episode involving a dying chipmunk and one student, Lucy, who physically defended the chipmunk from her peers. Lucy's position around the chipmunk changed in response to her physical interactions with her peers, which gave her the opportunity develop a role as a chipmunk protector. The analysis of agency and role development surrounding a crisis on the playground indicates how figured worlds that students inhabit are important influences on how they use their bodies to communicate and problem solve. This case study also indicates how an analysis of the embodied interactions of multiple bodies (as opposed to isolated bodies) provides a lens through which to understand physical experiences as a resource for meaning-making. The social structures that govern the figured worlds people inhabit have important influences in how people author themselves and begin to understand how their bodies are part of their roles within the figured worlds they both invoke and then inhabit.

References

Alibali, M. W., & Nathan, M. J. (2012). Embodiment in mathematics teaching and learning: Evidence from learners' and teachers' gestures. *Journal of the Learning Sciences*, *21*(2), 247-286.

Cook, S. W., Mitchell, Z., & Goldin-Meadow, S. (2008). Gesturing makes learning last. *Cognition*, *106*(2), 1047-1058.

Goldin-Meadow, S. (2005). *Hearing gesture: How our hands help us think*. Harvard University Press.

Goodwin, C. (2000). Action and embodiment within situated human interaction. *Journal of pragmatics*, *32*(10), 1489-1522.

Goodwin, M. H., Goodwin, C., & Yaeger-Dror, M. (2002). Multi-modality in girls' game disputes. *Journal of pragmatics*, *34*(10), 1621-1649.

Hayward, D. G., Rothenberg, M., & Beasley, R. R. (1974). Children's play and urban playground environments: A comparison of traditional, contemporary, and adventure playground types. *Environment and Behavior*.

Holland, D. C. (2001). *Identity and agency in cultural worlds*. Harvard University Press.

Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. *The journal of the learning sciences*, *4*(1), 39-103.

Nemirovsky, Rasmussen, Sweeney, & Wawro (2012). In *Journal of the Learning Sciences*, *21*(2), 287-323.

Stevens, R. (2012). The missing bodies of mathematical thinking and learning have been found. *Journal of the Learning Sciences*, *21*(2), 337-346.

Stevens, R., & Hall, R. (1998). Disciplined perception: Learning to see in technoscience. *Talking mathematics in school: Studies of teaching and learning*, 107-149.

Thorne, B. (1993). *Gender play: Girls and boys in school*. Rutgers University Press.

The Interplay of Self Regulated, Co-regulated and Socially Shared Regulated Learning during Tasks, Tools use, and Processes.

Suzanne Rhodes
University of Wisconsin - Madison, College of Education
serhodes@wisc.edu

Keywords: CSCL, SSRL, communication

Abstract: This poster describes preliminary research that addresses weaknesses such as individualized metacognition during tasks, fragmented learning with handheld mobile tools, and inadequate planning and low group cohesion along with teacher-centric monitoring during knowledge construction. I will design a CSCL intervention with netbooks that explores the interplay of SR, CR, and SSR learning during tasks, using tools, and processes.

Mobile devices receive their learning potential by virtue of the fact that students have to understand and decide on their learning discourse in school (Sharples, 2005). Therefore, face-to-face collaborative learning supported by mobile technologies must also be supported by communication (Zurita & Nussbaum, 2004, Dillenbourg & Evans, 2011). Yet "there is relatively little research on the social layer about how groups and individuals in groups engage in, sustain, support, and productively regulate collaborative processes" (Jarvela & Hadwin, 2013). "Regulated learning is the quintessential skill in collaborative learning" (Jarvela & Hadwin, 2013). Three types of regulation contribute to successful collaboration: self- (SRL), co- (CRL), and socially shared regulation learning (SSRL).

Weaknesses in regulated learning during tasks are that "even when student dyads appear to be working together students are self-regulating their own learning but not regulating together" (Winters & Alexander, 2010), 2) group members may refuse to take on their designated assignments in a way that contributes to the group, and 3) metacognition becomes visible *but not shared* (Hurme, Merenluoto, & Jarvela, 2009).

For tools, the lack of successful collaborative learning regulation is more of an issue when students are working with one-to-one handheld devices because of the fragmented learning that occurs (Yang et al., 2010). Gress and Hadwin (2010) argue for CSCL support for not just communicating or sharing but also guiding and supporting collaborative processes.

For SSRL subprocesses, low group cohesion diminishes the quality of planning because group members may not listen to one another or come together as a team during the reading of the directions. Processes such as planning, monitoring, and evaluating processes and joint understanding (e.g., Hmelo-Silver&Barrows, 2008) or asking questions and requesting explanations (e.g., Scardamalia & Bereiter, 2007) may prompt partners. However, for the most part, these processes are used to prompt collaborative knowledge construction, with little attention devoted to other facets of regulation such as motivation, emotion, strategy use, goals, and task perceptions.

Understanding SSRL as a complex process that plays a central role in collaborative success requires attention to both individual- and group-level data (Kempler, Rogat & Linnenbrink-

Garcia, 2011). To address the weaknesses during tasks, use of tools, and subprocesses, I will design a CSCL intervention with netbooks that builds on extant group programs to foster interdependence and sustained collaboration and communication resulting in high quality social interactions (Johnson & Johnson, 1981; Slavin, 1995, Cohen, 1994). My research questions are:

- What is the interplay between SRL, CRL, and SSRL during the intervention task?
- How does the intervention tool foster SRL, CRL, and SSRL?
- How do multiple team members join forces to regulate the ways they work together as a team via SSRL processes.

References

Dillenbourg, P., & Evans, M. (2011). Interactive tabletops in education. *International Journal of Computer-Supported Collaborative Learning*, *6*(4), 491–514. http://doi.org/10.1007/s11412-011-9127-7

Dillenbourg, P., Järvelä, S., & Fischer, F. (2009). The evolution of research on computer-supported collaborative learning. In *Technology-enhanced learning* (pp. 3–19). Springer. Retrieved from http://link.springer.com/chapter/10.1007/978-1-4020-9827-7_1

Hmelo-Silver, C. E., & Barrows, H. S. (2008). Facilitating collaborative knowledge building. Cognition and Instruction, 26, 48–94. doi:10.1080/07370000701798495

Hurme, T.-R.,&Jarvela, S. (2005). Students' activity in computer-supported collaborative problem solving in mathematics. International Journal of Computers for Mathematical Learning. 10, 49–73. doi:10.1007/s10758-005-4579-3

Hurme, T-R., Merenluoto, K., & J¨arvel¨a, S. (2009). Socially shared metacognition of pre-service primary teachers in a computer supported mathematics course and their feelings of task difficulty: A case study. Educational Research and Evaluation, 15, 503–524. doi:10.1080/13803610903444659

Hurme, T.-R., Palonen, T., & J¨arvel¨a, S. Järvelä, S., & Hadwin, A. F. (2013). New Frontiers: Regulating Learning in CSCL. *Educational Psychologist*, *48*(1), 25–39. http://doi.org/10.1080/00461520.2012.748006

Kempler Rogat, T. M., & Linnenbrink-Garcia, L. (2011). Socially shared regulation in collaborative groups: An analysis of the interplay between quality of social regulation and group processes. Cognition and Instruction, 29, 375–415. doi:10.1080/07370008.2011.607930

Kirschner, P. A. (2002). Cognitive load theory: Implications of cognitive load theory on the design of learning. Learning and Instruction, 12(1), 1–10. doi:10.1016/S0959-4752(01)00014-7

Liu, C.-C., & Kao, L.-C. (2007). Do handheld devices facilitate face-to-face collaboration? Handheld devices with large shared display groupware to facilitate group interactions: Handheld devices with large shared display groupware. *Journal of Computer Assisted Learning*, *23*(4), 285–299. http://doi.org/10.1111/j.1365-2729.2007.00234.x

Nestler, S., Echtler, F., Dippon, A., & Klinker, G. (2008). Collaborative problem solving on mobile hand-held devices and stationary multi-touch interfaces. In *Workshop on designing multi-touch interaction techniques for coupled public and private displays (PPD 08)*. Retrieved from http://www.nestlers.de/pub/2008-nestler-collaborative-problem-solving-mobile-devices-multi-touch-interfaces.pdf

Rogat, T. K., & Linnenbrink-Garcia, L. (2011). Socially Shared Regulation in Collaborative Groups: An Analysis of the Interplay Between Quality of Social Regulation and Group Processes. *Cognition and Instruction*, *29*(4), 375–415. http://doi.org/10.1080/07370008.2011.607930

Roschelle, J. (2003). Keynote paper: Unlocking the learning value of wireless mobile devices. *Journal of Computer Assisted Learning*, *19*(3), 260–272.

Scardamalia, M.,&Bereiter, C. (2007). “Fostering communities of learners” and “knowledge building”:An interrupted dialogue. In J. C. Campione,K. E. Metz, & A. S. Palincsar (Eds.), Children’s learning in the laboratory and in the classroom: Essays in honor of Ann Brown (pp. 197–212).

Sharples, M. (2005): Learning as conversation: transforming education in the mobile age. Centre for Educational Technology and Distance Learning. University of Birmingham. Retrieved from: http://www.eee.bham.ac.uk/ sharplem/Papers/Theory%20of%20learning%20Budapest.pdf

Winters, F. I., & Alexander, P. A. (2010). Peer collaboration: The relation of regulatory behaviors to learning with hypermedia. Instructional Science, 39, 407–427. doi:10.1007/s11251-010-9134-5

Yang, J.-C., Lin, Y. L., & others. (2010). Development and Evaluation of an Interactive Mobile Learning Environment with Shared Display Groupware. *Educational Technology & Society*, *13*(1), 195–207.

Zimmerman, B. J. (2008). Investigating self-regulation and motivation. Historical background, methodological developments and future prospects. American Educational Research Journal, 45, 166–183. doi:10.3102/0002831207312909

Zurita, G., & Nussbaum, M. (2004). Computer supported collaborative learning using wirelessly interconnected handheld computers. *Computers & Education*, *42*(3), 289–314. http://doi.org/10.1016/j.compedu.2003.08.005

Explore Spatial Thinking and Math Learning through the Game of Go

Yanning Yu[1], David Uttal[2] & Xinming Guo[3]
Northwestern University[12], Go and Math Academy[3]
yanningyu2018@u.northwestern.edu; daviduttal@northwestern.edu; simonguoxm@gmail.com

Keywords: math learning, spatial cognition, games, embodiment

Abstract:
The game of Go is an ancient board game with simple elements: line and circle, stone and wood, and simple rules—one wins by surrounding more space than one's opponent (Fig. 1). Yet, the elements and rules combined generate subtleties that have enthralled players for millennia. While Go professionals and educators have theorized how Go impacts cognitive development and learning (e.g., Laird, 2012; Shotwell, 2002; etc.), very limited studies have evaluated these claims (Chen, et al., 2003; Reitman, 1976). The aim of this study is to systematically and empirically examine the educational benefit of Go. In particular, we focus on investigating the features of Go that support spatial and mathematical thinking.


Figure 1. A traditional Go game board and stones

Having high levels of spatial skills have been shown to help students succeed in a variety of STEM fields (Uttal & Cohen, 2012) and especially in mathematics (Sorby, 2009). Playing Go utilizes various types of spatial skills such as pattern recognition and spatial interpolations. Moreover, the intrinsic feature of Go embodies many math concepts and the practice of playing Go resembles math problem solving. Although Go takes a lifetime to master, it has minimal rules so that young children can readily learn. Thus, this game presents an ideal situation to examine how young kids develop spatial and math thinking skills. In addition, the game of Go has unique features that distinguish itself from chess, scrabble, or number games, which allow younger kids to engage in more complex spatial and math tasks. This study will explore how Go differ from the other games and what the differences imply about designs of learning environments that support spatial thinking and math learning.

We have designed a Go and math curriculum to be offered through the Center for Talent Development at Northwestern in Fall 2016. Students in Grade 2-3 will enroll in an eight-week series of Go game activities. The design of the curriculum is guided by theories from embodied and distributed cognition (Barsalou,1999; Lakoff & Nunez, 2000; Martin & Schwartz, 2005; Schwartz, D. & Goldstone, R. 2015). The curriculum also included Go problems that align with several common core math standards at the elementary level, which include counting and cardinality, operations and algebraic thinking, number and operations, etc. Data will be collected in forms of pre- and post- tests as well as video records of classroom interactions and group interviews (Fig.2). We will incorporate quantitative analysis with fine-grained qualitative analysis of student activities as learning occurs. We will use a grounded-theory approach to explore strategies students use over time.

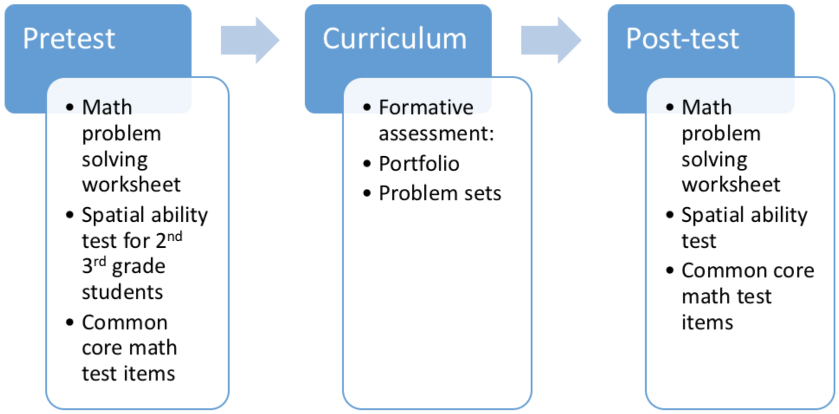

Figure 2. Design of the study

Our study will produce rigorous statistical findings on the correlation between the development of spatial skills and learning gains of the common core math. In addition, our qualitative analysis of student interactions with the Go game will uncover the trajectory in which mathematical thinking advances and highlight the learning processes in which spatial thinking plays a role. Moreover, we will produce principles for educators to design and implement spatial activities that are productive for math learning.

Reference:

Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences*, 22, 577–660.

Chen, X., Zhang, D., Zhang, X., Li Z., Meng, X., He S., Hu, X. (2003). A functional MRI study of high-level cognition. II. The game of GO. *Brain Res Cogn Brain Res*.16(1):32-7.

Laird, R. (2012). Play go and grow! Why every school and library should teach children go. *The American Go Foundation* (retrieved from web http://agfgo.org/pages/playgoandgrow.php)

Lakoff, G., & Núñez, R. (2000). *Where mathematics comes from: How the embodied mind brings mathematics into being*. New York: Basic Books.

Martin, T., & Schwartz, D. (2005). Physically distributed learning: Adapting and reinterpreting physical environments in the development of the fraction concept. *Cognitive Science*, 29, 587–625.

Reitman, J. S. (1976). Skilled perception in Go: Deducing memory structures from inter-response times. *Cognitive Psychology* 8(3): 336- 356.

Shotwell, P. (2002) Reflections on language and philosophy in regard to cognitive psychology, artificial intelligence and educational studies of chess and Go. *The American Go Journal* (retrieved from web http://www.usgo.org/files/bh_library/goandpsych.pdf)

Schwartz, D. L., & Goldstone, R. (2015). Learning as coordination: Cognitive psychology and education. In L. Corno and E. Aldemann (Eds.), *Handbook of Educational Psychology*. American Psychological Association, Washington, DC.

