Facilitating competency development in sustainable agriculture and food systems education: a self-assessment approach

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Abstract

The need to develop students' professional and personal competencies via sustainable agriculture and food systems education has received much recent attention, yet implementing competency-based education is challenging. This paper demonstrates how educators can approach identifying and teaching foundational competencies and assessing their students' competency development. Using the case of a Food Systems class in an undergraduate Sustainable Agriculture and Food Systems major at a U.S. land-grant university, we discuss the philosophical and practical aspects of implementing competency-based education and analyze data from students' use of a competency self-assessment framework in 2009 and 2010. We demonstrate specific analyses that instructors can use for assessing competency development in other contexts. The analysis and results from the case, highlighted in depth, demonstrate that utilizing these types of competency-based frameworks provides rich opportunities for multiple analyses that can connect teaching practices to specific learning outcomes and objectives. The resulting detailed dataset allows for focused improvements of teaching practice, from specific elements to entire courses. More broadly, we conclude that competency self-assessments serve several important purposes, including communication of a commitment to learner-centered teaching, instructors' accountability to their own goals, and articulation with other parts of the curriculum.

Keywords

competencies; learning society; self-assessment; sustainability education; sustainable agriculture and food systems; transformative learning

I. Higher education and competency development for sustainability

Creating a sustainable agriculture requires us, as teachers and students, to be competent change agents, developing ourselves, others, and society beyond current unsustainable ways of being and relating in the world. We see the creation of a learning society, first envisioned by John Dewey, as necessary in the movement toward sustainability. Dewey's vision requires "decentralization of authority, democratization of the workplace, redistribution of wealth, strengthening of civil liberties, and the representative institutions essential to dissent and the diffusion of power" (Mezirow 1995: 66). To create a learning society, those involved "need, above all, to be able to articulate the purpose of their activity — where they are trying to get to, in a sense, their *values* — and be able to understand and influence social and political processes, legal systems, and cultural concerns, thoughtways, and assumptions" (Raven 2001b: 15). A learning society depends on active democratic citizenship, which itself rests on many core *competencies*, a concept we develop and empirically examine in this paper.

A great deal of ambiguity surrounds the concepts of "competency" and "competence" (Raven and Stephenson 2001). The U.S. Department of Education states that a competency is "a combination of skills, abilities, and knowledge needed to perform a specific task" (cited in Voorhees 2001: 8). More recently, with an emphasis on sustainability, Wiek et al. (2011: 204) define a competency as "a functionally linked complex of knowledge, skills, and attitudes that enable successful task performance and problem solving." Drawing upon these definitions, we expand it to explicitly include learning and values; for us, competencies are *individuals' functionally bundled knowledge, skills, and attitudes — developed through learning — that allow them to do the things they want, and are ethically compelled, to do.* As such, competency development is always already value-laden.[1]

The need to cultivate students' competencies in higher education for a more sustainable agriculture and food systems has recently received attention in the U.S. (APLU 2009, NRC 2009). The National Research Council (2009: 25, 40) notes,

> Urgent change is required in agricultural education … The change needed today is a refocusing on the undergraduate curriculum and student experience so that the agriculture graduates of tomorrow will have the skills and competences to meet the needs of a changing workplace and world … Among the competences that students should develop are teamwork and working in diverse communities, working across disciplines, communication, critical thinking and analysis, ethical decision-making, and leadership and management.

If our professional and ethical obligation to society and our students is to help cultivate these competencies through our teaching, how do we do so? It has long been argued that learning how to learn and participatory learning are at the heart of sustainable agriculture (Bawden 1996, Ison 1990, Pretty 1995). Yet, from an educator's perspective, it is difficult to translate these views into specific practice, especially because few faculty "receive any formal training in how to be effective teachers or are exposed to pedagogy, the science of teaching" (NRC 2009: 36). Additionally, focusing on competencies in undergraduate programs "has presented serious teaching problems" (Tribe 2001: 153); as teachers, we often design assignments that require certain tasks and hope that students' performance of these tasks will inculcate certain skills, but we rarely make attempts to explicitly teach the skills needed. Indeed, Raven (2001a: 163-4), a leading thinker on competencies for decades, notes that "a huge amount of research and development remains to be done to develop the concepts, understandings, and tools that are needed to identify, nurture, place, develop, and utilise high-level competencies." Teaching for competency development can be challenging and time intensive and, to make matters worse, most of us feel ill-prepared to do the work.

Addressing this challenge, the central problematic of this paper is *(1) how do we teach competencies that are foundational for democratic citizenship and the sustainability of agriculture and food systems and (2) how do we assess how well we are doing*? We share our experiences facilitating competency development in a Food Systems course taught at a land-grant university by focusing on data from students' competency self-assessments. Our goal is to give our readers a better understanding of why and how they might use competency frameworks and assessments in their teaching and curriculum development. We also aim to further stimulate ideas about foundational competencies needed in the sustainable agriculture community (NRC 2009, Wiek et al 2011) and democratic society generally.

II: A philosophical base: from behaviorism to critical pedagogy

At first glance, basing teaching on competency development might seem to be reductionist and springing from its roots in behaviorism. Behaviorism is a pedagogical approach based on providing extrinsic motivation in the form of rewards, incentives, and punishments. Behaviorism continues to dominate higher education classrooms today, although most who subscribe to it would not name it as such because of little intentional articulation between educational theory and teaching practice. Behaviorism tends to cultivate a set of competencies, although these are often anti-democratic in nature because they center on obedience and test-taking in a context of authority-set, and often hidden, priorities. Given this context, little to no deliberation occurs within classrooms, between students, and between students and faculty. Since behaviorism holds that "[t]here is no subjective element to learning — either in determining what to study or in how information is interpreted, used, or understood" (Boghossian 2006: 716), there is a lack of scrutiny about what matters most to study or the best ways to go about an inquiry. While competency-based education has in many cases been shaped strongly by behaviorism (Raven 2001b), it need not remain limited to behaviorist practice.

Instead of starting with behaviorism, we draw on Bloom (1956), who provides a framework for conceptualizing different forms of learning by expanding into aspects of the learner ignored by behaviorism. Bloom's taxonomy conceptualizes learning in three distinct domains: the cognitive, psychomotor, and affective. The cognitive domain refers to the process of acquiring content knowledge: memorizing, comprehension, application, analysis, synthesis, and evaluation. The psychomotor refers to the physical and mechanical skills associated with a particular discipline, such as production practices or data collection during fieldwork. Lastly, the affective domain consists of the attitudes and feelings that accompany the learning process and resultant identity. While Bloom's framework is somewhat mechanistic, it highlights the importance of integration between distinct parts of the learning process.

