is a form of problem posing. In the iterative and cyclical design activities, I believe that Herr’s students frequently use the results of their problem solving actions to re-formulate problem conditions and individual goals. After developing their initial designs, through feedback and further reflection via problem solving and problem posing they advance their understandings of structures and create more formal design models by the end of the course. In this way, problem posing and problem solving co-evolve. Victor Cifarelli & Volkan Sevim (in press) have examined this dynamic process in the field of mathematics education.

« 4 » One possible line of research, then, that could provide insight into how students might develop personal goals and understandings within the design-based open-ended tasks is the examination of how problem solving and problem posing co-evolve (Cifarelli & Sevim in press). Edward Silver (1994) has referred to with-in-solution problem posing as “problem formulation or re-formulation [that] occurs within the process of problem solving” (Silver 1994: 19). In this way, we may refer to the solver’s problem formulation or re-formulation as the development of a set of goals and purposes that he or she is trying to achieve at any point in time. As problem solving progresses, the solver may continue to re-formulate the problem based on his or her interpretations of the results of his or her actions. Thus, problem posing could be viewed as a form of sense-making that helps to organize the solver’s on-going creation of goals and purposes throughout problem solving.

« 5 » For example, in the target article Herr clearly illustrates how design-based drawing exercises present opportunities for individual exploration and self-directed learning (§12). According to Herr, the presented design-based pedagogy differs from that of conventional statics, where teachers often give their students formulas and structural elements as problems that can be solved correctly (§2). In contrast, the employed design-based exercises resemble the experiences of architects, in which an architect is challenged to develop individual solutions to problems in an on-going fashion using existing knowledge. Central to this problem solving and problem posing activity is the solver’s experiences of a problematic situation. According to Gordon Pask (1985), these situations are phenomena within which individuals actively formulate particular problems they see fit to address and solve. The solver may assimilate situations using existing concepts and establish particular goals, but the solver may be yet to construct solution paths to reach the goals (Steffe & Cobb 1988). Thus, on-going creation of (sub) goals and purposes throughout problem solving ensue, and the solver progressively makes better sense of the problem and its possible solution (Cifarelli & Sevim in press). As demonstrated in the target article, requiring students to develop a visualization, express it by means of a drawing, and annotate the drawing with individual thoughts and explanations offer valuable opportunities for reflection. Herr notes that in-class case studies and reviews, and immediate feedback on initial drawings, help students to make further revisions and thus make progress in their problem solving. Examination of the co-evolution of problem posing and problem solving within individual students’ drawing activities can further provide insight into their reflections about structures and materials.

« 6 » Above, I offered a possible lens for examining students’ activity and learning in order to refine teaching interventions that promote and support intrinsic motivation, self-generated activity, and increasingly viable organizations of experience. Such focus on students’ individual goals and problem formulations is closely linked to Ernst von Glasersfeld’s radical constructivist epistemology, in that knowing is viewed exclusively as an ordering and organization of one’s world constituted by experience (Glasersfeld 1984). Self-generated questions (during problem solving) can help students to place the current problem in a broader perspective and thus expand its scope. This expansion of scope can further help students engage in unexpected generalizing activity that is rooted in students’ own goals and purposes (Cifarelli & Sevim in press). Thus, the presented line of research within the target paper could be extended by examining how individual students’ goal-directed activities evolve in the context of problem solving within design tasks and transform their understanding of structures.

Volkan Sevim is an assistant professor of mathematics education at Virginia Commonwealth University. His current research examines the co-evolution of problem solving and problem posing in the context of actual solution activity. Prior to being a faculty member, he taught upper level mathematics courses at a public high school in Charlotte, NC, for five years.

Received: 13 June 2014
Accepted: 16 June 2014

Forging a Constructivist Pedagogy: Focus on Teacher Decision-Making

Brian R. Lawler
California State University San Marcos, USA
blaw0013/at/gmail.com

> Upshot: In this comment, I take Herr’s proposition for a constructivist-informed pedagogy for structural design education to extract initial ideas for a framework for a constructivist pedagogy, a framework focused on the decision-making of a constructivist teacher. I enhance this initial framework with initial findings of a study I conducted with a constructivist mathematics teacher.