Sorby, S. (2009). Developing spatial cognitive skills among middle school students. *Cognitive Processing*, 10 (2). 312-315.

Uttal, D. H., & Cohen, C. A. (2012). Spatial Thinking and STEM Education: When, Why, and How? In B. Ross (Ed.), *Psychology of Learning and Motivation Volume* 57, 147-181 Oxford: Academic Press.

360° Makerspaces: Designing Youth-serving Makerspaces Using Virtual Reality Snapshots

Anna Keune
akeune@indiana.edu
Indiana University

Abstract:

Pitch and Poster Goals – Making durable youth-serving makerspaces means that the materials purchased today foster tomorrow's unanticipated learning goals. This is a challenge of *scale*, where possibilities grow while furniture, tools, and craft supplies remain. Taking a relational material perspective (Hultman & Lenz Taguchi, 2010; Lenz Taguchi, 2011) as recursive transformation of educational possibilities, this interactive poster explores the design of youth-serving makerspaces and the potential becomings that the spaces may condition through 360° photographs of makerspaces in diverse settings across the United States and beyond.

Theoretical Framework – This workshops takes a relational material perspective (Hultman & Lenz Taguchi, 2010; Lenz Taguchi, 2011) of learning, which theorizes everything in the world to be matter, including people, and that knowledge and agency emerge when people and things come together and form gatherings (Taylor & Ivinson, 2013). Teasing out particular material characteristics of makerspaces in relation to valued learning, this workshop builds on learning as relational possibilities that may be rather than should be (Lenz Taguchi, 2011). Intra-actions (Barad, 2003) highlight actions that unfold within gatherings of things and people, foregrounding particular ways of doing in physical setting, and condition new unanticipated possibilities. It is the possibilities for encounters that the poster is looking at within the makerspaces.

Interactive Poster Description – The poster gives an overview of the youth-serving makerspaces and their particular contexts. Setting the participants up to use smartphones and tablets to view 360° photographs of the makerspaces, they explore the photographs. The focus is on identifying material gatherings that form workstations, projects, and furniture within the makerspaces and how similar gatherings differ across spaces. Having selected specific material gatherings that sparked participants' curiosity, we dissect the gatherings in relation to material characteristics that condition possible formations. Participants jot materialized notes onto an empty space on the poster using yarn, markers, tape, pipe-cleaners, playdough and LEDs, collaboratively generating a shared artifact with transitory and changeable markings that themselves open up possibilities for transformation. This allows identified characteristics and dissected gatherings to merge in the representational power of the form something new. Questions that participants may ponder relate to how to discover, tame, and foster material relations in makerspaces over time as well as how to conceive of oneself as researcher within virtual-photographic-material data.

Experience and Expertise – Parts of this workshop were explored at FabLearn Australia 2016. The photographs have been taken between November 2015 and July 2016 by the author and collaborating makerspace educators, and represent data of an ongoing research project by the author and her advisor.

References

Barad, K. (2003). Posthumanist Performativity: Toward an Understanding of How Matter comes to Matter. Signs, 40(1).

Hultman, K., & Lenz Taguchi, H. (2010). Challenging Anthropocentric Analysis of Visual Data: A Relational Materialist Methodological Approach to Educational Research. International Journal of Qualitative Studies in Education, 23(5), 525-542.

Lenz Taguchi, H. (2011). Investigating Learning, Participation and Becoming in Early Childhood Practices with a Relational Materialist Approach. Global Studies of Childhood, 1(1), 36-50.

Taylor, C. A., & Ivinson, G. (2013). Material Feminisms: New Directions for Education. *Gender and Education*, 25(6), 665-670.

The Fallibility of Expert Scientists: How Score Calibration Talk Undermines Fairness in the Scientific Peer Review Process

Elizabeth L. Pier[1], Joshua Raclaw[2], Anna Kaatz[1], Markus Brauer[1], Molly Carnes[1], Mitchell Nathan[1] & Cecilia Ford[1]

University of Wisconsin-Madison[1]; West Chester University[2]

epier@wisc.edu; jraclaw@wcupa.edu; akaatz@wisc.edu; brauer2@wisc.edu; mlcarnes@cwhr.wisc.edu; mnathan@wisc.edu; ceford@wisc.edu

Keywords: distributed expertise, scientific argumentation, collaboration, decision making

Abstract: The grant peer review process is the bedrock of science; it is the means by which expert scientists allocate precious research funds to support the most promising and innovative scientific research. However, prior research has established that peer review is fraught with subjectivity and suffers from poor reliability (e.g., Cole, Cole, & Simon, 1981; Marsh, Jayasinghe, & Bond, 2008). Although many researchers have examined the *outcomes* of peer review (e.g., Langfeldt, 2001; Obrecht, Tibelius, & D'Aloisio, 2007), few have gained access to the actual deliberations of expert scientists engaged in peer review. The current study examines how different groups of *distributed experts* (Brown, Ash, Rutherford, & Gordon, 1993) engage in collaborative decision making as they evaluate the same pool of grant applications. Specifically, I explore how different groups of scientists attempt to establish *common ground* (Clark & Brennan, 1991) about scoring practices, and how such grounding may relate to the poor reliability of peer review. This study poses the research question: How do expert scientists establish common ground during peer review meetings, and does this grounding process impact the reliability of peer review outcomes? This work leverages a novel methodology, in which experienced reviewers for the National Institutes of Health (NIH) were recruited to participate in NIH-style peer review panels ("study sections"). Our research team conducted four of these "Constructed Study Sections" made up of eight to 12 reviewers, each evaluating six grant applications (two as primary, two as secondary, and two as tertiary reviewer), for a total of 16 to 24 applications per meeting. The videotaped meetings were transcribed in full, and all instances of grounding discourse related to scoring practices were coded. Our team identified 71 total instances of such discourse, which we call *Score Calibration Talk* (SCT), across the four meetings: 56 of which featured a reviewer accounting for his or her own scoring practices ("Self-Initiated SCT" or S-SCT), and 15 of which featured a panelist challenging another reviewer's scoring practices ("other-initiated" SCT or O-SCT). Using Krippendorff's α (Krippendorff, 2013) to compute interrater reliability, I show that there is little to no agreement across individual reviewers' evaluating the same grant applications, that agreement *within* a given panel increases as a function of collaboration, but that agreement *between* different panels decreases after collaboration. I also show that both types of SCT are associated with scores *converging* within panels (i.e., more agreement; $r_{\text{S-SCT}} = 0.657$, and $r_{\text{O-SCT}} = 0.858$), and such within-panel convergence is moderately associated with between-panel *divergence* ($r = -0.606$); thus, reviewers within a panel tend to agree more as they engage in SCT, but different panels agree very differently from one another. These results corroborate prior work showing that peer review may not deliver on its promise of fairness; however, this study extends this body of research by

demonstrating not only that reviewers accomplish agreement by negotiating or calibrating their scores with one another, but also that such calibration may be what undermines the validity of the outcome of peer review.

References

Brown, A. L., Ash, D., Rutherford, M. & Gordon, A. (1993). Distributed expertise in the classroom. In: G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (188–228). Cambridge: Cambridge University Press.

Clark, H. H. & Brennan, S. A. (1991) Grounding in communication. In: L.B. Resnick, J. M. Levine, and S.D. Teasley (Eds.), *Perspectives on socially shared cognition* (127-149). Washington, DC: American Psychological Association.

Cole, S., Cole, J. R. & Simon, G. A. (1981) Chance and consensus in peer review. *Science*, *214*(4523), 881-6.

Krippendorff, K. (2013). *Content analysis: An introduction to its methodology* (3rd ed.). Thousand Oaks, CA: Sage Publishing.

Marsh H. W., Jayasinghe, U. W. & Bond N. W. (2008). Improving the peer review process for grant applications: Reliability, validity, bias and generalizability. *American Psychologist*, *63*(3), 160–8.

Obrecht, M., Tibelius, K. & D'Aloisio, G. (2007). Examining the value added by committee discussion in the review of applications for research awards. *Research Evaluation*, *16*(2), 70–91.

BrickOpenCode: Embodied Cognition for Open Source Software

Caroline D. Hardin
University of Wisconsin-Madison
Caroline.Hardin@wisc.edu

Keywords: Computer Science Education; Open Source Software; Embodied Cognition; Constructionism

Abstract:

In order to create fully empowered digital citizens children need to be encouraged to be code creators and tinkerers, and not just consumers. And while an important part of code creation is understanding the rights and limitations of software licenses, resources available to teachers often focus narrowly on anti-piracy rhetoric. This work was motivated by a need for more hands-on curricular materials which teaches children about the differences between open source and closed source software.

Explaining the very abstract concepts of software licenses in a way that children understand is difficult. Common metaphors for software licenses are often based in content areas children have little experience in, such as repairing cars or cooking from recipes. This work describes the design of a workshop called BrickOpenCode, which uses a LEGO metaphor for software to ground the concepts in hands-on activities and situated actions, and uses embodied cognition theories to leverage concreteness fading in the construction of mental models.

The research question emerging from this workshop design is, when LEGOS are used as a metaphor for open vs closed software, what is the difference in children's understanding of the metaphor when the workshop includes physical play with LEGOs versus video of the same LEGOs?

Mirroring the McNeil & Fyfe (2012) experimental setup, the BrickOpenCode workshop starts with a concrete, hands-on metaphor of programming code as tinkering with LEGOs, moves to an intermediate example of customizing code using Scratch, and finally concludes with personalizing a JavaScript program on CodePen.io in which code is fully abstracted text. Scratch is an ideal intermediary because it graphically represents the code as 'blocks' with text which can be snapped together like LEGOs. This is helpful not only to fade the LEGOs exercise into the typed code exercise, but provides a graphical representation which supports "computational offloading" (Scaife & Rogers, 1996, 99) . This explicit fading, or "decontextualizing" from concrete into abstract, will help ground their mental model of software licenses with a metaphor they are experienced in.

Finally, for children to care about the difference between closed source and open source software they need more than a dictionary definition - they need to understand what it can do for them, for as Glenberg (1997) says, "what something means to us is what we can do with it" (Glenberg, 1997,

47). To make the benefits of understanding software licenses explicit, between each activity, BrickOpenCode initiates discussions of scenarios during which a child may choose open source or closed source software, and concludes with a ‘taking it home’ handout of resources.

The author has piloted the workshop three times with pre and post surveys which asked the children to explain the differences between open and closed source software, with follow up on select children two months after the workshop concluded. The very promising preliminary results were used to further improve the workshop, and a more formal study of learning gains, including comparing the effectiveness of the workshop with LEGOS compared to one using video of LEGOs, is planned.

References

Barsalou, L. W. (1999). Perceptual Symbol Systems. , 577–660.

Glenberg, A. M. (1997). What memory is for. Behavioral and Brain Sciences, 20 , 1–55. doi: 10.1017/S0140525X97000010

Goldstone, R. L., & Son, J. Y. (2005). The transfer of scientific principles using concrete and idealized simulations. Journal of Learning Sciences, 14 (1), 69–110. doi: 10.1207/s15327809jls1401

Lakoff, G., & Johnson, M. (1999). Chomsky’s Philosophy and Cognitive Linguistics. ,469–512.

McNeil, N. M., & Fyfe, E. R. (2012). " Concreteness fading" promotes transfer of mathematical knowledge. Learning and Instruction, 22 (6), 440–448. Retrieved from http://dx.doi 7.org/10.1016/j.learninstruc.2012.05.001 doi: 10.1016/j.learninstruc.2012.05.001

Nathan, M. J., Walkington, C., Boncoddo, R., Pier, E., Williams, C. C., & Alibali, M. W. (2014). Actions speak louder with words: The roles of action and pedagogical language for grounding mathematical proof. Learning and Instruction, 33 , 182–193. Retrieved from http://linkinghub.elsevier.com/retrieve/pii/S0959475214000450 doi:10.1016/j.learninstruc.2014.07.001

Scaife, M., & Rogers, Y. (1996). External cognition, interactivity and graphical representations. Thinking with Diagrams (Digest No: 1996/010). Retrieved from http://ieeexplore.ieee.org/xpls/abs{_}all.jsp?arnumber=646159

Designing to Support the Development of Modeling Practices and Epistemologies in Middle School Science

Ashlyn Karan
Vanderbilt University
ashlyn.e.karan@vanderbilt.edu

Keywords: scientific modeling, scientific practices, epistemology

Abstract:

Objectives. Modeling is epistemically challenging for K-12 students. Typically, school structures do not support students in seeing models as generative, predictive, revisable tools. Instead, students perceive models as answers for teachers. Although existing learning progressions describe students developing modeling practices, the highest levels of the progressions are hypothetical, because few students have demonstrated advanced modeling practices in these contexts (Fortus, Rosenfeld, & Schwartz, 2010; Schwarz et al., 2012). In order to (1) refine the modeling learning progression, (2) operationalize the highest levels of the progression, and (3) identify curriculum and classroom culture supports for developing advanced modeling practices, I conducted a semester-long study of eighth graders engaging in diagrammatic, physical, and computational modeling (Figure 1).

Theoretical Framework. Following Schwarz et al. (2012), I focus on explanatory mechanistic models, which are critical to building science knowledge (Russ, Scherr, Hammer, & Mikeska, 2008). My design and analyses stem from Schwarz, Fortus, and colleagues' (2012) articulation of learning goals for modeling (Fortus et al. 2010; Schwarz et al., 2009; Schwarz et al., 2010; Schwarz et al., 2012). This progression details five categories of epistemic perspectives that develop as students engage in modeling (Salience and Generality, Audience, Evidence, Mechanistic and Generative, and Revision). I chose this progression because it is one of the most elaborated in K-12 modeling literature, is consistent with the findings of other researchers in this field (Bamberger & Davis, 2013; Berland et al. 2015; Krell, zu Belzen, & Krüger, 2014), and reflects the science-as-a-practice perspective by analyzing students' actions as evidence of their epistemologies and engagement in practices.

Data. I conducted an iterative design-based classroom experiment (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). I met with the students' teacher weekly to develop and test conjectures. Data include video of each class period, audio of conversations with students during group and individual work, and artifacts (models, written reflections, interviews, and assessments).

Findings and Implications. I found students reaching the highest levels of the learning progression across all five categories of epistemic perspectives, enabling me to operationalize the highest level of each category (see Table 1 for an example of student growth in one category). In terms of curricula, creating and interrelating diagrammatic, physical, and computational models supported conceptual growth for students because this perspective-shift encourages students to re-negotiate their conceptions through constraint satisfaction, leading to more coherent understandings (Greeno & van de Sande, 2007, 2012). Moreover, each of the three model types highlights unique modeling practices: diagrammatic models emphasize the descriptive and communicative nature of models (Latour, 1990), physical models encourage students to grapple

with the material challenges of designing measures and interpreting data (Penner, Lehrer, & Shauble, 1998), and computational models facilitate abstraction and prediction (Sengupta et al., 2013). In terms of culture, I found that increasing student agency by not assigning grades, limiting authoritative resources, and encouraging student-designed questions and investigations supported learning and engagement. These findings have implications for how modeling curricula are designed and implemented.