While the process of acquiring knowledge and skills (cognitive and psychomotor domains) is a standard focus for many adult agriculture education programs, e.g., with the focus on soil science or practical farming skills, less attention is given to developing the affective domain — attitudes and values — that enable learners to bridge the gap between knowledge and action (Boyd et al 2006, Lieblein et al 2007). For learning to be deeply meaningful and transformative, it must engage learners' feelings, values, and motivations (Novak 2010), which means that teachers must pay attention to the affective domain (Lindgren et al 2003, Tribe 2001). According to Lieblein et al. (2007: 40), "an important part of the learning process builds on a foundation of personal attitudes and individual growth." In order to focus on the affective domain and address the learning goals therein, Lieblein and colleagues created an affective learning ladder that parallels Bloom's cognitive learning ladder. Within this dual learning ladder, "in each dual step, the individual learns more about the world and its complexity but also more about personal values and attitudes in connection to society and the environment" (Lieblein et al 2007: 40). By going through the dual steps, the learner gains the confidence, values, and vision to move forward and apply knowledge in action.

In addition to linking the cognitive and the affective domains, drawing upon critical pedagogy can further enhance facilitation of students' civic and scientific competency development. Critical pedagogy can provide a space for the critical questioning necessary for student development since it actively problematizes the power dynamics in the classroom and social configurations generally, examines values and scrutinizes the subjective and objective aspects of civic and scientific work, and increases the priority given to learners' prerogatives (Weimer 2002). By openly communicating with students about competencies, including decisions about instructional priorities, instructors engage in a public act of critical self-reflection that cultivates a learning environment where students are challenged to question the knowledge and skills they are being taught, and also to question the interests and purpose behind the class as it is being presented. When given this open space for questioning, students are empowered to analyze their own interest in assigned tasks, and, most importantly, to evaluate their own ways of purposefully interacting with their education more broadly. Throughout this reflective process, students are in dialogue with the instructors and peers about assignments and content knowledge, and the way they are presented and their attitudes about them, thereby allowing for the building of both the affective and cognitive domains of competencies.

III. Competencies in a food systems course

This section briefly explains the strategies used for identifying competencies and facilitating their development in our course, CRD 20: Food Systems (hereinafter "the course"), is an interdisciplinary, lower-division, social science-focused core class in the Sustainable Agriculture and Food Systems major at the University of California, Davis for which Galt is the instructor of record (see also Galt et al in review). As an introductory course, it is open to first-year students and has no prerequisites. The class was designed based on social constructivist learning theory (Jonassen 1994) and as such is

student-centered and inquiry-based. An activity-intensive lab with fieldwork features prominently in the course.

The course develops competencies grouped into seven realms: Ways of Knowing and Learning, Understanding Values, The Inquiry Process, Analysis, Interpersonal Skills, Writing, and Presenting (see Supplemental Material). As educators and life-long learners,[2] we see this list as containing many of the important competencies of critically conscious, reflexive learners who become active knowledge producers committed to the process of improving the sustainability of the agrifood system. Galt developed the realms and their constituent parts by integrating his own priorities with those identified by (1) stakeholders in a participatory survey used to guide the design and development of the UC Davis undergraduate major in Sustainable Agriculture and Food Systems (Khanna et al 2004, Parr et al 2007, Parr and Van Horn 2006, Trexler et al 2006), which identify many of the specific challenges and opportunities students will face in careers related to agriculture and food, and (2) other competencies-for-sustainability frameworks (Link et al 2008).[3] Although developed independently, these realms also overlap considerably with many competencies identified by the National Research Council (2009) for agricultural education and the framework developed for sustainability education by Wiek et al. (2011).

As with all competency frameworks, a variety of other groupings are possible, there is overlap between the realms, and they are not all at the same level of complexity; yet, these groupings were chosen for their overall importance to the learning objectives for the course. We see the articulation between the competencies need for a specific subject area (in our case, agriculture and food systems), sustainability education, and higher education generally as being composed of three concentric circles (Figure 1). Using the competency realms from our class as a demonstration, The Inquiry Process and Analysis have to be tailored to the specific object(s) of analysis, so will focus on particular components of agriculture and food that need to be understood through various

approaches and methods.[4] Ways of Knowing and Learning, Understanding Values, and Interpersonal Skills fit well under sustainability education generally, while Writing and Presenting are competency realms important for more general learning in higher education.

INSERT FIGURE 1 HERE

We must note the relationship between students competency self-assessments and their formal course grades. We deliberated on the relationship for some time, and ultimately decided that the two must be completely separated, and that this must be made clear to the students. This decision was based on two main considerations: (1) tying grade performance to the self-assessments of competency development would incentivize inflation of the self-assessments at the end of the class; and (2) there is no essential connection between one's level of competence and one's grades, since the application of one's effort — regardless of how skilled and knowledgable one is — mediates how well one does on graded assignments. Thus, our practice has been to have students self-assess using the competency rubric, but with full knowledge that their responses are not connected to course grades.

To encourage students to participate in the learning activities designed to develop these competencies, it is essential to engage students' motives and interests from the outset, as discussed in the previous section. We do this through a number of strategies and activities. First, from the start of the class, using the framing of an invitation to engage (cf. Bain 2004), students are invited to engage with each other, the educator, the material, and the food system itself. At the beginning of the first class the instructor acknowledges that the students are adults who are present of their own volition and who are making the choice to participate in the class. Second, students' first tasks are to reflect on their personal histories related to the topic of food systems and to vote for lecture topics that are of most interest. Those topics with the least interest are either maintained (with the instructor explaining why) or exchanged for other topics in which the students are more interested.

These steps acknowledge and prompt students' awareness of the experiences and interests that they bring to the class and require them to take responsibility for their learning. The next task is the Food Diary assignment, where they must document their food choices and find out where, how, and by whom their food was made and how it reached them. This activity sparks awareness of the food system in relation to the most familiar and intimate context, one's own body and life, and prompts a common interest and community surrounding the desire to learn more about what enters one's body. Third, we organize active lab sections around social science methods to allow for this community to grow and interact. Labs feature six field trips in the course of ten weeks, which are 3-hour excursions to different locations in the food system that involve interviewing site hosts and observing the location and activities within it. For each trip, small student teams, guided by teaching assistants, are responsible for creating their own research questions and the interview questions to answer them. Student teams rotate responsibility for planning a field trip with the oversight of the teaching assistants. Each excursion allows students to pay explicit attention to values — theirs and others' — as they see how values connect to an empirical inquiry. Students usually spend every minute of these field trips, from the drive to the research locations to the debriefing afterward, talking with teammates, lab mates, instructors, and the site host(s). Fourth, since essay exams based on large, open-ended questions are available many weeks before they are due, much of class time and many one-on-one and group sessions in office hours are devoted to answering students' questions about various topics in the syllabus and the exams directly, so that the students can formulate their own answers to the exam questions.