« 1 » In taking up the challenge to teach the professional knowledge characterizing the field of structural design, Christiane Herr examined in her target article how a pedagogical approach that may emerge from a radical constructivist theory of knowing and learning may improve personal and active attitudes toward what was learned. Herr reports a schism between how the technical and creative knowledge used in structural design are taught: the first following an instructionist pedagogy (Herr names this a science-based approach, or a transactional view of learning), versus a more personalized and applied mode of learning in the latter, which she suggests to be a constructivist pedagogy. I found this paper surprisingly relevant to my field as a mathematics educator, in particular with regard to efforts to theorize a constructivist pedagogy for the schooling environment, which val-
ues a particular set of technical knowledge in addition to a disposition toward mathematical creativity, intuitiveness, or insight. At present in the U.S. context, these two dimensions of the goals of mathematics education are evident in the Common Core State Standards for Mathematics\(^3\), distinguished as standards for content knowledge and mathematical practice. As in structural design education, the traditional pedagogy in mathematics has reflected a belief that knowledge can be delivered in a one-directional modality. This school-based practice seems to contribute to a cultural myth that assigns a transcendent nature to mathematics, that it is a knowledge that is universal, having an existence prior to the knower. Of course, constructivism would not take such a stand on the ontological status of knowledge. Further, constructivism reminds us that whatever the pedagogical activity enacted by the teacher, students learn as they (or preferably, their minds) organize their experiences of the classroom.

Herr presents the strategies and rationales she developed to teach the technical knowledge associated with structural design, in which she draws upon teaching strategies that seem to elicit student creativity and engagement. For the purpose of this commentary, I analyse Herr's constructivism-influenced instructional strategies to begin to formulate what might be a constructivist pedagogical theory. A constructivist pedagogical theory would not report only teaching behaviours. There are no particular teaching behaviours that cause learning in others more than nutrients cause a plant to grow (Steffe 1991). There may seem to be some instructional strategies, such as increased student-student interaction and problems that induce puzzlement, that seem to cause student learning. Such teaching strategies can create occasions for students to act or interact, but is it not the actions or interactions of the students that induce learning? In other words, teaching strategies that are often associated with constructivist learning may be better considered as providing the teacher with opportunity to gather empirical evidence on which to base their own learning of student learning and/or to inform their own decision-making on how to act.

Previous efforts to theorize a constructivist pedagogy often reflect a trivial (Glaserfeld 1989b: 162) or soft (Larochelle & Bednarz 1998: 3) constructivism, in which the second principle of constructivism is not embraced. In trivial constructivist pedagogies, the educational goal and acts of teaching treat knowledge as if it is external to the students then transmitted to students by means of the language and actions of the teacher or learned through some sort of guided discovery. Trivial constructivism is an inadequate if not dangerous epistemology (Lawler 2012), in which teaching is primarily an effort to transmit knowledge to students rather than to provide occasions for students to generate their own knowledge. Such an educational goal is not commensurate with a constructivist view of teaching. In the case of mathematics education:

Our goal should not be to transfer cultural knowledge to children in the particular way that we understand it. Rather, our goal should be to learn how to engender children's productive mathematical thinking and how to build explanatory models of that thinking.\(^6\) (Steffe 2007: 282)

To comment on Herr's target article, I draw upon her reflections to theorize a constructivist pedagogy. To do so, I first seek to determine to what extent I ascribe constructivism to be the personal epistemology of Herr as teacher. Second, I begin to generate models for the ways of thinking and knowing that I attribute to what Herr identifies as teaching actions. In other words, instead of naming constructivist teaching behaviors, I attempt to identify qualities of the decision-making of a constructivist teacher. However, evidence from Herr's article suggests that her personal epistemology (Larochelle & Désautels 1991; Muis 2004) may not be constructivist.

Herr's personal epistemology

Herr never self-identifies as a constructivist; rather, her writing discusses application of a constructivist theory of knowing (cf. §§3–6), an idea seemingly held external to her. When Herr does explicitly discuss constructivist ideas about learning, teaching, and goals for schooling, she occasionally attributes an external ontological status to them. For example, in her effort to emphasize the recognition that intrinsic motivation may be fostered by feelings of insight, Herr stumbles when she says, "the teaching approach presented in this paper seeks to motivate students intrinsically" (§6). The statement resounds with a belief system in which the teacher can cause some sort of occurrence in the learner, antithetical to Leslie Steffe's (1991) nutrient analogy.

As a teacher, Herr does seem to embrace Steffe's (2007) charge to foster generative (architectural) thinking: she views "learning as an outcome in itself" (§10). Yet she does not seem to adequately trouble the teaching effort to transfer architectural knowledge: "I have emphasized design tasks to encourage individual engagement with the subject matter" (§12). It seems as though Herr retains the view that a cultural knowledge is to be transferred to the student.

Again in §12, Herr embraces the activity of design because it requires students to become aware of a framework for their decision-making that "serves to integrate various concepts into a coherent understanding." For the constructivist, concepts learned would have been generated within a coherent understanding at the outset, one coherent to the knower.