References:

Bamberger, Y. M., & Davis, E. A. (2013). Middle-school science students' scientific modelling performances across content areas and within a learning progression. *International Journal of Science Education*, *35*(2), 213-238.

Berland, L. K., Schwarz, C. V., Krist, C., Kenyon, L., Lo, A. S., & Reiser, B. J. (2015). Epistemologies in practice: Making scientific practices meaningful for students. *Journal of Research in Science Teaching.*

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher*, *32*(1), 9-13. doi:10.2307/3699928

Fortus, D., Rosenfeld, S., & Shwartz, Y. (2010). High school students' modeling knowledge. In *Annual conference of the national association for research in science teaching (NARST), Philadelphia, PA.*

Greeno, J. G., & van de Sande, C. (2007). Perspectival understanding of conceptions and conceptual growth in interaction. *Educational Psychologist*, *42*(1), 9-23.

Greeno, J. G., & van de Sande, C. C. (2012). Achieving alignment of perspectival framings in problem-solving discourse. *Journal of the Learning Sciences, 21*(1), 1-44.

Krell, M., zu Belzen, A. U., & Krüger, D. (2014). Students' levels of understanding models and modelling in biology: Global or aspect-dependent? *Research in Science Education*, *44*(1), 109-132.

Latour, B. (1990). Drawing things together. In M. Lynch & S. Woolgar (Eds.), *Representation in scientific practice* (pp. 19-68). Cambridge, MA: The MIT Press.

Penner, D. E., Lehrer, R., & Schauble, L. (1998). From physical models to biomechanics: A design-based modeling approach. *Journal of the Learning Sciences, 7*, 429-449.

Russ, R. S., Scherr, R. E., Hammer, D., & Mikeska, J. (2008). Recognizing mechanistic reasoning in student scientific inquiry: A framework for discourse analysis developed from philosophy of science. *Science Education*, *92*(3), 499-525.

Schwarz, C., Reiser, B. J., Acher, A., Kenyon, L., & Fortus. (2012). MoDeLS: Challenges in defining a learning progression for scientific modeling. In A. Alonzo & A. W. Gotwals (Eds.), *Learning progressions in science: Current challenges and future directions.*

Schwarz, C. V., & White, B. Y. (2005). Metamodeling knowledge: Developing students' understanding of scientific modeling. *Cognition and Instruction*, *23*(2), 165-205.

Schwarz, C. V., Reiser, B. J., Davis, E. A., Kenyon, L., Achér, A., Fortus, D., Shwartz, Y., Hug, B., & Krajcik, J. (2009). Developing a learning progression for scientific modeling: Making scientific modeling accessible and meaningful for learners. *Journal of Research in Science Teaching*, *46*(6), 632-654.

Sengupta, P., Kinnebrew, J. S., Basu, S., Biswas, G., & Clark, D. (2013). Integrating computational thinking with K-12 science education using agent-based computation: A theoretical framework. *Education and Information Technologies*, *18*(2), 351-380.

Figure 1: A student's physical (left) diagrammatic (top right) and computational (bottom right) models of the symbiotic relationship between roots and rhizobia bacteria.

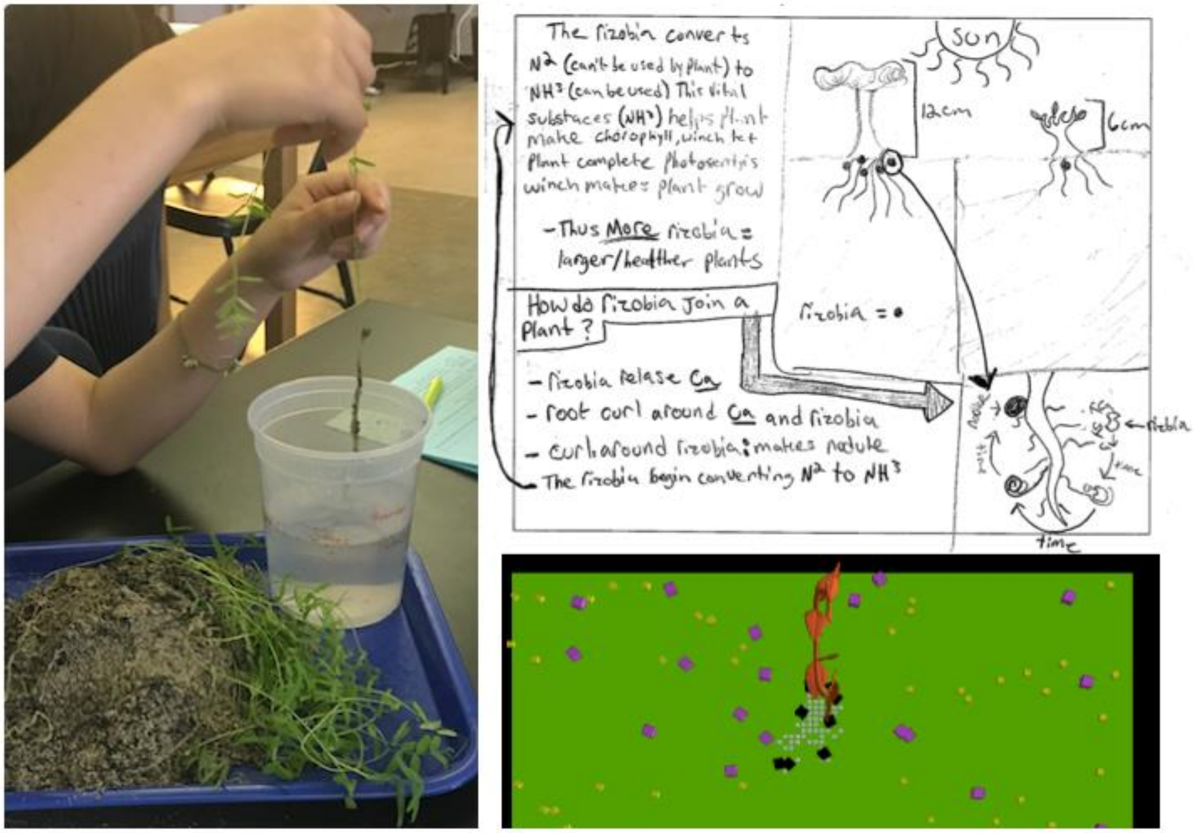

Table 1: Percentage of Students at Each Level of the Mechanistic and Generative Learning Progression

Day	Activity	No relevant response	Level 1: Descriptive Only	Level 2: Illustrates Pattern	Level 3: Explanatory mechanism	Level 4: Predictions, Questions
2	Reflection	16.7%	20.8%	0%	62.5%	0%
	Modeling	0%	63.7%	31.9%	2.2%	2.2%
	Average	8.2%	42.3%	16.0%	32.4%	1.1%
13	Reflection	0%	20.9%	0%	74.7%	4.4%
	Modeling	0%	15.9%	9.1%	75.0%	0%
	Average	0%	18.4%	4.6%	74.9	2.2%
28	Modeling	0%	0%	4.8%	50.0%	45.2%
31	Reflection	0%	0%	0%	37.6%	62.4%
	Modeling	0%	0%	0%	54.5%	45.5%
	Average	0%	0%	0%	46.1%	53.9%
33	Assessment	13.1%	3.3%	0%	18.7%	64.8%

Design Thinking for Conceptual Shift

Jonan Phillip Donaldson[1] & Amanda Barany[1]
Drexel University[1]
jonan.phillip.donaldson@drexel.edu; amanda.marie.barany@drexel.edu

Keywords: Design thinking, constructionist learning, conceptualization, metaphor, identity exploration

Abstract: This paper describes a study currently underway in which design thinking processes, designerly ways of knowing, and constructionist learning principles form the framework for the design of a two-week design thinking project intended to facilitate conceptual shifts regarding the nature of learning. This multi-case study uses grounded theory methodology, and is one stage in an ongoing design-based research project. Data analysis is currently underway and it is too early to describe preliminary findings, but we expect the findings to provide insight into the design of learning structured around design thinking and constructionist learning principles, as well as add to the conceptual shift literature.

Lit Review

Learning sciences researchers have a conceptualization of learning grounded in a construction metaphor, which sees learning as the individual, collaborative, and collective construction of meaning (Collins & Halverson, 2009; Bransford, Brown, & Cocking, 2000; Stahl, Koschmann, & Suthers, 2014). Learning designs informed by this conceptualization engage learners in meaning-making: "The 'reality' that we impute to the 'worlds' we inhabit is a constructed one. . . Reality construction is the product of meaning making shaped by traditions and by a culture's toolkit of ways of thought." (Bruner, 1996, p. 19).

Outside the learning sciences, the dominant conceptualization of learning is grounded in a transfer metaphor, which portrays learning as the transfer of knowledge into the minds of learners (Kincheloe, Steinberg, & Tippins, 1999). Learning designs aligned with this conceptualization are characterized by transfer/acquisition modalities such as lectures, drills, textbooks, and exams (Hager & Hodkinson, 2009). Such designs are pervasive in society: "So fixed are acquisition and transfer in the popular mind that this conceptual lens can be dubbed the 'common-sense account of learning'" (p. 622).

Conceptualizations of learning directly impact practices, communication, cognitive filtering, and values (Lakoff & Johnson, 1980; Kincheloe & Steinberg, 1998). This suggests that if individuals who hold conceptualizations of learning grounded in the transfer metaphor can experience conceptual change toward conceptualizations of learning grounded in the construction metaphor, their practices in learning may change toward more effective and powerful learning. Furthermore, such conceptual shifts may be desirable because learning sciences research findings can be misinterpreted or misapplied in practical settings if those doing so hold a conceptualization of learning grounded in the transfer metaphor.

The concept of identity, defined as "a coherent sense of one's roles and occupational pathway, one's self in relation to others, and one's values and purpose in life" (LaGuardia, 2009, pp. 91), may play an interactional role in the development of students' learning metaphors over time. Sfard (1998) explores how the use of metaphor shapes identity conceptualizations: transfer metaphors emphasize how the acquisition of knowledge might shape a learner's identity, while more collaborative and situative construction metaphors portray identity in relation to learners' progressive membership in greater social entities (Sfard, 1998). As learners write, construct, and engage verbally in identity exploration, the "deliberate internal or external action of seeking and processing information in relation to the self" (Flum & Kaplan, 2006, p. 100), a learner's underlying metaphors, as well as changes in those metaphors, may become more apparent.

Design thinking for conceptual shift

Design thinking may serve a potential structure for the design of learning intended to facilitate conceptual shift and identity exploration. The term design thinking refers to a particular type of creative problem-solving process (Johansson-Sköldberg et al., 2013), as well as to a set of characteristics which describes the thought processes used by expert designers, such as treating all problems as wicked problems and using abductive reasoning (Dorst, 2011; Cross, 2006).

Design Thinking as a Process

One area of design thinking literature explores design thinking as a collaborative problem-solving process by which product, process, or experience innovations can be generated (Welsh & Dehler, 2013). Most design thinking process models describe stages such as (Bell, 2008; Cleary, 2015; Mickahail, 2015; Watson, 2015):

1. empathy and perspective-taking in understanding a problem
2. brainstorming using divergent thinking
3. sense-making of the results of brainstorming using convergent thinking
4. creating prototypes
5. testing the prototype with real-world users

Design Thinking as Designerly Ways of Knowing

Another line of design thinking literature describes design thinking as designerly ways of knowing—a set of cognitive skills and approaches unique to design experts. The literature suggests that designerly ways of knowing include:

- Treating all problems as wicked problems (Cross, 2006; Rittel & Webber, 1973)
- Framing (creating novel perspectives) (Schon & Rein, 1994; Dorst, 2011; Cleary, 2015; Glen, Suciu, Baughn, & Anson, 2015; Mickahail, 2015)
- Empathetic thinking (Luka, 2014; Cross, 2006; Bell, 2008; Cleary, 2015; Mickahail, 2015; Watson, 2015)
- Contextualized thinking (Cross, 2006; Bell, 2008; Cleary, 2015; Mickahail, 2015; Watson, 2015; Brown, 2008; Fuge & Agogino, 2015)
- Abductive reasoning (Dorst, 2011; Benson & Dresdow, 2015)
- Divergent and convergent thinking (Luka, 2014; Benson & Dresdow, 2015; Bell, 2008; Cleary, 2015; Mickahail, 2015; Watson, 2015; Runco & Acar, 2012)
- Synthetic and integrative thinking (Benson & Dresdow, 2015; Dorst, 2011)
- Constructing prototypes according to the meaning you construct (Dorst, 2011; Razzouk & Shute, 2012; Cleary, 2015; Glen, Suciu, Baughn, & Anson, 2015; Mickahail, 2015; Deci, Koestner, & Ryan, 2001; Ryan & Deci, 1996, 2000; Reeve & Tseng, 2011)
- Rapidly changing goals and constraints (Razzouk & Shute, 2012)
  Prototyping from abstract to concrete (Cross, 2006; Razzouk & Shute, 2012; Papert, 1993; Papert & Harel, 1991)

- Engaging in reflection-in-action (Schön, 1983; Hutchinson & Tracey, 2015; Kimbell, 2011; Winne & Azevedo, 2014; Garrison & Akyol, 2012; Kafai & Resnick, 1996)
- Reflecting on relevance (Hutchinson & Tracey, 2015; Kimbell, 2011; Dimmitt & McCormick, 2012; Zimmerman & Labuhn, 2012; Deci, Koestner, & Ryan, 2001; Ryan & Deci, 1996, 2000; Kaplan, Sinai, & Flum, 2014; Assor, Kaplan, & Roth, 2002)

Constructionist Learning

Because design thinking is not native to the domain of the learning sciences, nor to the broader realm of educational research, design thinking alone is insufficient as a structure for the design of learning. Because the constructionism aligns remarkably well with design thinking, the principles of constructionist learning can provide additional structure to complement the structuring aspects of design thinking in the design of learning. The core principles of constructionist learning are:

- Situating learners as designers (Papert, 1993, 1999; Thomas, 2000; Mehta & Fine 2012)
- Creation of artifacts structured around metacognitive practices (Papert, 1993, 1999; Winne & Azevedo, 2014; Garrison & Akyol, 2012)
- Focused tinkering (Papert, 1993, 1999; Kafai, Peppler, & Chapman, 2009; Martinez & Stager, 2013; Hamilton, 2014)
- Learner agency (Papert, 1993, 1999; Deci, Koestner, & Ryan, 2001; Ryan & Deci, 1996, 2000; Appleton, Christenson, & Furlong, 2008; Reeve & Tseng, 2011)
- Authentic audience (Papert, 1993, 1999; Kafai, 1996; Blikstein, 2008; Martinez & Stager, 2013; Kafai & Burke, 2014)

Methodology

The purpose of this study was to investigate the impact of a design thinking project on pre-service teachers' conceptualizations of learning and their identities in relation to teaching and learning. Our research questions asked: What, if any, is the nature of the shift in metaphors of learning and identity conceptualizations in relation to teaching and learning experienced by participants in an intensive design thinking project?

This study is the first of several classroom iterations in an ongoing design-based research project investigating the design of learning activities and environments created to shift future educators' conceptualizations of learning toward the construction metaphor. Participants (n=11) were students in a teacher education program.