These long periods of dialogue around various inquiries, in lab and lecture, create a dialogical relationship between learners in the class, including the instructors. This relationship is "*problem posing* because from the outset learners must begin to reflect on their co-participation in the process of knowing" (Morrow and Torres 2002: 130, original emphasis). Following Freire, the teacher takes responsibility for direction in posing the problems initially (Freire 1993: 50, cited in Morrow and

Torres 2002: 130). This does not mean denying that asymmetrical power relations distort communication in learning settings. To overcome these, identifying and problematizing unequal power are but the first steps. The focus then proceeds to stimulating "doubt, criticism, curiosity, questioning, a taste for risk-taking, the adventure of creating"(ibid.). Thus, Galt as an instructor seeks to establish a sort of *authentic authority* for spurring students' development in which leadership points the way, but learners turn this into a new form of autonomy (Horton and Freire 1990).

The strategies employed in the course, and the many student-directed inquiries in which they result (cf. Galt et al in review), tend to strongly motivate students' engagement because students are encouraged to use their own values and interests to drive much of their experience in the class. Competency self-assessments, the exam format, and the self-evident high amounts of work put into the lab and course design help Galt establish authentic authority in a class environment in which students are encouraged to pursue their interests. It is a "bounded freedom" of learner-centered, student-directed inquiry rooted within authentic authority.

IV. Methodology

A crucial step in freeing competencies from behaviorist philosophy, and its underlying ideology and practice of domination, is encouraging students to evaluate themselves. Self-evaluation is both an act and a philosophy stemming from critical pedagogy (Fernández-Balboa 2007). Self-assessments are also a practical necessity because assessing competencies externally is very labor-intensive for instructors. Regardless of practicalities, we maintain that self-assessments can be theoretically and pedagogically sound. Theoretically, students have the most unmitigated access to the data needed for the assessment because they can reflect on how well they do these things. This does not mean there is necessarily agreement between students' own evaluation and an external evaluation nor that they are free of self-deceptive perceptions. Rectifying these issues might be possible with external assessments via critical incident studies and attempts to ascertain validity and reliability. Yet,

pedagogically, self-evaluation is a competency in itself that can only be developed through practice, and one has to start somewhere. Thus, the key goal of increasing students' self-awareness (Weimer 2002) is achieved through the very practice of self-assessment. In this way, self-assessments are a learning and instructional activity in themselves, in addition to producing data with which to understand students' experiences and personal and professional development.

In the course, self-evaluation occurs in two complementary ways: students complete the competency self-assessment rubric at the beginning, middle, and end of the class (see Supplemental Material), and write a graded Reflective Essay about their learning process in the course (data is not analyzed here, but see Galt et al in review). Completing the competency self-assessment rubric involves students doing three things for each identified competency: (1) marking the "level of development" they identify with at the time, (2) identifying the activities and assignments that helped them develop that competency, and (3) indicating whether their understanding of the competency itself has changed over time.

Below we use the competency self-assessment data from the 2009 and 2010 class (Table 1). Before doing so, we note a few differences in the self-assessment rubric between 2009 and 2010, as the 2010 class reflected improvements in instructional practices based on feedback from the 2009 course. First, for the 2009 class, we used a simple level of development typology with minimal explanation and four steps: preparatory, intermediate, advanced, and mastery. For the 2010 class, Galt adopted the Dreyfus model of skill development, which has five stages — novice, advanced performer, competent performer, proficient performer, and expert (Dreyfus and Dreyfus 1986, Flyvbjerg 2001) — and wrote a 3-page explanation about the model that accompanied the self-assessment rubric (Galt et al 2010). Second, in 2009 students were not able to see their previous assessments, while in 2010 they used the same form (with all previous markings) for each of the three assessments and were thereby able to see where they placed themselves before. Third, one

competency changed on the rubric (see asterisk in Table 1). While these changes mean that some elements of the datasets are not directly comparable, the 2009 and 2010 datasets are similar enough to allow for the same type of analyses. We included both years to increase the robustness of the analysis.

INSERT TABLE 1 HERE

For data analysis, we quantified the level of development, giving each step a numerical value, e.g., preparatory = 1, intermediate = 2, etc. (Table 1) Means of each were determined for each competency in the self-assessment for each period of assessment (beginning, middle, and end). This quantification allows rankings and statistical comparisons in the form of t-tests made below.

V. Analysis of the competency self-assessments

Quantifying the competency self-assessments allows for many more analyses than presented here. We focus on the five specific questions below to demonstrate some possible analyses and what instructors can gain from adopting this approach.

(1) Which competencies rank highest and lowest by the end of the course?
(2) How do students' competencies shift from the beginning to the end of the course?
(3) How do first-year students compare with their more senior peers in their development?
(4) Which activities help develop which competencies?
(5) What emergent properties result from explaining competency development to students?

Identifying highest and lowest ranked competencies

In looking at the top-ranked competencies at the end of the course (Table 1, in the column "Rank at E"), two major lessons about competency development come into focus. First, the wide spread between competencies' final ratings demonstrates, on the one hand, the heterogenous level of complexity of the different competencies on the rubric and, on the other, large differences in the

beginning level of familiarity with important concepts and skills embedded in them. Generally, the simpler competencies are rated higher at the end of the course. For example, *identification* as a cognitive process is easier than many others listed, so the complexity of the competency itself is considerably less than the competency of demonstrating systems thinking. Similarly, epistemology, theoretical lenses, and the structure-agency relationship are some of the most complex issues within the social sciences (Benton and Craib 2001). These more complex competencies tend to be fairly low ranked at the end, but we do not see this as a failure. Many students in the class are in their first two years of undergraduate education. In developing complex competencies, students need a starting place in which they can rank themselves low because this is their first step in a developmental journey that will last throughout their undergraduate education. Building self-awareness of limitations is critically important at this stage of development.

Second, the competency self-assessments can be sensitive instruments. In our case, the rubrics registered a major change in the class between 2009 and 2010; in 2010, Galt greatly increased his expectations of students' outlines for their exams, and took over the responsibility of approving their outlines from the teaching assistants. For most students this meant more revisions to clarify their arguments in their exam outlines. *Organize and express ideas clearly in outline and/or draft form* was ranked sixth in 2009, but third in 2010. Similarly, *Engage in the revision process as a necessary part of good writing* ranked seventh in 2009 but third in 2010. That two writing competencies went from bottom-three ranking in 2009 to top-three ranking in 2010 — reflecting the increase in expectations explained above — speaks to the potential sensitivity of these kinds of instruments.