Lastly, Herr concerns herself more with reporting outcomes achieved rather than on building explanatory models for how students were thinking (Glaserfeld 1989b; Steffe 2007). Herr comments that "such inferences may be of little use in a class of 200" (§9). This idea doesn't, per se, strike me as contradictory to the reasoning of a constructivist and what Herr might elect to report in this paper – it is quite pragmatic in many ways. Herr left this contradiction unresolved, and I shall leave it as an open question. I recognize that my interpretation of one paper is an inadequate and unfair measure of Herr's personal epistemology. Statements that appear contradictory with those I would attribute to a constructivist should not be taken too strongly; our present language and expectations for communication are constractive toward expressing post-epistemological (Noddings 1990) views on knowledge and knowing. However, since Herr sees her teaching decisions as influenced by constructivist principles, I do

---

extend the analysis to phase two, to identify her ways of thinking, in particular decision-making, that might inform a model for constructivist pedagogy.

**Herr’s instructional decision-making**

- **9** Given the many constraints of the learning environment, including class size, student-held expectations for learning, and tendency toward lack of interest in the field of study, Herr made many strategic decisions, framed by her taken-as-constructivist orientation toward knowing and course goals. I select two decisions for discussion, and use these to identify possible characteristics of a model for a constructivist pedagogy. It is not my intent to evaluate Herr’s teaching strategies as constructivist, rather to consider them as strategies of a constructivist teacher. Herr infused drawing-based exercises into the lectures. Herr saw this as the activity of practicing architects, and so asked her students to do the same. She recognized that architects develop their own thoughts while drawing and sharing results, ideas, and challenges with others – suggesting a recognition that students generate their own knowing, aligned with Steffe’s (2007) goal to engender the learner’s constructivist activity.

- **10** Herr argued that the drawing strategy reflected several qualities of constructivist implications for teaching, in particular the opportunity to engage in open-ended activity, rather than completing tasks with specific responses expected. Furthermore, failure was routine, and identified by the learner rather than through the gaze of an instructionist educator. Lastly, the opportunity to provide whole-class feedback on a few products and individually to all allowed Herr to encourage consideration of how students might proceed next. Feedback also informed Herr in her decision-making on what to teach next, what her class of students may be ready to learn. Amid these rationales, it is unclear if Herr had in mind to correct student misunderstandings of the knowledge she attributed to the field, or to evoke questions in the learner herself, questions that may be further generative.

- **11** A second instructional activity was to build a cardboard bridge. Herr wished students to experience structural design in action, seeking to increase student interest in the field. Similar to drawing tasks, Herr again reported intent to utilize open-endedness to create opportunities for interaction, failure, and public demonstration of ideas. Herr’s instructional decisions focused primarily on engaging her students in doing structural design. However, like Herr’s providing feedback on student work, her rationale for doing structural design seemed to focus on application or sense-making of the pre-determined knowledge of the discipline. This decision-making may be guided by what I suspect to be Herr’s soft constructivism.

- **12** Yet other of Herr’s rationales for the same tasks reflected Herr’s primary teaching goal, for students to find themselves, their own interests and ideas, in the content that constituted the coursework. Herr addresses this final idea when discussing authority for knowing. Piaget determined empirically that the developing child was on a path toward intellectual and moral autonomy, declaring the aim of education should be as such (Kamii 1984). Teacher decision-making regarding efforts to instill personal authority for knowledge in students seems well aligned to a constructivist pedagogy. Herr made intentional pedagogical decisions to shift students away from habits to look to textbooks or teachers for correct answers, toward reasoning and trusting their own conclusions.

**Mathematics teacher decision-making**

- **13** In my current research, I am analyzing a constructivist high school mathematics teacher’s activity with the intent to build a model for his decision-making. This teacher, Bryan Meyer, identified tensions between two sorts of educational goals, as did Herr. However, he recognized the tension differently; he wished to engage students in doing mathematics, concerned with how his mathematics interfered with or made possible this generative activity. In his decision-making, Meyer worked to refine the presentation of mathematical problems, concerned for the manner in which initial information was provided, the value of a context, and what role there was for examples. Similar to presentation, Meyer also considered providing hints or questions, concerned about the degree to which a task’s structure might foster divergence or convergence in students’ thinking. While divergence among student explorations could create opportunities for productive interaction, at times it seemed to be detrimental – students lacked the shared experience necessary to see their own ideas in those they attributed to others. Meyer considered to what extent can divergence be productive? Finally, Meyer often expressed the tension between what he intended for students to come to know and his desire to respect students’ constructed knowledge. He wrestled with what to do when his efforts toward collective ways of knowing proved illusive.