Consistent with descriptions of the process of design research offered by Reeves (2000), we first identified our developmental goal as the creation and refinement of a design thinking project that can encourage conceptual shifts in pre-service teachers, and ultimately inform a body of design principles that might support future development efforts. We then explored existing literature to understand the issue, and inform initial curricular design. The principles we used to inform design were: 1) align as closely as possible with the principles of constructionist learning described in the previous section, 2) integrate all design thinking processes as described in the previous section, and 3) all aspects of the design aim to facilitate development of designerly ways of knowing as described in the previous section.

Participants were divided into three groups. Each group engaged in a two-week design thinking project. They were told that the "wicked problem" their designs should address is the disconnect between the common conceptualization of learning grounded in the transfer/acquisition metaphor, and the conceptualization of learning found in the learning sciences which is grounded in the construction metaphor. Prior to and after the study, students were asked to record audio clips of themselves talking about the nature of learning and their own approaches to teaching and learning. During the project, students also wrote reflection pieces after completing each of the five major stages of the design thinking process.

In the evaluation phase of the DBR process (Reeves, 2000), students' reflections and transcribed written recordings were entered into the MAXQDA qualitative analysis software. Student responses were deductively coded for explicit use of transfer or construction metaphors, as well as for the inclusion of other relevant constructs derived from and defined by the literature (i.e. "describing a wicked problem" defined by Dorst, 2011). Student responses were also coded inductively using grounded theory methods (Charmaz, 2006) to explore emergent categories.

Upon completion, codes will be organized to form individual descriptive cases of students' identity exploration and shifting metaphor conceptualizations over time. Examinations of each of the three group projects, in conjunction with individual data from participants, will inform inter-group comparisons to reveal commonalities and aspects unique to each group.

We are currently in open and in vivo coding stages. Future stages of the research project will involve a) axial and selective coding to reveal patterns which will be analyzed for conceptual shift over time, b) organization and formulation of data into individual and group cases, c) inter-case analysis to explore commonalities and differences between groups, and d) researcher documentation and reflection to produce design principles for future project iterations (Reeves, 2000).

Results

Findings from these case study analyses (both individual and inter-group) will illustrate students' conceptual shifts over time, and inform the design of future iterations of design thinking projects. We expect the results of this study to provide valuable insight into the effectiveness of the design thinking process as a means by which to shift conceptualizations and identity exploration regarding learning.

Discussion

Research along these lines is important because the overwhelmingly dominant conceptualization of learning grounded in the transfer metaphor directly impacts practices of learning and teaching. This study contributes to the literature regarding shifting conceptualizations toward the learning sciences conceptualization of learning grounded in the construction metaphor.

References

Appleton, J. J., Christenson, S. L., & Furlong, M. J. 2008. Student engagement with school: Critical conceptual and methodological issues of the construct. *Psychology In The Schools*, 45(5), 369-386.

Assor, A., Kaplan, H., & Roth, G. (2002). Choice is good, but relevance is excellent: Autonomy-enhancing and suppressing teacher behaviours predicting students' engagement in schoolwork. *British Journal Of Educational Psychology, 72*, 261-278.

Bell, S. J. (2008). Design thinking. *American Libraries*, *39*(1-2), 44-49.

Benson, J., & Dresdow, S. (2015). Design for thinking: Engagement in an innovation project. *Decision Sciences Journal of Innovative Education, 13*(3), 377-410. doi:10.1111/dsji.12069

Blikstein, P. (2008). Travels in Troy with Freire: Technology as an agent for emancipation. In P. Noguera & C. A. Torres (Eds.), *Social Justice Education for Teachers: Paulo Freire and the possible dream* (pp. 205-244). Rotterdam, Netherlands: Sense.

Bransford, J., Brown, A. L., & Cocking, R. R. (2000). *How people learn: Brain, mind, experience, and school*. Washington, D.C: National Academy Press.

Brown, T. (2008). Design thinking. *Harvard Business Review, 86*(6), 84-92.

Bruner, J. S. (1996). *The culture of education.* Cambridge, Mass: Harvard University Press.

Carroll, M., Goldman, S., Britos, L., Koh, J., Royalty, A., & Hornstein, M. (2010). Destination, imagination and the fires within: Design thinking in a middle school classroom. *International Journal of Art & Design Education, 29*(1), 37-53. doi:10.1111/j.1476-8070.2010.01632.x

Charmaz, K. (2006). *Constructing grounded theory*. London: SAGE Publications.

Cleary, B. A. (2015). Design thinking and PDSA: Don't throw out the baby. *The Journal for Quality and Participation, 38*(2), 21-23.

Collins, A. & Halverson, R. (2009). *Rethinking education in the age of technology: The digital revolution and schooling in America.* Teachers College Press: New York.

Cross, N. (2006). *Designerly ways of knowing*. Dordrecht, London: Springer.

Deci, E. L., Koestner, R., & Ryan, R. M. (2001). Extrinsic rewards and intrinsic motivation in education: Reconsidered once again. *Review of educational research, 71*(1), 1-27.

Dimmitt, C., & McCormick, C. B. (2012). Metacognition in education. In K. R. Harris, S. Graham, T. Urdan, C. B. McCormick, G. M. Sinatra, & J. Sweller (Eds.), *APA educational psychology handbook, Vol 1: Theories, constructs, and critical issues.* (pp. 157-187). Washington, DC, US: American Psychological Association.

Dorst, K. (2011). The core of 'design thinking' and its application. *Design Studies, 32*(6), 521-532. doi:http://dx.doi.org/10.1016/j.destud.2011.07.006

Flum, H., & Kaplan, A. (2006). Exploratory orientation as an educational goal. *Educational Psychologist, 41*(2), 99-110.

Fuge, M., & Agogino, A. (2015). Pattern analysis of IDEO's human-centered design methods in developing regions. *Journal of Mechanical Design, 137*(7), 071405-071405. doi:10.1115/1.4030047

Garrison, D. R., & Akyol, Z. (2012). Toward the development of a metacognition construct for communities of inquiry. *The Internet and Higher Education, 17*, 84-89. doi:10.1016/j.iheduc.2012.11.005

Glen, R., Suciu, C., Baughn, C. C., & Anson, R. (2015). Teaching design thinking in business schools. *The International Journal of Management Education, 13*(2), 182-192. doi:http://dx.doi.org/10.1016/j.ijme.2015.05.001

Hager, P., & Hodkinson, P. (2009). Moving beyond the metaphor of transfer of learning. *British Educational Research Journal, 35*(4), 619-638. doi:10.1080/01411920802642371

Hamilton, S. (2014). The standards of critical digital pedagogy. *Hybrid Pedagogy*, July 17, 2014. Retrieved July 2, 2016 from http://www.digitalpedagogylab.com/hybridped/standards-critical-digital-pedagogy/

Hutchinson, A., & Tracey, M. (2015). Design ideas, reflection, and professional identity: How graduate students explore the idea generation process. *Instructional Science, 43*(5), 527-544. doi:10.1007/s11251-015-9354-9

Johansson-Sköldberg, U., Woodilla, J., & Çetinkaya, M. (2013). Design thinking: Past, present and possible futures. *Creativity and Innovation Management, 22*(2), 121-146. doi:10.1111/caim.12023

Kafai, Y. (1996). Learning design by making games. In Y. B. Kafai & M. Resnick (Eds.), *Constructionism in practice: Designing, thinking, and learning in a digital world* (pp. 71-96). Mahwah, N.J: Lawrence Erlbaum Associates.

Kafai, Y. B., & Burke, Q. (2014). *Connected code: Why children need to learn programming.* Cambridge, Mass: MIT Press.

Kafai, Y. B., & Resnick, M. (1996). *Constructionism in practice: Designing, thinking, and learning in a digital world*. Mahwah, N.J.: Lawrence Erlbaum Associates.

Kafai, Y., Peppler, K., & Chapman, R. (2009). *The Computer Clubhouse: Constructionism and creativity in youth communities.* Teachers College Press: New York.

Kaplan, A., Sinai, M., & Flum, H. (2014). Design-based interventions for promoting students' identity exploration within the school curriculum. In S. Karabenick & T. C. Urdan (Eds.), *Motivational Interventions* (pp. 243-291). Bingley, UK: Emerald Group Publishing Limited.

Kimbell, L. (2011). Rethinking design thinking: Part I. *Design and Culture, 3*(3), 285-306. doi:10.2752/175470811X13071166525216

Kincheloe, J. L., & Steinberg, S. R. (1998). Students as researchers: Critical visions, emancipatory insights *Students as Researchers: Creating Classrooms That Matter* (pp. 2-19). Independence, KY, USA: Taylor & Francis.

Kincheloe, J. L., Steinberg, S. R., & Tippins, D. J. (1999). *The stigma of genius: Einstein, consciousness, and education*. New York, NY: Peter Lang

La Guardia, J. G. (2009). Developing who I am: A self-determination theory approach to the establishment of healthy identities. *Educational Psychologist, 44*(2), 90-104.

Lakoff, G. & Johnson, M. (1980). *Metaphors we live by*. Chicago: The University of Chicago Press.

Luka, I. (2014). Design thinking in pedagogy. *Journal of Education Culture and Society, 2014*(2), 63-74. doi:10.15503/jecs20142.63.74

Martinez, S. & Stager, G. (2013). *Invent to learn: Making, tinkering, and engineering in the classroom.* Torrance, Ca: Constructing Modern Knowledge Press.

Mehta, J., & Fine, S. 2012. Teaching differently...Learning deeply. *Phi Delta Kappan*, 94(2), 31-35.

Mickahail, B. (2015). Corporate implementation of design thinking for innovation and economic growth. *Journal of Strategic Innovation and Sustainability, 10*(2), 67-79.

Papert, S. (1993). *The children's machine: Rethinking school in the age of the computer.* New York: Basic Books.

Papert, S. (1999). Eight big ideas behind the constructionist learning lab. In G. S. Stager (Ed.), *Constructive Technology as the Key to Entering the Community of Learners* (pp. 4-5). Philadelphia, PA: 2005 National Educational Computing Conference (NECC).

Papert, S., & Harel, I. (1991). Situating constructionism. In I. Harel & S. Papert (Eds.), *Constructionism* (pp. 1-11). New York, NY: Basic Books, Inc. Publishers.

Razzouk, R., & Shute, V. (2012). What Is design thinking and why is it important? *Review of educational research, 82*(3), 330-348. doi:10.3102/0034654312457429

Reeve, J., & Tseng, C. M. (2011). Agency as a fourth aspect of students' engagement during learning activities. *Contemporary Educational Psychology, 36*(4), 257-267. doi:10.1016/j.cedpsych.2011.05.002

Reeves, T. (2000, April). Enhancing the worth of instructional technology research through "design experiments" and other developmental strategies. Paper presented at the American Educational Research Association Annual Meeting. Retrieved from http://itech1.coe.uga.edu/~treeves/ AERA2000Reeves.pdf

Resnick, M., Berg, R., & Eisenberg, M. (2000). Beyond black boxes: Bringing transparency and aesthetics back to scientific investigation. *Journal of the Learning Sciences, 9*(1), 7-30. doi:10.1207/s15327809jls0901_3

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, *4*(2), 155-169.

Runco, M. A., & Acar, S. (2012). Divergent thinking as an indicator of creative potential. *Creativity Research Journal*, *24*(1), 66-75. doi:10.1080/10400419.2012.652929

Ryan, R. M., & Deci, E. L. (1996). When paradigms clash: Comments on Cameron and Pierce's claim that rewards do not undermine intrinsic motivation. *Review of educational research*, *66*(1), 33-38.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*(1), 54-67. doi:10.1006/ceps.1999.1020

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.

Schön, D. A., & Rein, M. (1994). *Frame reflection: Toward the resolution of intractable policy controversies*. New York: Basic Books.

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational researcher*, *27*(2), 4-13.

Stahl, G., Koschmann, T., & Suthers, D. (2014). Computer-supported collaborative learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (2nd ed., pp. 479-500). New York, NY: Cambridge University Press.

Thomas, J.W. 2000. *A review of research on project-based learning*. San Rafael, CA: Autodesk Foundation.

Watson, A. D. (2015). Design thinking for life. *Art Education*, *68*(3), 12-18.

Welsh, M. A., & Dehler, G. E. (2013). Combining critical reflection and design thinking to develop integrative learners. *Journal of Management Education, 37*(6), 771-802. doi:10.1177/1052562912470107

Winne, P. H., & Azevedo, R. (2014). Metacognition. In R. K. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences* (2nd ed., pp. 63-87). New York, New York: Cambridge University Press.

Zimmerman, B. J., & Labuhn, A. S. (2012). Self-regulation of learning: Process approaches to personal development. In K. R. Harris, S. Graham, T. Urdan, C. B. McCormick, G. M. Sinatra, & J. Sweller (Eds.), *APA educational psychology handbook, Vol 1: Theories, constructs, and critical issues.* (pp. 399-425). Washington, DC, US: American Psychological Association.

Games and Learning: Making Virology Fun

Jennifer Dalsen[1], Craig G. Anderson[2], Vishesh Kumar[3], Matthew Berland[4], & Constance Steinkuehler[5]
University of Wisconsin – Madison
jdalsen@wisc.edu; cganderson4@wisc.edu; vishesh.kumar@wisc.edu; mberland@wisc.edu; steinkuehler@wisc.edu

Keywords: games-based learning, science education, big data

Abstract: A student's authentic learning process is complicated by their experiences in formal and informal learning. However, using multiple streams of data provides a more detailed view of these processes, thereby allowing us to articulate learning experiences in new ways. Prior studies show games as having a crucial advantage over traditional approaches to science education (Clark, 2013; Clark, Tanner-Smith, & Killingsworth, 2013; Sitzmann, 2011; Vogel et al, 2006; Young et al, 2012), which can increase participation in science activities (Bell & Lewenstein, 2009). While past research studies examine qualitative or quantitative measures of learning outcomes, the number of data streams is typically limited.

The purpose of our study was to connect qualitative, quantitative, and mixed analyses in a game-embedded informal learning activity. In doing this, our goal was to situate "big" gameplay data with other traditional qualitative data in order to trace the learning outcome of middle school students participating in an educational app called *Virulent*. We already know that some data mining techniques identify relationships between in-game behavior, cognitive-affect and performance metrics (Baker et al, 2010). Our primary research question was aimed at capturing a deeper look at authentic learning processes in games-based learning, and similar relations between learning, gameplay, and activity participation.

Participants were recruited from a local private school, a community organization and a separate spring break event. Each session was held outside the classroom setting. Participants (n=81) role-played as scientists recruited by the CDC to stop a fictional Ebola-like virus from causing a global pandemic. Divided into groups of 3-4, participants investigated "microscopic slides" (aka game levels) in order to determine virus and immune system behaviors. Over the course of five days participants played *Virulent*, created models of virus behavior, wrote letters to the CDC, recorded group videos and presented models for feedback. These activities allowed us to collect a wide array of data, including pre-post content knowledge and attitudinal responses, as well as actions carried out during gameplay, physical artifacts and talk audio.

Results from pre-post surveys indicate significant gains in scientific knowledge. On average, participants (n=59) scored 29% accuracy on their pre-test of scientific content knowledge. This increased to 49% accuracy during the post-test. Additionally, varied behaviors were observed across participants during gameplay. While some participants only completed a couple levels of the game, others were highly active in playing "extra-curricular" levels, and some chose to continue their gameplay at home. Future analyses will integrate these different data streams in order to establish a more authentic and nuanced picture of these participants' learning

experiences. This includes analyzing data line-by-line (Gee, 2010) and frame-by-frame (Jewitt, 2009; Kress, 2009) in order to pinpoint themes that arise within identified constructs.