Comparing levels of development at the beginning and end

Another key question for competency development is how students' competencies change over a course. When looking at change from the beginning to the end of the course in both 2009 and 2010 (Table 1, column "Change E-B"), the general pattern is that students increased their level of each

specified competency, with the average end assessments being significantly higher than the average beginning assessments. For both 2009 and 2010, paired, one-tailed t-tests[5] comparing student average at the beginning and end show that statistical significance is below or near the 1% level for all competencies except two in 2009. These exceptions, significant at the 10% level in 2009, are the two writing competencies identified above — *Organize and express ideas clearly in outline and/or draft form*, and *Engage in the revision process as a necessary part of good writing*. The changes for these two competencies are significant at the 1% level in 2010, further highlighting that the instrument registered this change in teaching practice.

Averaging across all competencies, the class in 2009 shifted up from a level of 2.0 to 2.7 (of 4), or 0.7 levels of development. In 2010, the class shifted from 2.3 to 3.7 (of 5), or 1.4 levels. That 2010 shows slightly more development is largely attributable to the scales used (4 steps in 2009 and 5 steps in 2010), and perhaps also to differences in seeing previous assessment (available in 2010 but not in 2009). But greater development in 2010 is also likely a result of some improvements to the way the class was taught, as discussed above vis-à-vis writing expectations.

In looking at which competencies developed most, interesting patterns emerge. In Table 1, column "Change E-B" shows each competency's quantified change from the beginning to the end, while the various grey fills show its position relative to the average change for all competencies for that year. The average change in 2009 is 0.7 and the standard deviation is 0.2 and in 2010 the average change is 1.4 and standard deviation is 0.4. Four competencies increased at above one standard deviation from the average change in 2009, and five did in 2010. These are designated with the darkest grey fill in Table 1 and are listed together below. The parentheses show the level of change for 2009 and 2010, respectively, and bold shows that it was above one standard deviation from the average change.

Assess multiple locations within the food system using questions related to social, economic, and environmental criteria (**1.2**, **1.9**)

Identify differences between various epistemologies (**1**, **1.9**)

Identify values underlying peer and popular conceptions of sustainable food and food systems (**0.9**, 1.7)

Identify sections of the food system (production, processing, distribution, retail, consumption, disposal) (**1.1**, 1.8)

Use field-based research methods (interviews and observation) involving food system actors and locations (0.7, **1.9**)

Compare and contrast segments of the food system (conventional, organic, etc.) (0.7, **1.9**)

Operationalize theoretical lenses used in agri-food studies (NA, **2**)

All of these competencies are heavily emphasized in the various components of the class. As noted above in reference to those that were highest ranked, many are relatively easy cognitive tasks, such as identification. Additionally, those competencies that show the largest change — in our case, those based on epistemologies and theoretical lenses, others' values, food system sections and locations, field-based methods — tend to involve novel practices and/or novel objects of analysis for most students. Thus, one might expect relatively rapid progress if students are immersed and adequately supported in new activities and concepts.

In contrast, while writing, group processes, and presenting are heavily emphasized in the course, we see the least change in these relative to other competencies (except for writing in 2010, as noted above). Students have been working on most of these particular competencies for most of their student lives, meaning that they start at a higher level than the more novel ones (see the "B" columns for Table 1). Writing, group processes, and presentation are all fairly complex, being composed of a large array of bundled sub-competencies not specified in the rubric. Thus, overall, it seems that both novel and less complex competencies show greater change relative to the more complex ones that students have been developing for many years already.

Understanding first-year students' learning

The competency self-assessment data also allow for comparing groups of students, e.g., by year in school, women and men, etc., as long as these data are also collected. Here we compare first-year students (FYs) with those who had been in college longer (non-FYs), many of whom were juniors and seniors. This requires an exclusive focus on the 2009 course since it had eight FYs, compared to only three FYs in the 2010 class. While eight students is a small sample size, the eight account for 23 percent of the class of 35, which is large enough to meaningfully compare averages between FYs (n=8) and non-FYs (n=27). We do not maintain that the data below predict how all FYs will experience the class, but they are an important sub-group since the class was designed with them in mind. Given the level of difficulty of the class, it is important to be able to focus on their experience to see if the learning experiences were accessible to them.

FYs scored themselves lower, often considerably lower, than their more senior peers on all competencies at the beginning (Table 2); FYs' average at the beginning was 1.5, while non-FYs' was 2.2. This suggests further validity of the self-assessment instrument. FYs also tended to develop more than non-FYs, with an average change of 1 step compared to non-FY's 0.6 steps. In only one competency — being aware of gaps in knowledge and perspective — did FYs score themselves higher at the end than their more senior peers (FYs moved from 1.4 to 2.6 while non-FYs went from 2 to 2.5).

INSERT TABLE 2 HERE

FYs developed most in the realms of The Inquiry Process, Analysis, Understanding Values, and Ways of Knowing and Learning. Non-FYs tended to develop similarly, but experienced the larger gains in the realm of Analysis, with three of four of their most-changed competencies in that realm. We suspect that the activities that developed non-FYs' analytical realms connected well with their general student development as mostly upper division students.

FYs at the end of the course scored themselves higher on average (2.4) than the non-FYs at the beginning of the course (2.2). That this is true of course-specific competencies is not surprising, but that it occurred with more generic competencies (e.g., all competencies in the Ways of Knowing and Learning realm and two of three Interpersonal Skills) suggests that FYs developed, in a single quarter, a level of confidence in these competencies that usually takes considerably longer to develop. The intensity of the course experience, captured qualitatively in the Reflective Essays, appears to have positive developmental effects.

The course appears to have worked well overall for FYs' competency development, as they came in at a lower level than non-FYs, but went through greater development than non-FYs and ended up at a higher level, on average, than non-FYs at the start of the course. The coursework is a considerable challenge for FYs, but the competency self-assessment data suggest that the class is accessible to these students. If the results were more unfavorable for FYs, the data could be used to understand where their learning was and was not occurring, as we discuss below.

Linking specific activities to competency development

Basing courses on a communicated competency framework can also improve teaching and the curricular design skills of those involved in designing and running the class, including teaching assistants. Competency self-assessments help the quality of the course in two major ways: the rubric (1) collects data on which assignments develop which competencies, and (2) conveys to students expectations of their performance and notes activities in which they will engage.

Linking the competency self-assessment data directly to each course assignments allows the instructors to see how activities in the course enhance student learning or development, both individually and as a group. In this way, they act as a detailed course evaluation tool, producing a scope of data with levels of detail not commonly possible with other kinds of evaluation (Table 3). The data show students' identification of which assignments helped them develop each specific

competency, thereby allowing instructors to determine whether the competency development that assignments are designed to facilitate occurs according to students' experiences.