An **constructivist pedagogy**

- **14** To conclude I revisit the identified tension observed in many teachers between knowledge to be taught and the constructive activity of the learner. Herr recognized it between the distinct pedagogical traditions associated with the technical and design courses. In mathematics education, a naive view of the field draws similar parallels between content and practice standards. A constructivist’s perspective would not draw such a distinction, one on the nature of the knowledge constructed. The constructivist would express concern over their own mathematical ways of knowing and the mathematical knowledge attributed to students – Steffe’s (1991) mathematics for children and mathematics of children. Meyer addressed this tension explicitly, affirming his constructivist personal epistemology:

   **5** Cf. my presentation “The need for mathematics education to go the way of Latin: An epistemological and ethical justification” at the lecture series “Alternative forms of knowledge construction in mathematics” hosted by B. Greer & S. Mukhopadhyay at Portland State University, Portland OR, on 28 May 2014.

---

4 | Note: A different purpose than Steffe and D’Ambrosio’s (1995) attending to students to postulate a Zone of Potential Construction.
Meyer shared with Herr a concern regarding authority for knowing. It is evident that the decision-making framework of a constructivist pedagogy takes maintenance of student authority seriously (Lawler 2010; Meyer 1992: 443f).

While radical constructivist pedagogy is typically explicitly conceptualized and planned as such from the beginning, the teaching approach described in my target article has developed in a different manner. Starting from the more immediate challenge of teaching the module Structures and Materials in a qualitative manner to large cohorts of Chinese students, I have initially developed its pedagogy in an immediate and applied manner by gradually strengthening pedagogical strategies that seemed to support students best in their learning. In this process, I have come to realize that “viable” pedagogical strategies I developed in this manner are closely related to radical constructivist understandings of learning and education, and that I had independently arrived at a radical constructivist approach to education. Following this realization, I have more recently begun to develop the approach further by relying more explicitly on radical constructivist theory and research. The resulting teaching approach does not completely adhere to radical constructivist theory as it would have if it had it been developed as an application of theory. This offers a unique opportunity to ask questions that may not have been brought up otherwise. In the following, I briefly summarize and respond to the main themes addressed and developed in the open peer commentaries.

**Lecture-based teaching in radical constructivist education**

Several peer commentators support and extend my suggestion that lectures can form part of a radical constructivist approach to education. Victor Cifarelli (§11) notes that “lecturing remains a useful teaching approach in contexts where active learning is encouraged and supported.” Ben Sweeting (§7) states that “even the apparently monological format of lecturing to a large cohort can still be part of a dialogical structure for learning and teaching.” Both authors emphasize the relevance of establishing a social climate in the classroom that values and encourages the contributions of individuals in the learning process, as outlined in my article and as suggested by Ernst von Glasersfeld: “it is one of the primary duties of the teacher to create an atmosphere in the classroom that not only allows but is also conducive to conversation, both between student and teacher and among students” (1992: 443f). Sweeting (§10) suggests that the lecture format “can present an opportunity for a constructivist approach to work within the constraints of large cohorts,” and recommends having more than one teacher offering conflicting points of view to each other, or changing the spatial setting of the class for increased student interaction and enriched learning experiences generated by “chance occurrences.” A renewed discussion of the lecture format in a radical constructivist spirit may be a next step to be further developed among a broader variety of disciplines.

**Deferral of formal assessment and variety in types of feedback**

Cifarelli (§§6, 10) finds noteworthy that I have chosen to avoid formal assessment until the end of the course and to emphasize feedback rather than assessment. This strategy is part of the aim of cultivating and maintaining a social climate that values and encourages individual and self-motivated learning even in large cohorts, and is also commented on positively by Sweeting (§8), who contrasts my focus on “keeping the conversation going in students’ minds.”

**Author’s Response: The Productive Challenge of Large Cohorts in Radical Constructivist Education**

Christiane M. Herr

> Upshot • Responding to and further developing the points raised by the open peer commentaries, I discuss a range of themes, including possible roles of lecture-based teaching in a radical constructivist approach to education, approaches to the teaching of large cohorts in a radical constructivist manner, the role of assessment in students’ learning experiences, the distinction of “models of” student learning, contrasted with “models for” student learning, the distinction of literal conversation from an atmospheric conducive to conversation, and the use of design-based tasks to support and encourage students’ individual conceptual constructing.

Brian R Lawler is an associate professor of mathematics education at California State University San Marcos. He draws upon a constructivist foundation to build theory for an ethical mathematical education. He studies socio-epistemological problems related to both the teaching and learning of what may be named mathematical knowledge as well as the mathematical knowledge of the discipline. He writes curriculum for high school students and teachers.

Received: 18 June 2014
Accepted: 24 June 2014

http://www.univie.ac.at/constructivism/journal/9/3/393.herr