References

Baker, R .S. J. d., D'Mello, S. K., Rodrigo, M. M. T., Graesser, A. C. (2010) Better to be frustrated than bored: The incidence, persistence, and impact of learners' cognitive-affective states during interactions with three different computer-based learning environments. International Journal of Human-Computer Studies, 68(4), 223-241.

Bell, P., Lewenstein, B., Shouse, A. W., & Feder, M. A. (Eds.). (2009). *Learning science in informal environments: People, places, and pursuits*. National Academies Press.

Clark, D. (2013). *Meta-analysis of digital games and learning in terms of the NRC's Education for Life and Work outcomes*. Paper presented at the Games+Learning+Society Conference 9.0, Madison WI, June 12-14.

Clark, D. B., Tanner-Smith, E. E., & May, S. K. (2013). Digital games for learning: A systematic review and meta-analysis.

Gee, J. P. (2010). *An Introduction to Discourse Analysis: Theory and Method (3rd Edition*). London: Routledge.

Jewitt, C. (2009). *The Routledge Handbook of Multimodal Analysis*. London: Routledge.

Kress, G. (2009). *Multimodality: A social semiotic approach to contemporary communication.* London: Routledge.

Sitzman, T. (2011). A meta-analysis examination of the instructional effectiveness of computer-based simulation games. *Personal psychology, 64*, 489-528.

Vogel, J. J., Vogel, D. S., Cannon-Bowers, J., Bowers, C. A., Muse, K., & Wright, M. (2006). Computer gaming and interactive simulations for learning: A meta-analysis. *Journal of Educational Computing Research*, *34*, 229-243.

Young, M. F., Slota, S., Cutter, A. B., Jalette, G., Mullin, G., Lai, B., Simeoni, Z., Train, M. & Yukhymenko, M. (2012). Our princess is in another castle a review of trends in serious gaming for education. *Review of educational research, 82*(1), 61-89.

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Secondary STEM Projects Cultivate Rural Agricultural Communities in Latin America

Rebecca L. Shareff
University of California, Berkeley
rlshareff@berkeley.edu

Keywords: civic engagement, STEM learning, project-based learning, Honduras

Abstract:

In Central America, cost and proximity limit rural youth from secondary schooling[1]. The Honduran government's standard secondary program, Centro de Educación Básica (CEB), has highly theoretical curriculum—not applicable to rural lifestyles[2]. Aware of this discrepancy, a Nongovernmental initiative (now formally recognized), Sistema Apredizaje Tutorial (SAT), contextualizes its curriculum for rural students. A matched-sample assessment of 94 CEB and SAT schools demonstrated SAT students' higher test scores after 2 years[3]. Yet understood is the qualitative nature of this distinction.

The literature for improving education in poor countries often describe incentives for school personnel or directly improving instruction; contrastingly, this project follows a systemic innovation. Informed by outdoor-science instruction and project-based learning, this study explores SAT's agricultural STEM projects through the lens of civic engagement. Specifically, how are projects designed and implemented; how is community investment sustained; and what are their practical and philosophical outputs? Analysis across multiple settings reveals resources promoting educational and economic growth among students and their families.

Data consist of 30 video hours and 13 interviews collected in Honduras during May 2016 (Figure 1). To understand lesson development, Stage 1 included tutor training for five courses (math, science, and community service); to witness the projects and their impact, Stages 2 & 3 used four SAT communities. Student workbooks for each training course were also collected for analysis. In alignment with the research questions, the workbooks, videos, and interviews will be examined for key themes:

- Methods of training/teaching STEM
- Agricultural/economic context of STEM
- Co-construction of knowledge between trainers, teachers, students, and families
- Community sites/ resources in projects
- Evolution of environmental attitudes

[1] Urquiola, M., & Calderón, V. (2006), *Journal of Educational Development*
[2] Murphy-Graham, E. (2012), *Vanderbilt University Press.*
[3] McEwan, P., & Murphy-Graham, E. (2014), *Educational Evaluation and Policy Analysis*

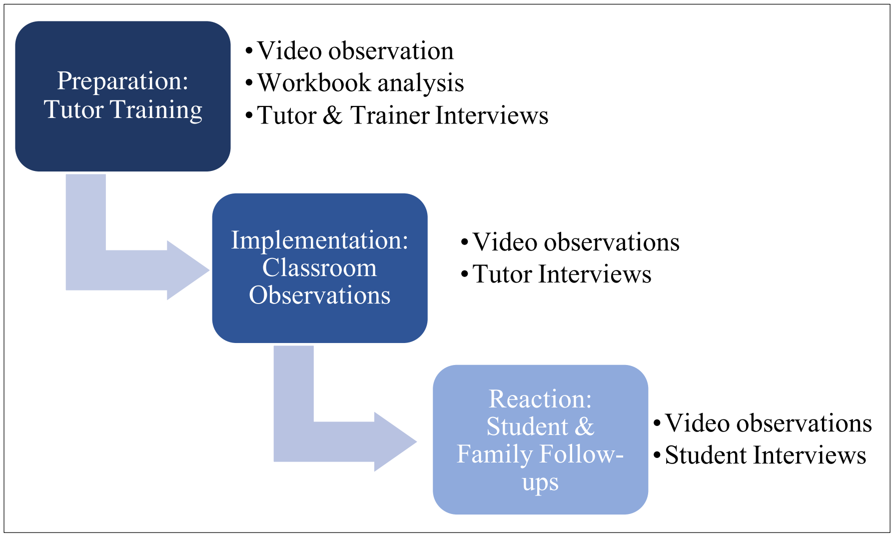

Figure 1: Chronological Stages of Data Collection

From the themes, specific instances [ex: *accountability*, *relevance*, *community participation*, *hands-on instruction*] will be coded and cross-referenced across stages. Frequency across stages as well as triangulation between data sources will determine utility toward successful projects. Discourse analysis will uncover patterns of subjects' knowledge sharing and environmental philosophies. Roundtable participants will be invited to examine samples of video, workbook, and interview transcripts to draw connections between the themes proposed.

Initial findings indicate strong family and civic involvement: as sites of project investigation, data collection and dissemination, land and tool resources, and inclusion in celebration. Tutors and trainers emphasize hands-on education, using local landscape and materials to teach STEM concepts, while demonstrating students' potential to run small businesses. A point of tension is teaching conservation and organic faming methods, counter to current practices of chemical fertilizers and forest burnings.

These points indicate the projects as a source of leadership for students within their community, with careful consideration to include community members throughout the process. The practice of sharing results is pivotal to the understated goal of shifting agricultural practices towards sustainability.

Implications for complete analysis include advocating accessible STEM content for underserved populations through economic and ecologically relevant project-based instruction.

Betty's Resilience in the Moment: Refugee Youth's 'Hidden' Resilience in an Afterschool STEM Program

Mavreen Rose Tuvilla[1] & Minjung Ryu[2]
Purdue University
mtuvilla@purdue.edu; mryu@purdue.edu

Keywords: equity, science education, multimodal analysis

Abstract: Despite the increasing number of resettled refugee youth (UNHCR, 2015), our understanding of how they learn subject area content is limited. Research on refugee youth focuses mainly on language acquisition and traumatic experiences (McBrien, 2005). To fill this gap, we examine how Betty, a Burmese refugee youth, participated and learned science in an afterschool STEM learning setting, through the lens of resilience.

In education, resilience denotes "achievement of positively (or the avoidance of negatively) valued outcomes in circumstances where adverse outcomes would be normally expected" (p.39, Kaplan, 2005). Despite common usage of the construct, studies on resilience are strongly associated with high-risk populations, who are often racial, linguistic, and socioeconomic minority (Borman & Overman, 2004). With this association, lies an assumption that at-risk students are anticipated to fail desirable outcomes set by the dominant group. Without asking "resilient for what purpose, and resilient according to whom?" (p. 49, McMahon, 2007), we may reinforce the existing hegemonic structure in the attempt to advance youth's resilience. Here, we attempt to demonstrate how students enact resilience in the micro-moments. We draw on practice theories that seek to understand dialogic interactions between the structure and individual's agency in our social lives (Holland, Lachicotte Jr, Skinner, & Cain, 1998). We investigate the moments in which resilience may emerge and be negotiated in the ecology of interactions from members' perspective (Garfinkel, 1967).

This study is part of a larger project that engages resettled Burmese refugee high school youth in learning about weather and climate in an afterschool setting in 2015-2016. Using principles of video analysis (Derry, et al., 2010), we analyzed 41-minute long screencast of Betty's computer use and 90-minute long classroom video- and audio-recording. We transcribed utterances of Betty and people around her, and annotated kinetic features (e.g., gesture, body posture, gaze), computer use (e.g., search terms used), and other contextual features (e.g., organization of artifacts and space; Knoblauch & Schnettler, 2012). In coding data, we adapted the definition of resilience, "manifest competence despite exposure to significant stressors" (p. 7, Rolf & Glantz, 1999). We analytically defined resilience as action demonstrated to overcome moment-to-moment stressors in order to achieve a micro-moment goal by utilizing abilities and available resources. We coded annotated transcripts in terms of micro-moment goals, stressors and Betty's immediate action to them and wrote analytic notes of how she enacted resilience. We generated higher level themes through constant comparison (Lincoln & Guba, 1985).

From the analysis, we identified three different ways in which Betty enacted her resilience: 1) spatial coordination of artifacts (e.g., obtaining material resources such as a worksheet), 2) negotiation of knowledge (e.g., meaning making via text/images and hand gestures), and 3) crafting of opportunities to display knowledge (e.g., translating for group members). This study provides a new way to conceptualize resilience in the moment and insights into resettled refugee youth's learning and participation in STEM. This emerging resilience

demonstrated through a multimodal analysis of multiple video-/audio-data may be overlooked if we perceive resilience based on prescribed notions of valued outcomes.

Collaboration at Multiple Levels: Combining Learning Analytics with Quantitative Ethnography Methods

Catherine Dornfeld[1], Matthew Berland[2], and Sadhana Puntambekar[1]
University of Wisconsin–Madison, Educational Psychology[1] and Curriculum & Instruction[2]
cldorneld@wisc.edu; mberland@wisc.edu; puntambekar@education.wisc.edu

Keywords: collaboration, CSCL, discourse analysis, learning analytics/EDM, mixed-methods

Abstract:
To understand collaborative learning, we must first consider the intersection of the individual and the group (Puntambekar, 2013). One way to understand learning at each level is to use mixed-methods approaches (Puntambekar, 2013). These approaches allow us to study processes and products of learning at multiple grain sizes through qualitative and quantitative lenses (Strijbos & Fischer, 2007).

One such approach is quantitative discourse analysis, which often involves transcription, development of coding schemes and reliability measures, and statistical testing (Strijbos & Fischer, 2007). While this methodology permits fine-grained analysis, grounded coding comes with potential for bias in findings. To reduce bias, we may explore automated analyses of data sets (Martin & Sherin, 2013; Puntambekar, 2013). For example, certain algorithms, such as those used in natural language processing, can find patterns in word usage (Witten, Frank, & Hall, 2011). However, if these algorithms rely on measures unrelated to research questions (e.g., frequency), these patterns may be uninformative. As both human and automated analyses have limitations, a combined approach may be most appropriate (Sherin, 2013). In an exploratory study, Sherin (2013) found that statistical natural language processing converged with human analyses *and* identified theory-relevant data features. Integrating automated analyses may benefit researchers by triangulating results, supporting theory, and revealing unanticipated patterns in data (Puntambekar, 2013; Martin & Sherin, 2013).

An integrated approach to analytics may be especially useful for studying small-group collaboration, especially through discourse. Individuals' conceptual outcomes are impacted by their participation in collaborative meaning-making discourse (Barron, 2003; Wegerif, Mercer, & Dawes, 1999; De Wever, Van Keer, Schellens, & Valcke, 2010). One way to promote positive conceptual outcomes is to ensure that talk is equitably distributed among group members (Rafal, 1996; Bennett, Hogarth, Lubben, Campbell, & Robinson, 2009; Esmonde, 2009). This is especially important when we consider that inequitable participation in discourse is associated with less positive conceptual outcomes (Barron, 2003; Esmonde, 2009; Strijbos & Weinberger, 2010). To promote equitable patterns in group discourse, we must first uncover how small groups naturally enact said patterns.

In this exploratory study, we investigate how the dynamics of group discourse may be linked to individual conceptual outcomes. We combine quantitative discourse analysis with automated analyses to examine how small groups of students learning biology participate in collaborative activities. We use a diversity of data sources at multiple levels to identify participation patterns, including: written responses to prompts and assessment scores (for the individual level); log data of e-textbook actions (for the group level); and audiovisual recordings of group work (for the intersection of individual and group levels). Our research question is: *how do the data sources (individually and collectively) reveal associations between individual- and*

group-level collaboration and outcomes? Based on prior research, we expect convergence between individual assessments and group discourse (Dornfeld & Puntambekar, 2015; Dornfeld & Puntambekar, 2016) and between group discourse and log data. By understanding alignment between data sources, we hope to uncover how collaborative processes unfold and find opportunities to improve collaboration through visualization (e.g., Gweon, Jun, Lee, Finger, & Rosé, 2011; Kay, Maisonneuve, Yacef, & Reimann, 2006).

References

Barron, B. (2003). When smart groups fail. *Journal of the Learning Sciences*, *12*(3), 307-359.

Bennett, J. , Hogarth, S., Lubben, F., Campbell, B., & Robinson, A. (2009). Talking science: The research evidence on the use of small-group discussions in science teaching. *International Journal of Science Education, 32*(1), 69-96.

De Wever, B., Van Keer, H., Schellens, T., & Valcke, M. (2010). Roles as a structuring tool in online discussion groups: The differential impact of different roles on social knowledge construction. *Computers in Human Behavior*,*26*(4), 516-523.

Dornfeld, C. & Puntambekar, S. (2015, June). Emergent roles and collaborative discourse over time. In O. Lindwell, P. Hakkinen, T. Koschman, P. Tchounike, & S. Ludvigsen (Eds.), *Exploring the Material Conditions of Learning: Computer-Supported Collaborative Learning (CSCL) Conference 2015, Volume 1* (pp. 380-387). Gothenburg, Sweden: The International Society of the Learning Sciences.

Dornfeld, C. & Puntambekar, S. (2016, June). Negotiation towards intersubjectivity and impacts on conceptual outcomes. Full paper presented at the International Conference of the Learning Sciences (ICLS) 2016. Singapore: The International Society of the Learning Sciences.

Esmonde, I. (2009). Mathematics learning in groups: Analyzing equity in two cooperative activity structures. *Journal of the Learning Sciences, 18*(2), 247-284.

Gweon, G., Jun, S., Lee, J., Finger, S., & Rosé, C. P. (2011). A framework for assessment of student project groups on-line and off-line. In *Analyzing Interactions in CSCL* (pp. 293-317). Springer US.

Kay, J., Maisonneuve, N., Yacef, K., & Reimann, P. (2006, June). The big five and visualisations of team work activity. In *International Conference on Intelligent Tutoring Systems* (pp. 197-206). Springer Berlin Heidelberg.