INSERT TABLE 3 HERE

Using the framework also increases the transparency of an instructor's intentions and helps explain and justify the learning process. In our case, we do the self-assessment in the first week, and it acts as a red flag saying "this is a different kind of class." The importance of this communication became obvious when comparing key indicators of course quality between 2008, when the competency development framework was not revealed to the students, and 2009 and 2010, when the course's intentions were made explicit to students through the self-assessment rubric (Table 4). The first part of Table 4 shows questions and average responses for five of the standard questions asked of our college in evaluating its classes. These standard evaluation questions show a considerable increase from 2008 to 2009 and 2010 in students' views of class expectations and the value of assignments, even though the assignments did not significantly change; the change occurred instead in the way they were explained and in explicitly tying coursework to competency development. Students' very high ratings of their own learning, the course, and the instructor speak to the overall positive experience in the course, even though expectations are so different from the norm and demands are very high. As such, revealing the competency development framework as the foundation of the course helps demonstrate (1) course expectations, (2) the value of the course assignments, (3) that students indeed learn a great deal in addition to content knowledge, and (4) that the instructor cares about their learning and development as citizens and people.

INSERT TABLE 4 HERE

Considering emergent properties of competency self-assessments: empowerment and life-long learning

We propose that implementing certain competency-based frameworks in higher education teaching can facilitate student learning and empowerment. In terms of learning, there was a significant increase in students ratings of the evaluation question "I learned a great deal in this course" between 2008 and 2009 (one-tailed t-test with unequal variance assumed, significant at the 1 percent level). We have also seen the course have an empowering effect on students within it, including FYs. This was demonstrated in students' Reflective Essays starting in 2008, which we analyze elsewhere (Galt et al in review). Evidence also comes from the student-created evaluation questions that summarize their experiences (Table 4).[6] The student-created questions occurred in the final class sessions of 2009 and 2010, in which Galt introduced the idea of appending the standardized, university-provided teaching evaluations by asking the students how *they* wanted to evaluate their experience and the class. In a 10-minute process, Galt called on students to volunteer ideas for additional evaluation questions, then he facilitated turning their questions into statements conforming to the Likert-scale format of the standard evaluation.

All student-generated questions have widespread agreement, and they help capture some of the qualitatively different aspects of the course, including students' gaining incentives and abilities to continue life-learning, direct engagement with questions around values, thinking criticality about instruments and data (e.g., *This form inadequately measures my learning experience*), and being explicit about the learning process as a companion to learning particular content knowledge. These student-created questions are more interesting still since they are part of an epistemic process of students thinking about evaluating their classes in ways that matters to them, rather than in a manner imposed upon them by an authority.

Conclusion

Our data suggest that basing curricular and course design on competency development and communicating the competency framework to students can improve learning in university courses.

Frameworks for competency development do not have to be grounded in behaviorism; from our experience, critical pedagogy has proved fertile theoretical ground for conceptualizing and facilitating students' competency development. And while there is no formal "standardization" between students in our competency self-assessment data, our analysis suggests that the instruments have produced valid and reliable data from which we can assess student learning outcomes, and the quality of our teaching activities.

Our experience with the Food Systems course shows that competency self-assessments can serve multiple purposes. They communicate to students the intent of, and commitment to, learner-centered teaching. They serve to hold instructors accountable for leading learning activities that fulfill the expectations created by the communicated competency framework. They also help show instructors how much learning occurred in terms of content knowledge, life skills, and self-awareness. Additionally, the competency self-assessments allow instructors to see in a very detailed fashion how students experience the connection between the assignments and competency development; from an instructors' perspective, this is valuable feedback. Lastly, though not explored here, they can connect individual classes to other parts of a curriculum to show that students will have the opportunity elsewhere to continue developing the same or similar competencies, thus building curriculum-wide articulation capacity in sustainable agriculture and food systems.

We also note qualitative changes we have witnessed in our students. Being explicit about values and providing experiences within the agrifood system where students experience tensions between what is and what they think should be (Galt et al in review), together with taking students' intrinsic motivations seriously and allowing them to pursue those interests within a supportive structure, catalyzes student engagement with the agrifood system in their broader campus community and beyond. As such, facilitating competency development in this manner is one of the most profound

actions that faculty members can take to promote sustainable agriculture and food systems, as their students' development and empowerment has important and continuing ripple effects.

We conclude by highlighting the importance of the scholarship of teaching and learning and the need to recognize it and the immense value of quality teaching in research-focused universities like our own, in which most institutional rewards go to research independent of our teaching. As the NRC (2009: 8) notes, "Achievements in teaching are only rarely rewarded in substantive ways, so faculty are generally motivated to focus their attention elsewhere … [I]mproving undergraduate education in agriculture depends on raising the profile of teaching." When we apply to our teaching the same rigorous, scholarly mindset we use in our research, it is necessarily transformed, as many of the beliefs we held before do not stand up to scrutiny. When we make explicit our position on the value and purpose of higher education and then seek to empirically demonstrate student learning to ourselves and others to better understand learning outcomes, the bar is raised, setting the stage for more transformative learning that will help us develop a learning society that must underpin the transition to a more sustainable future.

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[1] Competencies such as making one's own observations, understanding and intervening in society, and initiative "are all heavily value-laden" (Raven 2001b: 21). Desjardins and Huff (2001: 94) point out that "underlying values drive the development and application of competencies as strongly as other 'social motives,' such as the needs for achievement, affiliation, and power." As such, we conceptualize competencies as abstractions that are constituent parts of adult human beings, who are emergent entities "who must be understood at [her/]his own level and in [her/]his own totality" (Gould 1996: 34).

[2] Galt is a professor and the course's sole instructor of record. Parr was completing a Ph.D. in agricultural and environmental education during course development in 2007-08. Galt hired Parr to co-design the class, with specific attention to experiential learning activities and assessments that integrated the lab with the course as a whole. They have worked closely on revising and evaluating the course since 2008, with Galt teaching it each year. Jagannath was a student in the 2010 class and a student organizer around agricultural sustainability on our campus.

[3] The process was done in consultation with Lori Thorp of Michigan State University.

[4] Critical realism, one of the most well-developed modern philosophies, maintains that ways of knowing must be appropriate to the object of study (Sayer 1992).

[5] The t-tests are paired (or dependent) since they are comparing the same people at different points in time, and are one-tailed since we hypothesized that going through the course would increase their competency self-assessments. The results are not shown since all but two are significant at the 1 percent level.

[6] As with all college-structured evaluations, the forms were anonymous, the instructor was not in the room while students answered the questionnaire, and a student delivered completed questionnaires to staff overseeing the major.

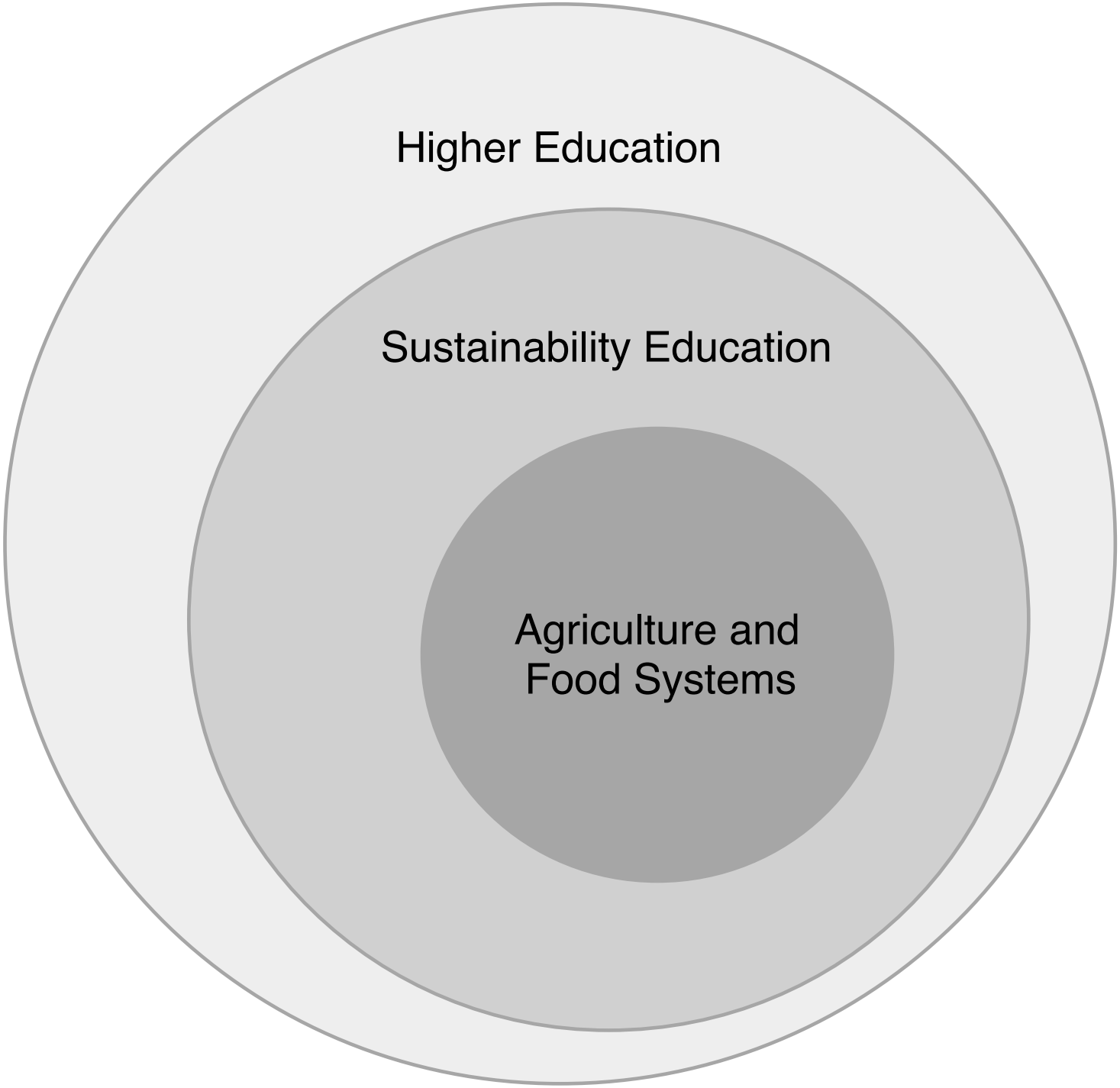
Higher Education
Sustainability Education
Agriculture and
Food Systems