Martin, T. & Sherin, B. (2013). Learning analytics and computational techniques for detecting and evaluating patterns in learning: An introduction to the special issue. *Journal of the Learning Sciences, 22*(4), 511-520.

Puntambekar, S. (2013). Mixed methods for analyzing collaborative learning. In C. E. Hmelo-Silver, C. A. Chinn, C. Chan, & A. M. O'Donnell (Eds.), *The International Handbook of Collaborative Learning* (pp. 220-232). New York, NY: Routledge.

Rafal, C. T. (1996). From co-construction to takeovers: Science talk in a group of four girls. *Journal of the Learning Sciences, 5*(3), 279-293.

Sherin, B. (2013). A computational study of commonsense science: An exploration in the automated analysis of clinical interview data. *Journal of the Learning Sciences*, *22*(4), 600-638.

Strijbos, J. W., & Fischer, F. (2007). Methodological challenges for collaborative learning research. *Learning and Instruction*, *17*(4), 389-393.

Strijbos, J. W. & Weinberger, A. (2010). Emerging and scripted roles in computer-supported collaborative learning. *Computers in Human Behavior, 26*, 491-494.

Wegerif, R., Mercer, N., & Dawes, L. (1999). From social interaction to individual reasoning: an empirical investigation of a possible socio-cultural model of cognitive development. *Learning and Instruction*, *9*(6), 493-516.

Witten, I. H., Frank, E., & Hall, M. A. (2011*). Algorithms: The Basic Methods Data Mining: Practical Machine Learning Tools and Techniques* (3rd ed., pp. 85-146). Burlington, MA: Morgan Kaufmann.

Literary Inquiry: Exploring Literature Collaboratively in a Digital Learning Space

Renato Carvalho[1] & Allison H. Hall[2]
University of Toronto[1], University of Illinois at Chicago[2]
renato.carvalho@mail.utoronto.ca; ahall33@uic.edu

Keywords: inquiry-based learning, literary reasoning, Knowledge Community and Inquiry, Common Knowledge, design-based research

Abstract

This design-based study is motivated by the need to support students in building interpretive communities around literary inquiry. Our design adapts the Knowledge Community and Inquiry (KCI) model (Slotta & Najafi, in press) to support collective inquiry and building of a knowledge community in the study of literature. According to Slotta & Najafi, KCI is based on three principles:

> "(a) that students work together as a community to produce a knowledge base; (b) that a sequence of collaborative inquiry activities draw upon the knowledge base as a resource; and (c) that the inquiry activities must address the basic themes that emerge within the community and result in assessable outcomes that are indexed to the learning goals."

Despite previous enactments of KCI having been in science curricula, these principles ground a model that has sufficient flexibility to support designs in other disciplines.

In adapting KCI specifically to support literary inquiry, we examined the nature of literary reasoning and epistemologies around the study of literature. Lee, Goldman, Levine, and Magliano (2016) explore the nature of epistemic cognition in literary reasoning, finding it fundamentally interdisciplinary, appealing to multiple domains in addressing its problems and inquiries (e.g., reading comprehension, cultural understandings of psychological states and human events, literary theory and criticism). Central to literary reasoning is the idea that literary texts are open to multiple interpretations that may depend on one's critical lens or one's own experiences of the world. Expert readers rely on various types of knowledge as they read, including knowledge of other texts, genres, interpretive problems, authors, and cultural and historical contexts of texts (Lee & Spratley, 2010). Research around instructional interventions to support students in literary reasoning indicates the importance of sequencing texts and tasks, providing students opportunities to learn explicit interpretive strategies (Lee, 2007; Levine, 2014), and using class discussions to build understanding (Applebee, Langer, Nystrand, & Gamoran, 2003). These instructional strategies are in accordance with the KCI principles, therefore suggesting that the model can be used to guide the design of learning environments to support students in developing the skills and practices of literary reasoning.

Our research attempts to address two questions: 1) How does the KCI pedagogical model support classroom inquiry around literary texts? 2) How do ideas initiated by individuals develop across small groups and the entire class through collective inquiry?

In order to address these questions, we will collaborate with the classroom teacher to design and enact a multi-week curriculum unit for high school level literary study, guided by KCI. During the enactment, we will collect video and audio recordings of daily classroom observations as well as classroom and student artifacts. We will analyze these data to inform further iterations of the design.

At our roundtable, we will elaborate on our theory and design and guide participants in a demonstration of the digital learning space. Then, participants will have the opportunity to explore the interactive prototype by themselves. We will ask participants for feedback on the design and discuss ideas for how to address our research questions.

References

Applebee, A. N., Langer, J. A., Nystrand, M., & Gamoran, A. (2003). Discussion-based approaches to developing understanding: Classroom instruction and student performance in middle and high school English. *American Educational Research Journal, 40,* 685–730.

Lee, C. D. (2007). *Culture, literacy, and learning: Taking bloom in the midst of the whirlwind.* New York, NY: Teachers College Press.

Lee, C. D., Goldman, S. R., Levine, S., & Magliano, J. (2016). Epistemic cognition in literary reasoning. *Handbook of epistemic cognition,* 165-183.

Lee, C. D., & Spratley, A. (2010). *Reading in the disciplines: The challenges of adolescent literacy*. New York, NY: Carnegie Corporation of New York.

Levine, S. (2014). Making Interpretation Visible With an Affect-Based Strategy. *Reading Research Quarterly*, *49*, 283–303.

Slotta, J.D. & Najafi, H. (in press). Supporting Collaborative Knowledge Construction with Web 2.0 Technologies. In *Emerging Technologies for the Classroom: A Learning Sciences Perspective* (N. Lavigne, Ed.).

Connected Design Rationale: Modeling and Measuring Design Thinking

Golnaz Arastoopour & David Williamson Shaffer
UW-Madison
arastoopour@wisc.edu; dws@education.wisc.edu

Keywords: engineering education, design thinking, measurement, discourse analysis

Abstract:

Design is central to 21st century engineering practice and thus, is central to engineering education. Design is inherently complex and multi-faceted but fundamentally requires two key skills: (1) making appropriate *design moves*—actions taken during the design process (Schön, 1987) and (2) providing explicit *design rationale*—justifications for chosen design moves (Rittel, 1987). Moreover, learning sciences research argues that learning a practice, such as engineering design, centers on understanding meaningful connections among actions and justifications rather than measuring isolated instances of skills and knowledge (Shaffer, 2006). Modeling and measuring the complex nature of authentic design learning, however, remains a challenge (Razzouk & Shute, 2012). Thus, the goal of this work is to merge current learning sciences research with engineering design education to develop an approach for modeling and measuring design thinking.

Research in engineering education suggests that design is most effectively learned through experience in professional practica, spaces where students participate in a simulation of the practice under the guidance of senior practitioners (ABET, 2014; Johri, 2010). In undergraduate education, one common example of engineering design practica are *real-world internships* in which students complete their design work at actual engineering companies. Such internships allow students to experience authentic aspects of the design practice such as collaborating in teams, communicating with clients, and iterating through potential solutions. Another option for professional learning is *virtual internships*, online simulations of authentic practice where all student work is recorded digitally (Chesler et al., 2015). One key advantage of virtual internships is that the digital system captures a logfile of student design moves and rationale and therefore allows for a rich analysis of design learning development. Thus, in this study, we will investigate how connected design rationale develops both in real-world and virtual internships.

We will use prior research in which we conducted an ethnographic study on how students in a real-world engineering internship learned design under the supervision of professional mentors (Arastoopour & Shaffer, 2015). This work measured the differences between how experienced engineers and novices think about design work. Based on this study, we developed a framework which models the ways in which students understand the patterns of relationships among design moves and the rationale for such moves—a *connected design rationale*. To continue this line of research, we will investigate connected design rationale in more detail by examining student work in a virtual internship program which captures student work in digital forms. Using epistemic network analysis (Arastoopour, Shaffer, Swiecki, Ruis, & Chesler, 2016; Shaffer et al., 2009), we will measure connected design rationale and argue that measuring connectedness in design thinking is more effective than measuring skills and knowledge in isolation. Thus, the

fundamental research question in this work is whether design learning can be effectively modeled as a connected design rationale. By better understanding the development of design skills, this work will begin to shed light on an implicit process that is fundamental to design education.

References

ABET. (2014). Criteria for Accrediting Engineering.

Arastoopour, G., & Shaffer, D. W. (2015). Epistemography and professional CSCL environment design. In O. Lindwall, P. Hakkinen, T. Koschmann, P. Tchounikine, & S. Ludvigsen (Eds.), *The Computer Supoprted Collaborative Learning Conference* (pp. 204–211). Gothenberg, Sweden.

Arastoopour, G., Shaffer, D. W. D. W., Swiecki, Z., Ruis, A. R. R., & Chesler, N. C. N. C. (2016). Teaching and assessing engineering design thinking with virtual internships and epistemic network analysis. *International Journal of Engineering Education*, *32*(3), 1–10.

Chesler, N. C., Ruis, A. R., Collier, W., Swiecki, Z., Arastoopour, G., & Shaffer, D. W. (2015). A novel paradigm for engineering education: Virtual internships with individualized mentoring and assessment of engineering thinking. *Journal of Biomechanical Engineering*, *137*(2), 1–8.

Johri, A. (2010). Situated Engineering in the Workplace. *Engineering Studies*, *2*(3), 151–152. doi:10.1080/19378629.2010.536427

Razzouk, R., & Shute, V. (2012). What Is Design Thinking and Why Is It Important? *Review of Educational Research*, *82*(3), 330–348.

Rittel, H. W. J. (1987). The Reasoning of Designers. In *Congress on Design Planning and Design Theory*. Boston, MA.

Schön, D. A. (1987). *Educating the reflective practitioner: Toward a new design for teaching and learning in the professions*. San Francisco: Jossey-Bass.

Shaffer, D. W. (2006). Epistemic frames for epistemic games. *Computers and Education*, *46*(3), 223–234.

Shaffer, D. W., Hatfield, D., Svarovsky, G., Nash, P., Nulty, A., Bagley, E. A., … Mislevy, R. J. (2009). Epistemic Network Analysis: A prototype for 21st century assessment of learning. *The International Journal of Learning and Media*, *1*(1), 1–21.

Developing Interest Scaffolding in a STEM Lesson

Joseph E Michaelis & Mitchell J Nathan
University of Wisconsin - Madison
jemichaelis@wisc.edu; mnathan@wisc.edu

Keywords: interest, scaffolding, STEM education, intelligent tutoring systems

Abstract: In this paper we describe work-in-progress for an initial evaluation of an intelligent tutoring system (ITS) that scaffolds instruction based on individual interest. Modifying instruction to meet the needs of individual students is essential in modern, diverse classrooms (Tomlinson et. al, 2003), and *scaffolding* is an effective means to do so (Puntambekar, 2009). Scaffolds are often designed to address cognitive (Koedinger & Corbitt, 2006), affective (Picard, 2000), as well as both cognitive and affective needs (D'Mello & Graesser, 2010). However, while these interventions show positive results, they do not address the development of interest for the academic content being studied, which, particularly in STEM domains, is a well-documented national concern (National Academy of Sciences, 2007).

Interest development research prescribes different academic supports appropriate for differing phases of interest (Renninger & Su, 2011). In general, those at lower phases of interest need feedback that appreciates effort, acknowledges that the work is difficult for them, and provides short, direct guidance for next steps in the work. At higher phases of interest students need to be challenged, and supported in exploring their own ideas. We use this framework to develop *interest scaffolding* – scaffolded instruction to meet student needs based on their current individual interest for that domain. We believe interest scaffolding will provide similar engagement and learning gains as other scaffolding interventions, while simultaneously developing interest in these important areas. To examine the efficacy of interest scaffolding in STEM, we begin by scaffolding the feedback received during a lesson. In this study we conduct an initial pilot test of the scaffolded feedback, and ask the research question: What feedback is most appropriate for students with high or low interest in chemistry while participating in a chemistry lesson?

To test this, we will modify the feedback in an existing chemistry ITS (ChemTutor; Rau, 2015). First, we develop two protocols, *high interest* and *low interest feedback*, by modifying tutor feedback in response to student actions at specific points in the lesson. Next, undergraduate students (N=8; split high/low interest in engineering) will complete a lesson, where half of the lesson uses low interest feedback and the other half uses high interest feedback (randomly ordered). We will video record each lesson, and conduct post-lesson interviews about how they perceived each type of feedback. Lesson activity logs and transcriptions of interviews will be coded for analysis, and emerging themes that reveal positive and negative responses to the feedback will be identified.

The study makes a practical contribution to program and curriculum designers who may benefit from this example and assessment of interest scaffolding, as well as student feedback on their experience with the scaffolding. The study also provides a theoretical contribution of empirical evidence that tests theoretically prescribed student needs at different interest levels.

Future work will use results from this pilot testing to improve the feedback, and test its effectiveness on a larger scale. We hope that as a result of this study we will improve the implementation and utility of interest scaffolded lessons.

References

D'Mello, S. K., & Graesser, A. (2010). Multimodal semi- automated affect detection from conversational cues, gross body language, and facial features. User Modeling and User-Adapted Interaction, 20(2), 147-187.

Koedinger, K., & Corbett, A. (2006). Cognitive tutors: Technology bringing learning science to the classroom. In K. Sawyer (Ed.), *Cambridge Handbook of the Learning Sciences* (pp. 135-175). Cambridge: Cambridge University Press.

National Academy of Sciences. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter future.* Washington, D.C.: National Academies Press.

Picard, R. (2000). Toward computers that recognize and respond to user emotion. *IBM Systems Journal*, *39*(3/4), 705-719.

Puntambekar, S. (2009). Scaffolding student learning. In E. Anderman & L. Anderman (Eds.), *Psychology of Classroom Learning.* Farmington Hills, MI: MacMillan.

Rau, M.A. (2015). Enhancing undergraduate chemistry learning by helping students make connections among multiple graphical representations. *Chemistry Education Research and Practice, 16*, 654-669.

Renninger, K. A., & Su, S. (2011). Interest and its development. In R. Ryan (Ed.), *Oxford Handbook of Human Motivation* (pp. 167-187): Oxford University Press.

Tomlinson, C., Brighton, C., Hertberg, H., Callahan, C. M., Moon, T., Brimijoin, K., Reynolds, T. (2003). Differentiating instruction in response to student readiness, interest, and learning profile in academically diverse classrooms: A review of literature. *Journal for the Education of the Gifted*, *27*. 119-145.

Two are Better Than One: The Power of School Community Partnerships for the Developing Adolescent

Y'Shanda Rivera
yshandarivera@u.northwestern.edu
Northwestern University

Keywords: Adolescents, At-Risk, School/Community Collaboration

Abstract:
On any given day, many schools find themselves stretched to not only meet the academic, but the socio-emotional and physical needs of their adolescent student population. And on any given day, there are a multitude of adolescent students riddled with a number of in-school and out-of-school risks factors, placing them under the label of being “at risk”. So what’s a school to do to when faced with such vast range of student needs? And what’s an adolescent to do, to escape such a brand?

Because schools don’t exist in silos and they recognize that they alone can’t bear the weight of such heavy needs, many of them have turned to school community partnerships as a means of supporting the academic and social development of their student population.