Table 1: Students' competency self-assessments at three points in the quarter

Competencies	2009, all students (n=35) B	M	E	Change E-B	Rank at E	2010, all students (n=38) B	M	E	Change E-B	Rank at E
Ways of Knowing and Learning	*2.1*	*2.5*	*2.8*	*0.7*		*2.5*	*3.1*	*3.8*	*1.3*	
Understand your preferred learning style	2.4	2.7	3.0	0.6	**2**	3.0	3.4	3.9	0.9	**3**
Develop ideas for improving your individual and collaborative learning	2.0	2.4	2.7	0.7	5	2.5	3.0	3.7	1.2	5
Reflect on experiences learning as an individual and as a group, in the classroom and in the field	2.3	2.7	2.7	0.5	5	2.9	3.3	4.0	1.1	**2**
Identify differences between various epistemologies (a.k.a. research perspectives, theoretical lenses)	1.7	2.2	2.7	1.0	5	1.7	2.8	3.7	1.9	5
Understanding Values	*2.1*	*2.5*	*2.9*	*0.8*		*2.4*	*3.1*	*3.9*	*1.6*	
Examine personal values as they relate to food and the food system	2.4	2.7	3.1	0.7	**1**	2.7	3.2	4.1	1.4	**1**
Identify values underlying peer and popular conceptions of sustainable food and food systems	2.0	2.4	2.9	0.9	**3**	2.2	3.1	3.9	1.7	**3**
Explain the differences between one's own values and the values of others concerning the sustainability of food and food systems	2.1	2.4	2.8	0.7	4	2.2	3.0	3.8	1.6	4
The Inquiry Process	*1.9*	*2.4*	*2.6*	*0.7*		*2.0*	*2.9*	*3.6*	*1.6*	
Pose research questions that address your interests and correspond to a theoretical lens used in agri-food studies	1.8	2.3	2.5	0.7	*7*	2.1	2.9	3.6	1.5	6
Create interview questions to answer research questions	1.8	2.5	2.7	0.8	5	2.1	2.9	3.6	1.5	6
Use field-based research methods (interviews and observation) involving food system actors and locations	1.9	2.4	2.6	0.7	6	1.7	2.9	3.6	1.9	6
Perform collaborative learning in teams through field research and analysis	2.1	2.3	2.6	0.6	6	2.3	3.0	3.7	1.4	5
Identify gaps in current knowledge and perspective	1.8	2.3	2.5	0.7	*7*	1.9	2.8	3.7	1.8	5
Analysis	*1.8*	*2.3*	*2.6*	*0.8*		*1.8*	*2.7*	*3.6*	*1.8*	
Identify sections of the food system (production, processing, distribution, retail, consumption, disposal)	2.0	2.6	3.0	1.1	**2**	2.2	3.0	4.0	1.8	**2**
Compare and contrast segments of the food system (conventional, organic, etc.)	2.2	2.3	2.9	0.7	**3**	2.0	2.7	3.9	1.9	**3**
Assess multiple locations within the food system using questions related to social, economic, and environmental criteria	1.6	2.5	2.8	1.2	4	1.6	2.6	3.5	1.9	7
Demonstrate systems thinking, including identification of components, relations, and setting boundaries	1.6	2.1	2.4	0.8	*8*	1.5	2.4	3.2	1.7	10
Interpret food choices based on different cultural identities and positions in society	1.8	2.5	2.5	0.7	*7*	2.3	3.1	3.7	1.5	5
* Describe the relationship between structure and agency (2009) / Operationalize theoretical lens used in agri-food studies (2010)	1.5	1.9	2.1	0.6	*9*	1.2	2.4	3.2	2.0	10
Interpersonal Skills	*2.2*	*2.7*	*2.8*	*0.6*		*2.7*	*3.2*	*3.7*	*1.0*	
Understand small group processes	2.2	2.8	2.9	0.7	**3**	2.7	3.2	3.6	0.9	6
Practice group decision-making through dialogue and consensus	2.4	2.8	2.8	0.4	4	3.0	3.5	3.9	0.9	**3**
Co-manage fieldwork project logistics	1.9	2.6	2.6	0.7	6	2.4	2.8	3.5	1.1	7
Writing	*2.5*	*2.6*	*2.7*	*0.2*		*3.0*	*3.3*	*3.9*	*0.9*	
Organize and express ideas clearly in outline and/or draft form	2.5	2.5	2.6	0.2	6	3.0	3.1	3.9	0.9	**3**
Connect concepts and ideas from class, labs, readings/videos, and your own ideas	2.5	2.6	2.9	0.4	**3**	2.9	3.4	4.0	1.0	**2**
Engage in the revision process as a necessary part of good writing	2.4	2.5	2.5	0.1	*7*	3.0	3.4	3.9	0.8	**3**
Presenting	*2.1*	*2.6*	*2.6*	*0.5*		*2.8*	*3.2*	*3.4*	*0.6*	
Demonstrate understanding of principles of public speaking	2.2	2.6	2.6	0.4	6	2.7	3.2	3.3	0.7	9
Present research findings using visual, oral, and textual communication	2.1	2.5	2.7	0.6	5	2.8	3.3	3.4	0.6	8
* = competency different betwe — Average	2.0	2.5	2.7	0.7		2.3	3.0	3.7	1.4	
St. Dev.	0.3	0.2	0.2	0.2		0.5	0.3	0.2	0.4	

Legend

Timing
B = beginning (first day)
M = middle (mid-quarter)
E = end (last day)

Extent of positive change between B and E	2009	2010
Very large positive change for group (>+1 st dev above average)	≥ 0.9	≥ 1.8
Large positive change for group (within +1 st dev above average)	0.66 - 0.89	1.4 - 1.79
Moderate positive change for group (within 1 st dev below average)	0.42 - 0.65	1 - 1.39
Low positive change for group (<-1 st dev below average)	< 0.42	< 1

NOTE: all average changes between B & E are in the positive direction, so the scale shows the relative extent of that positive change.

Levels (2009)
1 = Preparatory level
2 = Intermediate level
3 = Adavnced level
4 = Master level

Levels (2010)
1 = Novice
2 = Advanced performer
3 = Competent performer
4 = Proficient performer
5 = Expert

Table 2: FY and non-FY students' competency self-assessments at three points in the quarter, 2009

	FYs (n=8)					Non-FYs (n=27)				
Competencies	B	M	E	Change (E-B)	Domain average	B	M	E	Change (E-B)	Domain average
Ways of Knowing and Learning					1.0					0.6
Understand your preferred learning style.	1.9	2.2	2.6	0.8		2.5	2.9	3.2	0.7	
Develop ideas for improving your individual and collaborative learning.	1.6	2.0	2.6	1.0		2.1	2.6	2.7	0.6	
Reflect on experiences learning as an individual and as a group, in the classroom and in the field.	1.6	2.2	2.6	1.0		2.5	2.9	2.8	0.3	
Identify differences between various epistemologies (a.k.a. research perspectives, theoretical lenses).	1.3	2.1	2.4	1.1		1.8	2.2	2.8	1.0	
Understanding Values					1.0					0.7
Examine personal values as they relate to food and the food system.	1.9	2.3	2.8	0.9		2.5	2.8	3.3	0.7	
Identify values underlying peer and popular conceptions of sustainable food and food systems.	1.6	2.3	2.9	1.3		2.1	2.4	2.9	0.8	
Explain the differences between one's own values and the values of others concerning the sustainability of food and food s	1.6	2.2	2.6	0.9		2.2	2.5	2.9	0.7	
The Inquiry Process					1.2					0.6
Pose research questions that address your interests and correspond to a theoretical lens used in agri-food studies.	1.1	2.1	2.2	1.0		2.0	2.3	2.6	0.7	
Create interview questions to answer research questions.	1.1	2.5	2.4	1.3		2.1	2.5	2.8	0.7	
Use field-based research methods (interviews and observation) involving food system actors and locations.	1.1	1.9	2.5	1.4		2.1	2.6	2.6	0.5	
Perform collaborative learning in teams through field research and analysis.	1.4	1.9	2.5	1.1		2.3	2.4	2.7	0.5	
Identify gaps in current knowledge and perspective.	1.4	2.0	2.6	1.2		2.0	2.4	2.5	0.6	
Analysis					1.1					0.8
Identify sections of the food system (production, processing, distribution, retail, consumption, disposal).	1.1	2.0	2.8	1.6		2.2	2.8	3.2	1.0	
Compare and contrast segments of the food system (conventional, organic, etc.).	1.4	1.9	2.4	1.0		2.3	2.5	3.1	0.8	
Assess multiple locations within the food system using questions related to social, economic, and environmental criteria.	1.1	2.1	2.2	1.1		1.7	2.6	3.0	1.3	
Demonstrate systems thinking, including identification of components, relations, and setting boundaries.	1.3	1.7	2.1	0.7		1.7	2.2	2.6	0.9	
Interpret food choices based on different cultural identities and positions in society.	1.2	2.0	2.4	1.2		2.1	2.6	2.6	0.6	
Describe the relationship between structure and agency.	1.2	1.3	1.9	0.7		1.6	2.1	2.1	0.5	
Interpersonal Skills					0.9					0.6
Understand small group processes.	1.8	2.2	2.7	1.0		2.3	3.0	3.0	0.6	
Practice group decision-making through dialogue and consensus.	1.8	2.1	2.5	0.8		2.7	3.0	3.0	0.4	
Co-manage fieldwork project logistics.	1.5	2.3	2.4	0.9		2.0	2.7	2.8	0.7	
Writing					0.4					0.3
Organize and express ideas clearly in outline and/or draft form.	2.0	1.9	2.1	0.1		2.6	2.7	2.9	0.4	
Connect concepts and ideas from class, labs, readings/videos, and your own ideas.	1.8	2.1	2.7	0.9		2.8	2.8	3.1	0.3	
Engage in the revision process as a necessary part of good writing.	1.9	2.0	2.2	0.3		2.5	2.7	2.7	0.2	
Presenting					1.0					0.4
Demonstrate understanding of principles of public speaking.	1.5	2.1	2.3	0.8		2.4	2.8	2.7	0.3	
Present research findings using visual, oral, and textual communication.	1.3	2.0	2.4	1.1		2.3	2.7	2.8	0.5	
Average	1.5	2.1	2.4	1.0		2.2	2.6	2.8	0.6	
St. Dev.	0.3	0.2	0.2	0.3		0.3	0.2	0.2	0.3	

Legend

Timing
B = beginning (first day)
M = middle (mid-quarter)
E = end (last day)

Extent of positive change between B and E	FYs	Non-FYs
Very large positive change for group (>+1 st dev above average)	≥ 1.27	≥ 0.87
Large positive change for group (within +1 st dev above average)	0.96 - 1.26	0.62 - 0.86
Moderate positive change for group (within 1 st dev below average)	0.65 - 0.95	0.37 - 0.61
Low positive change for group (<-1 st dev below average)	< 0.65	< 0.37

NOTE: all average changes between B & E are in the positive direction, so the scale shows the relative extent of that positive change.

Levels (2009)
1 = Preparatory level
2 = Intermediate level
3 = Adavnced level
4 = Master level

Table 3: Assignments and activities that students identified as developing specific competencies (end self-assessment), 2009

Competencies	Number of students who checked each box (n=26)								
	LS	RN	FD	TP1	E1	TP2	CTP	E2	LD
Ways of Knowing and Learning									
Understand your preferred learning style.	14	7	4	7	5	10	4	7	6
Develop ideas for improving your individual and collaborative learning.	8	1	3	15	2	19	13	2	4
Reflect on experiences learning as an individual and as a group, in the classroom and in the field.	4	8	10	11	9	17	12	10	11
Identify differences between various epistemologies (a.k.a. research perspectives, theoretical lenses).	2	8	5	15	8	20	17	12	11
Understanding Values									
Examine personal values as they relate to food and the food system.	3	16	18	11	16	15	10	16	13
Identify values underlying peer and popular conceptions of sustainable food and food systems.	1	11	8	8	7	14	11	7	5
Explain the differences between one's own values and the values of others concerning the sustainability of food systems.	2	14	13	7	14	12	11	14	12
The Inquiry Process									
Pose research questions that address your interests and correspond to a theoretical lens used in agri-food studies.	1	4	9	17	9	17	5	9	6
Create interview questions to answer research questions.	0	1	8	15	3	20	5	3	2
Use field-based research methods (interviews and observation) involving food system actors and locations.	0	1	5	19	3	21	7	3	3
Perform collaborative learning in teams through field research and analysis.	0	1	0	19	2	20	17	0	1
Identify gaps in current knowledge and perspective.	4	13	11	12	12	16	13	16	15
Analysis									
Identify sections of the food system (production, processing, distribution, retail, consumption, disposal).	2	13	9	15	11	20	13	13	8
Compare and contrast segments of the food system (conventional, organic, etc.).	0	15	10	10	11	18	8	16	6
Assess multiple locations within the food system using questions related to social, economic, and environmental criteria.	0	7	9	11	12	20	9	18	9
Demonstrate systems thinking, including identification of components, relations, and setting boundaries.	1	6	9	8	11	15	11	17	7
Interpret food choices based on different cultural identities and positions in society.	1	13	13	6	6	10	8	8	8
Describe the relationship between structure and agency.	0	8	5	12	10	13	9	10	8
Interpersonal Skills									
Understand small group processes.	0	1	3	16	0	20	15	1	2
Practice group decision-making through dialogue and consensus.	0	1	0	17	0	21	17	0	2
Co-manage fieldwork project logistics.	0	0	0	16	1	22	11	0	2
Writing									
Organize and express ideas clearly in outline and/or draft form.	1	8	6	3	20	2	3	19	14
Connect concepts and ideas from class, labs, readings/videos, and your own ideas.	2	12	12	10	19	11	9	18	16
Engage in the revision process as a necessary part of good writing.	0	3	5	1	15	1	3	14	9
Presenting									
Demonstrate understanding of principles of public speaking.	0	0	3	14	0	18	16	1	0
Present research findings using visual, oral, and textual communication.	0	3	3	14	4	19	15	5	4
Sum of boxes checked	46	175	181	309	210	411	272	239	184
Percentage of all boxes checked	2%	9%	9%	15%	10%	20%	13%	12%	9%
Percentage of grade	—	5%	10%	5%	15%	15%	5%	20%	15%

Legend

LS=VAK Learning Style Activity, RN=Reading Notebooks, FD=Food Diary, TP1=Team Project 1, E1=Midterm Exam, TP2=Team Project 2, CTP=Cross-Team Project, E2=Final Exam, LD=Learner Document

Table 4: Course evaluations, on 5-point Likert-scale (1=strongly disagree, 2=disagree, 3=-mixed feelings, 4=agree, 5=strongly agree)

Question	2008 score n=21	2009 score n=34	2010 score n=32
Standardized evaluaton questions			
I know what is expected of me in this class	3.5	4	4.4
Course assignments are valuable components of this course	3	4.1	4.6
I learned a great deal in this course	4.4	4.8	4.9
This is an excellent course	4	4.4	4.9
The instructor is an excellent teacher, overall	4.6	4.9	4.9
2009 student-created questions			
I gained incentives and abilities to continue life-long learning		4.7	
This class provided opportunities for experiential learning		4.8	
I felt engaged and involved in the learning process		4.5	
This form inadequately measures my learning experience		4.4	
The learning style used in this class helped me learn more, and more deeply		4.6	
2010 student-created questions			
This teacher supported my personal learning style			4.7
My understanding of the learning process developed along with my understanding of the material			4.8
This teacher was unafraid to engage my values			4.9
This teacher was receptive to my evaluation of her/his teaching			4.7
The material was made applicable to the real world			4.8