This study looks at the power of how an ecological partnership operating across three community organizations (a local school, community center and faith-based organization), leverages each organizational space to afford a cohort of 6^{th}-8^{th} grade students, facing multiple risk factors, an affinity space (Gee, 2004) in the physical place of the community center and faith-based organization, in which to develop a leadership identity.

Using pre and post surveys, transcribed interviews from ten adolescents and four organizational leaders, observations and transcriptions of audio-recorded cohort sessions, I use process coding analysis to extend on Bronfenbrenner’s EST (1977) and Spencer’s (1997, 2006) PVEST model of ecological frameworks and identity theories. I posit and find that participation in the cohort contributed to building the adolescents’ leadership identities. This was done first by offering them a physical place, outside-of-school building, where they could disassociate with the “at-risk” identity. In this out-of-school setting, where they were now primed to take on a new identity, they were given and connected to the “new” identity of leader. They were addressed and engaged in those spaces around that identity, and in time they took ownership of it, referring to themselves as leaders and acting in a leadership capacity. I’ve constructed this phenomenon to be an identity development process of understanding, branding, and landing.

Implications for this study speak to how schools and organizations can partner to give students who might be experiencing risks inside of the school building, a physical place where they can go, connect and engage around an identity that counters that label of “at-risk” in school.

Learning Computational Thinking without Technology: An Exploration in Knitting

Amanda M. Bell & Panchompoo Wisittanawat
Vanderbilt University
Amanda.m.bell@vanderbilt.edu; panchompoo.wisittanawat@vanderbilt.edu

Keywords: computational thinking, crafts, K-12, out of school/informal learning

Abstract

Since Wing's paper in 2006 sparked renewed interest in computational thinking (CT), many now consider CT a basic skill that should be available to everyone. However, researchers are still debating the definition of CT, how it can be applied outside computer science, and how to incorporate CT into schools (Barr & Stephenson, 2011; Grover & Pea, 2013). Understanding CT in different contexts is essential for providing students with more learning opportunities. We need to study how CT can be incorporated into K-12 education, both in and out of schools, with and without technology.

In particular, we focus on learning CT through knitting for several reasons: 1. As a traditionally female craft, knitting affords more opportunities for women to learn CT skills; 2. Many expert knitters we've interviewed have STEM backgrounds and point to connections between knitting and CT or math; 3. Not all classrooms have advanced computing technologies, so it's important to develop activities for learning CT without technologies. Namely, we ask:

1. What practices are common to CT and knitting?
2. How can students learn CT skills through knitting?

Data includes audio, pictures, and field notes from knitting classes, a knitting conference, interviews with expert knitters, and some workshops where we piloted early designs.

Although there is still no widely agreed-upon definition of CT, researchers have listed some of the skills, practices, and dispositions involved. We briefly explore how some CT practices are similar to those in knitting.

First, debugging errors is a large part of CT (Bers et al., 2014; Grover & Pea, 2013). When we ask knitters how to define expertise in knitting, the overwhelming response is that good knitters are not afraid of making mistakes and figuring out how to fix them. Second, programmers frequently remix others' work (Brennan & Resnick, 2012). Similarly, knitters modify patterns for style or fit and use existing patterns to develop new projects. Third, CT involves balancing time and space to work towards efficient solutions (Barr, Harrison, & Conery, 2011; Wing, 2008). Knitters must be efficient with time and materials, and they want instructions to be as simple as possible.

An example of a knitting activity that may engage students in these three CT practices is when students design and knit an object, for example a bag, from available stitch patterns. This involves understanding the pattern instructions and modifying them to fit the shape of the desired object. For example, students may have to modify a stitch pattern that requires multiples of 8

rows into a 12-row repeat. Once the pattern is put together, there are many ways to represent the pattern, e.g. spelling out consecutive stitches on each row, or grouping some section of stitches in ways that make knitting more efficient. As students knit their designed object, they have to engage in debugging both in their written patterns and in their knitted artifact.

Implications of this work include more opportunities for students to learn CT skills outside of computer science courses, along with a better understanding of the nature of CT.

References

Barr, B. D., Harrison, J., & Conery, L. (2011). Computational Thinking : A Digital Age. *Learning & Leading with Technology*, *5191*(March / April), 20–23.

Barr, V., & Stephenson, C. (2011). Bringing computational thinking to K-12. *ACM Inroads*, *2*(1), 111–122.

Bers, M. U., Flannery, L., Kazakoff, E. R., & Sullivan, A. (2014). Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers and Education*, *72*, 145–157.

Brennan, K., & Resnick, M. (2012). New frameworks for studying and assessing the development of computational thinking. In *annual American Educational Research Association meeting, Vancouver, BC, Canada* (pp. 1–25).

Grover, S., & Pea, R. (2013). Computational Thinking in K-12: A Review of the State of the Field. *Educational Researcher*, *42*(1), 38–43.

Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, *49*(3), 33–35.

Wing, J. M. (2008). Computational thinking and thinking about computing. *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences*, *366*(1881), 3717–3725.

Trading Realizations: Finding ways to assess people's progress in unraveling a complex trading game

Vishesh Kumar,
University of Wisconsin-Madison,
vishesh.kumar@wisc.edu

Keywords: complex systems, economics, data mining, analytics

Abstract:
Frequently, well designed games represent complex systems with meaningful embedded problems for players to solve (Shaffer; et al, 2004). These "solutions" of complex systems, transpire in a variety of ways. They are often marked by realizations regarding phenomena that emerge in the game, as a result of the system's rules/structures, and the participants' strategizing and interacting with the same (Berland, 2008).

At the same time, these realizations are not necessarily reflected as immediate, visible changes in the participants' actions. Such understanding is often a gradual developmental process. Thus, we can make digital games that make it easy to collect data and track players'/learners' actions. But people's realizations aren't easily visible in the logs of their actions.

To this end, we want to find ways to look at telemetry data that enable us to see people's many realizations, learnings, and changes in behavior, while engaging with meaningful complex systems. The breadth of possible realizations, including more creative solutions, is further widened when such a system supports people interacting with each other – valuable skills of collaboration as well as interpersonal interaction are engaged and developed (Aragon, et al, 2011).

With these ideas and goals in mind, we designed a game called Lead Caravan, that involves teams of people managing 'markets' of resources, and the ability to trade resources with members of other teams. The different markets have different priorities (in terms of 'events' that happen to them, the resources they value, and the resources they can manufacture), and all teams compete to maximize the value of their market, by negotiating trades with others, and collecting the resources most valuable for them. The game interface does not show anything to the players, but their own markets and stockpiles – compelling them to talk and negotiate with others to overcome the lack of information, and move towards the desired state of greater profits. The mechanics of price changes give potential for ideas of economics to emerge from the players' discussions, strategizing, lending the game an authenticity of experience and meaningful learning.

The game will collect data of all the attempted trades between different people. We plan to organize runs of this game in spaces where we can also track different people's movements, and conversations, giving us richer data about who interacted with whom in the real world.
We plan to analyze the data to: a) identify what kinds of goals people strive for in this activity; b) what are the different kinds of events around which the evolution and development of their

strategies might be visible; c) and find ways to mine the data, including triangulating from the multiple streams, that can reveal markers of people making or failing to make progress.
This kind of data mining would be helpful for future designers and researchers of such interpersonal real-world activities – regarding ideas about which aspects of such complex games are successful in enabling learning and development of player skills, and which aren't. These data mining techniques can also be used to make such activities more productive in real-time, if they were used by facilitators who helped struggling learners make better sense of the game, and enabling more productive learning behaviors.

References

Aragon, C. R., & Williams, A. (2011, May). Collaborative creativity: a complex systems model with distributed affect. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1875-1884). ACM.

Berland, M. W. (2008). VBOT: Motivating computational and complex systems fluencies with constructionist virtual/physical robotics. ProQuest.

Shaffer, D. W., Squire, K. R., Halverson, R., & Gee, J. P. (2004). Video games and the future of learning.

"Repulsion is Hard to Understand!"
Learning about Chemical Bonding with the ELI-Chem Simulation

Asnat Zohar & Sharona T. Levy
University of Haifa, Faculty of Education
asnat3@gmail.com; stlevy@edu.haifa.ac.il

Keywords: Chemical bonding simulation, Embodied learning, Intuition

Abstract:
This work seeks to solve one of the basic problems in learning about matter: understanding the chemical bond as dynamic equilibrium between attraction and repulsion forces. This abstract and non-intuitive topic is difficult to grasp as there are no examples or analogues from everyday life of both attractions and repulsions happening simultaneously (Taber & García Franco, 2009). Normal teaching often misleads by: presenting chemical bonds as different categories (e.g. ionic, covalent) without relating to the shared principles underlying all bonding; explaining chemical stability of molecular structures using the 'octet rule' heuristic (i.e. with eight electrons in the outer shells) rather than the more fundamental balance between electrostatic attractions and repulsions (Nahum et. al, 2007; Taber & Coll 2002). The theoretical framework is based on embodied cognition theory (Barsalou, 1999) by relating conceptual learning to intuition development through repeated and varied bodily experiences (Fischbein, 1987). The working hypothesis is that learning chemistry as a complex system based upon a simple set of electrostatic interactions and direct bodily physical manipulation, removes some of the abstraction and makes such understanding deeper and more accessible to many more learners. To this goal, we designed and developed the ELI-Chem environment - Embodied Learning Interactive simulation-based environment. It enables interactions with atoms while observing the attraction and repulsion forces. Students select an atom, drag it across the screen closer and further away from another atom and experience the resulting forces and energy. The study uses qualitative methods with 14 high-school advanced-level chemistry students in a pretest-intervention-posttest design, capturing students' gestures and articulations. During the pre- and post-interview students were asked to describe verbally chemical bond and related concepts while gesturing. Our findings show that before intervention, students don't consider repulsion forces when reasoning about the chemical bond, a new finding in describing conceptual understanding in chemistry. Learning about bonding with the ELI-Chem environment helps students shift from a naïve perception of bonding as static attached atoms to the more scientific perception of balance between attraction and repulsion forces. This shift occurred for both sensory-motor perception as accessed through participants' gestures, and for conceptual understanding based on their articulations. Gestures were changed from static touching fists to oscillating motion around an equilibrium distance. Articulations were changed from explanations based on the 'octet rule' depicting the atoms as static "touching" balls, to considering the role of repulsion and the dynamic balance between attraction and repulsion forces. Moreover, after working with ELI-Chem environment students were able to apply their understanding and explain why their naïve example of magnet isn't a good example for bonding. Learning with ELI-Chem

overcomes two persistent hurdles in learning about the chemical bond that have been highlighted by several leading chemistry education researchers: (1) chemical bonds result from *attractive and repulsive* electrostatic forces; (2) a chemical bond is most stable when attractive and repulsive forces are equal and energy is minimal. The study also contributes towards the development of learning theory by incorporating intuitions and sensory-motor knowledge in frameworks that describe conceptual learning.

References

Barsalou, L. W. (1999). Perceptions of perceptual symbols. *Behavioral and Brain Sciences, 22*(04), 637–660.

Fischbein, H. (1987). *Intuition in science and mathematics: An educational approach* (Vol. 5). Springer Science & Business Media.

Nahum, T. L., Mamlok-Naaman, R., Hofstein, A., & Krajcik, J. (2007). Developing a new teaching approach for the chemical bonding concept aligned with current scientific and pedagogical knowledge. *Science Education*, *91*(4), 579–603.

Taber, K. S., & Coll, R. K. (2002). Bonding. In *Chemical education: Towards research-based practice* (pp. 213-234). Springer Netherlands.

Taber, K. S., & Garcia Franco, A. (2009). Intuitive thinking and learning chemistry. *Education in Chemistry, 46*(2), 57.

Learning in a Community of Practice: Legitimate Peripheral Participation and Identity Development in a Living-Learning Community

Andi M. Rehak
Indiana University
amstrack@indiana.edu

Keywords: communities of practice, higher education, ethnography

Abstract:

The notion of *communities of practice* (Lave & Wenger, 1991) has been a part of the discourse on learning for over three decades. Participants become members of a community through *legitimate peripheral participation*, moving towards fuller participation in the practices of the community (Lave & Wenger, 1991). The community and its practices are constantly under construction by participants as they jointly negotiate what it means, or looks like, to be a member of the community. Learning occurs as participants become enculturated into a community of practice (Brown, Collins, Duguid, 1989).

This study examines a particular community of practice situated in a university residence hall. Learn-Lead is a Living-Learning Community (LLC) comprised of approximately 42 first-year college students and 12 upperclassmen. The first author is one of the three staff members that leads the community. The 54 students live together on one floor of a suite style residence hall and participate a 1-credit seminar and in extracurricular activities together. Learn-Lead events and seminars address issues of equity and social justice in education. Becoming, and being recognized as, a member of a particular university requires participation in particular practices, or ways of “being.” Learn-Lead activities are intended to enculturate students into the immediate Learn-Lead community and simultaneously into the University community by providing them with opportunities to legitimately peripherally participate.

This ethnographic study addresses the overarching research question: What is the process of becoming (or not becoming) a member of Learn-Lead? Additional guiding research questions are: (a) What are the shared practices of the Learn-Lead community? (b) How do these practices change across the school year on an individual and community level? (c) What features and practices support (or impede) legitimate peripheral participation? Through examination of Learn-Lead from a communities of practice perceptive, the understanding of communities of practice can continue to deepen and broaden, while simultaneously building on the higher education literature to contribute a more nuanced understanding of learning in LLCs.

Researcher observations, interactions with students, and fieldnotes are the primary sources for data, additionally semi-structured interviews are to be conducted and the beginning and end of the school year to directly capture students’ thinking and allow for member checking. Data collection and simultaneous analysis will begin August 2016. Pilot interview data conducted in the spring of 2016 suggest students take up the identity of being a “Learn-Lead student” in a variety of ways. Additionally, not all students believed their Learn-Lead peers actually desired to become fuller participants in this community of practice. One pilot participant articulated how education majors were much more interested in attending and organizing optional Learn-Lead events and that with an influx of non-education majors excitement and interest had waned and even caused problems for the community. The intention of collecting a full school year’s worth of observations and strategically times interviews is to capture the

trajectories different students' legitimate peripheral participation either in, or as tangential to, the Learn-Lead community of practice and to also address how students' identities are tied up in their participation.

References

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*(1), 32–42.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. New York, NY: Cambridge University Press.

Epistemic Network Analysis Workshop

Brendan Eagan, Zachari Swiecki, Golnaz Arastoopour, and David Williamson Shaffer
University of Wisconsin-Madison, Department of Educational Psychology – Learning Sciences
beagan@wisc.edu; swiecki@wisc.edu; arastoopour@wisc.edu; dws@education.wisc.edu

Keywords: educational research methods, educational data mining/learning analytics, complex thinking, discourse analysis

Proposal:

Learning in the 21st century means thinking in complex and collaborative ways that are situated in a real world context. Epistemic Network Analysis (ENA) is a method of modeling complex thinking and collaboration. This workshop will introduce participants to ENA and how they could use it in their own research.

A central premise of ENA is that complex thinking is characterized by a network of discourse connections in a domain. By modeling patterns of connections in discourse, ENA can help researchers quantify and visualize the development of such connections over time for individuals and groups, compare networks between different people or contexts, create trajectories for the development of expertise, and model the contribution of individuals to group discourse.

Although originally designed to assess epistemic frames—collections of skills, knowledge, identities, values, and ways of making decisions—in virtual game environments, ENA is now being used broadly to quantify the structure of connections that constitute complex thinking in various contexts. Some examples include large-scale datasets and log files of many kinds, including but not limited to chat, email, actions online, surgical performance, as well as brain scan data.

The goal of this workshop is to introduce the use of ENA, including the theoretical and methodological underpinnings of ENA, and use of the online ENA toolkit available at epistemicnetwork.org. Participants will be able to create accounts and perform analyses with their own or sample data during the workshop. Additionally we aim to develop a broader community of users and, as a result, create opportunities for the advancement and improvement of ENA. Ongoing support will be available following the workshop.

ENA was developed with learning sciences graduate students in mind by learning sciences graduate students. Workshops of this type and scope have been successfully run by this group of facilitators who have extensive experience using and teaching researchers and graduate students to use ENA.

Data Visualization for the Learning Sciences: Perceptual Principles and Prototyping for Presenting Your Data

Sarah White, Steven Franconeri & Bruce Sherin
Northwestern University
sarahwhite2020@u.northwestern.edu; franconeri@northwestern.edu; bsherin@northwestern.edu

Keywords: data visualization, perception, graph comprehension, presentation skills

Proposal:

In the learning sciences, we often deal with unconventional or unwieldy data – for example, changes in or comparisons of qualitative codes of interviews, mouse-clicks, or external representations from several students over the course of a week-long curriculum – that cannot be easily summarized into APA-style bar graphs. So how should we display our data so that we can find the most interesting patterns, and so that those patterns will be clear to our diverse audiences?

In this workshop, attendees will 1) learn research-based perceptual principles for creating data visualizations and gain hands-on experience in applying these principles to learning sciences data.

In the first part of this workshop, I will present research and examples from my own work and the work of several others in visual cognition (e.g., Gleicher, Albers, Walker, Jusufi, Hansen, & Roberts, 2011; Knaflic, 2015) about principles that govern the comprehension of data visualizations, both simple and complex. From eye-tracking and think-aloud data during experiments (e.g., Michal, Uttal, Shah, & Franconeri, 2016) to discourse analysis of students' collaboratively processing graphs in classrooms (e.g., Kramarski, 2004), several researchers have been working to explain why and how certain aspects of data visualizations facilitate graph comprehension. The findings from this work have practical implications for how learning scientists present their data at conferences and how they design data visualizations for learning environments.

In the second part of this workshop, attendees will apply these principles to learning sciences data. To ensure a well-structured and efficient workshop, the application portion will focus primarily on presenter-supplied data, but efforts will be made to gather examples of data visualizations from attendees before the workshop as well. This will make the workshop both more personalized and interesting for each attendee as well as showcase research representative of our community. Attendees will apply the content learned from the first part of the workshop by prototyping hand-drawn sketches on poster paper with colored pencils. Due to time constraints, instruction on how to use more advanced data visualization programs such as Tableau and D3 will not be provided, but recommended resources for further learning will be included at the end of the presentation.

As a result of this workshop, graduate and post-doctoral students and professors alike will gain new skills for visually analyzing and presenting their data. Additionally, through the workshop's planned cooperative activities, they will expand their professional network, which will engender research and design collaborations on data visualization in the learning sciences.

References

Gleicher, M., Albers, D., Walker, R., Jusufi, I., Hansen, C. D., & Roberts, J. C. (2011). Visual comparison for information visualization. *Information Visualization*, *10*(4), 289-309.

Knaflic, C. N. (2015). *Storytelling with Data: A Data Visualization Guide for Business Professionals*. John Wiley & Sons.

Kramarski, B. (2004). Making sense of graphs: does metacognitive instruction make a difference on students' mathematical conceptions and alternative conceptions?. *Learning and Instruction*, *14*(6), 593-619.

Michal, A. L., Uttal, D., Shah, P., & Franconeri, S. L. (2016). Visual routines for extracting magnitude relations. *Psychonomic bulletin & review*, 1-8.

How to Define Input and Output Data and Create Rules for Artificial Intelligence Models to Build Personalized Learning Paths

Aybuke G. Turker, aybuke@nyu.edu

Keywords: personalized learning paths, artificial intelligence

Goals and intended outcomes of the workshop. The goal of this workshop is to better understand how to define the input and output data and establish rules to train Artificial Intelligence (AI) models to create personalized learning paths. The intended outcome of the workshop is to be able to imitate the expert process of creating learning paths for individuals they know. At the end of the workshop we will be able to create different learning paths with the input data, output data and rules for the model.

Relevant theoretical background. Past research demonstrates that an increase in interest among researchers and practitioners to study artificial intelligence in education (Santos, Kravcik, & Boticario, 2016). One of these research areas is to build personalized learning paths. Although similar work has focused on creating individualized learning paths (Chi, Chen & Tsai, 2014, Pirrone, Cossentino, Pilato, Rizzo & Russo, 2005), they use different methodologies. With this workshop, the author is proposing a new methodology and implementing it with the audience. Her methodology emphasis the importance of having learning scientists and educators throughout the process of building AI-based personalized learning systems so that we can imitate the experts' process of creating learning paths then use this knowledge while creating rules for the models.

Brief description of the workshop. In this workshop, the organizer will ask participants to create a quick learning path on a topic they are comfortable with teaching for someone they know. They will be provided with a template Excel file.

The agenda for the workshop:

- Introduce the Topic (5 Minutes)
- Hands-On Activity (45 minutes)
    - Create a learning path on a topic provided to someone you know individually.
    - Combine the learning paths you created with your group and create rules
    - Combine each groups' artifacts and create rules collaboratively
- Discussion (10 minutes)

Author's experience and expertise with the content of the workshop. The workshop organizer is currently a part of a multidisciplinary team as a learning scientist and data scientist. She creates the input data and output data and is involved in building the rules for the models. By running this workshop, the organizer aims to have other learning scientists go through the same process as she does and encourage them to work with multidisciplinary teams that will lead them to breakthroughs in education.

Sample pitch to encourage participation. If you are working with multidisciplinary teams with data scientists and machine learning experts or if you plan to work with them in the future, this is for you. The workshop will give you plenty of hands-on experience in creating input and output data for AI systems while also encourage you to think through your teaching process to create rules for AI models.

Required materials. Each participant should have their own computer. The workshop room should have a whiteboard.

Anticipated audience. This workshop plans to have up to 20 participants. Participants will be working individually in the beginning then will be working in groups of 5 for the second round.

References

Chi, Y. L., Chen, T. Y., & Tsai, W. T. (2014, June). Creating individualized learning paths for self-regulated online learners: An ontology-driven approach. In *International Conference on Cross-Cultural Design* (pp. 546-555). Springer International Publishing.

Pirrone, R., Cossentino, M., Pilato, G., Rizzo, R., & Russo, G. (2005, June). Discovering learning paths on a domain ontology using natural language interaction. In *International Conference on Industrial, Engineering and Other Applications of Applied Intelligent Systems* (pp. 310-314). Springer Berlin Heidelberg.

Santos, O. C., Kravcik, M., & Boticario, J. G. (2016). Preface to Special Issue on User Modelling to Support Personalization in Enhanced Educational Settings. *International Journal of Artificial Intelligence in Education*, 1-12.

Traditionally Feminine Textile Crafts in the Math Classroom: A Hands-on Exploration

Sophia Bender, Anna Keune, Naomi Thompson
Indiana University
sobender@indiana.edu, akeune@indiana.edu, naothomp@indiana.edu

Keywords: mathematics, crafting, hands-on, design, women in STEM

Proposal:

The purpose of this session is to explore how traditionally feminine crafting practices (e.g., sewing and weaving) can engage mathematical thinking. This workshop presents data from the Recrafting Mathematics project, which examines women's sustained participation in mathematics by studying women's crafting activity, and build on those instances of success to explore how to incorporate these practices into the institutional contexts from which women often depart. Our research questions target the mathematical practices inherent in crafting traditions, and the mathematical reasoning of expert crafters as they engage in sustained practice. We draw upon Papert's theory of constructionism, Lave's "everyday math," and theories of embodied cognition to explain how these tangible materials help crafters to seamlessly incorporate math into their work.

We will begin the workshop with a brief overview of ethnographies from the Recrafting project that focused on the key practices, materials, and activities that connected in profound ways to mathematical activity. We will then divide into two interactive groups that will explore: 1) the complex work of 2D-3D transformations that arise in sewing; and 2) the mirroring and reflection that occur in fabric manipulation. These interactive groups will then rejoin as a whole session to discuss the connections between mathematical problem solving and design-based thinking that emerged through the creation of small projects, and to provide feedback as we continue to iterate these activities. We will bring all required fabric, needles, thread, yarn, and looms. Across this session, our core focus will be on highlighting potential for engaging students and educators in mathematical thinking through hands-on crafts, an approach that leverages a range of mathematical ideas to provide middle- and high-school-age youth with new tangible manipulatives as "objects-to-think-with" in mathematics education. As we work to move these activities from the pilot stage into classrooms, we hope that new perspectives from the LSGS community will help to push our thinking and enhance the activities in future implementations. We expect to attract anyone interested in middle or high school math education and/or in hands-on project-based learning.

Sample pitch: The low participation of women in STEM is a well-known problem. But while hands-on projects that may spark more girls' interest are common in science, technology, and math, there are few equivalent efforts in math, especially at higher levels. This workshop explores the math inherent in traditionally feminine textile crafts like sewing and weaving, and considers how these craft materials could be moved into middle and high school math classrooms. Join us in sewing a doll's skirt, or folding a fabric pinwheel, and help us think through how these projects could fit into schools. You'll leave with your own small craft to take home, and a whole new perspective on math class! We welcome anyone interested in grade 6-12 math education, both formal and informal, as well as anyone interested in learning through making!

The Learning Sciences: Figuring out what it means together

Lauren Vogelstein
lauren.e.vogelstein@vanderbilt.edu
Vanderbilt University

Keywords: learning sciences, graduate students, communities of practice

Proposal:

"I'm getting my PhD in Learning Sciences,"
"What's that?"
"…"

This is a common conversation that many Learning Sciences graduate students have at family gatherings and cocktail parties. This can be frustrating for many reasons. First, it can be difficult because when you are immersed in a Learning Sciences community, it can be hard when it feels that nobody else speaks your language. However, this seems to be a problem in academia across disciplines, communicating seemingly niche expertise can be difficult and scholars have struggled with this for a long time. The second reason is that our answers are constantly evolving as our understanding of what the Learning Sciences entails is also constantly evolving. While being a part of an emerging field is exciting and inspiring, it can also be confusing and frustrating. Departments are made up of scholars with diverse backgrounds ranging from computer science to anthropology, using methods and norms that are still being defined. As a graduate student, I have had many conversations with my peers about how we view the field we are in and what it means to practice in this community of practice (Wenger, 1998). As the Learning Sciences Graduate Student Conference seeks to bring graduate students together from Learning Sciences communities at universities across the country, it creates an opportunity for us to come together and start a conversation about the community we are all a part of as we shape its future.

The goal of this workshop is to gather graduate students from multiple Learning Sciences programs to discuss what it means to be a Learning Scientist in this new and innovative field. The workshop will begin with a brainstorming session in the spirit of IDEO (Kelley & Littman, 2001) in which participants will be given post-it notes and markers and asked to write down as many attributes or facets of the Learning Sciences as they can in 5 minutes, with a goal of 50 aspects each. Participants will be encouraged to ground their definition in something concrete related to their research. Then participants will be broken up into groups of 3-4 dispersing students from the same university so that each group contains representatives from multiple universities. These small groups will be given 30 minutes to share their brainstorms and look at any patterns that might emerge within their submissions as they share the varying facets each participant sees as critical to the Learning Sciences community. Finally, each group will share with the entire workshop, as a larger discussion of emerging patterns will take place. The hope is that through creating a grounded definition, connections may emerge pointing the way towards a shared definition of LS from the group. In bringing together young scholars to share their perspectives of the field of Learning Sciences, institutional knowledge, and specific research interests, we can expect attendees to gain a richer, broader, and more operationalizable view of

Learning Sciences, both to shape future research agendas as well as respond to cocktail party conversation.

References

Kelley, T., & Littman, J. (2001). *The art of innovation: lessons in creativity from IDEO, America's leading design firm* (1st ed.). New York: Doubleday (Chapters 3,4, & 6).

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge university press.

Antropology: Netlogo Digital Sandboxes for the Classroom with Ants

Kit Martin
Northwestern Univsersity
davidmartin2015@u.northwestern.edu

Keywords: Sociocultural learning, Complex thinking, Computational methods, Computer-supported collaborative learning, Game-based learning, K-12, Online learning

Proposal:

Goals and intended outcomes of the workshop

This workshop is more PhD skills based with room for a brainstorm session for new projects that use the presented models as thinking frameworks. It was inspired because I think workshops should be skills based, but could for sure be used in a brain stormy way. Like a "here's how to use this cool tool what would you want to use it for."

In this workshop, will I present two models, ("Cool Tools") using NetLogo Web, as presented on www.antropology.org. Once the demonstration is complete we can expand on these models and discuss how we would use ant models to teach other social science content.

Relevant theoretical background/frameworks

Research has shown how complex systems thinking will be required to face 21st century challenges (Jacobson and Wilensky, 2006). To assist meeting this need in social science, we have designed a digital sandbox, Antropology, with social behavior at its core. The product is built from off the shelf, free software (HTML, JavaScript and NetLogo). Antropology is a multimodal expression of how to develop science, and then share back the models on an online affinity space (Gee, 2006; Gee & Hayes, 2011). Each model has both scaffolded material, and aims to teach core concepts about sociality in through ants.

Brief description of the workshop

This is a NetLogo programming workshop that uses two ant models as demonstrations. The workshop will consist of an exploration of one of two ant simulations. First, we'll look into the base models, then as a group we'll discuss possible extensions of the models, and then we'll work through implementing those extensions to the base models, upload those to Antropology.org and shared with the world in the affinity space.

Your experience and expertise with the content of the workshop

I have taught 500 people how to program in NetLogo, mostly using ant models as the demonstration model.

Sample pitch to encourage participation

Ants are the premier organism in most ecosystems worldwide. Understanding how ants accomplish foraging and resource use helps students conciece of complex systems through the modelling of a remarkable, yet familiar system. By becoming more familiar with this system, and thinking through how teachers use it, while constructing our own models, we'll be tackling several interesting aspects that go into modeling in the classroom as a core means of learning science content.

Required materials
Individuals with Laptops with NetLogo installed.

Anticipated audience
Researchers with an interest in implementing NetLogo models for their intervention. People interested in participating in an Affinity space based around ants.

References

Gee, J.P. (2005). Semiotic Social Spaces and Affinity Spaces: From *The Age of Mythology* to Today's Schools. In D. Barton & K. Tusting, *Beyond Communities of Practice* (pp. 214-232). Cambridge University Press.

Gee, J. P., & Hayes, E. R. (2011). *Language and learning in the digital age*. Routledge.

Jacobson, M. J., & Wilensky, U. (2006). Complex systems in education: Scientific and educational importance and implications for the learning sciences. *The Journal of the learning sciences, 15*(1), 11-34.