AC 2011-1541: ANALYSIS OF THE IMPLEMENTATION OF THE HOW PEOPLE LEARN FRAMEWORK THROUGH DIRECT CLASSROOM OBSERVATION IN SELECTED FOOD ENGINEERING COURSES

lourdes gazca, American University in Puebla, Mexico

Lourdes Gazca is Science, Engineering, and Technology Education Ph.D. Student at Universidad de las Americas Puebla in Mexico. She teaches mathematics and statistics related courses. Her research interests include faculty development, active and cooperative learning, and creating effective learning environments.

Aurelio Lopez-Malo, Universidad de las Americas Puebla
Enrique Palou, Universidad de las Americas Puebla

Enrique Palou is Director, Center for Science, Engineering, and Technology Education; and Professor, Department of Chemical, Food, and Environmental Engineering at Universidad de las Americas Puebla in Mexico. He teaches engineering design, food science, and education related courses. His research interests include emerging technologies for food processing, creating effective learning environments, and building rigorous research capacity in science, engineering and technology education.

Analysis of the Implementation of the *How People Learn* Framework through Direct Classroom Observation in Selected Food Engineering Courses

Abstract

The *How People Learn* (HPL) framework[1, 2] was used to redesign two food engineering courses, Introduction to Engineering Design (EI-100) and Food Chemistry (IA-332), to further promote an interactive classroom while integrating multiple formative assessments by means of Tablet PC technologies[3, 4]. The HPL framework highlights a set of four overlapping lenses that can be used to analyze any learning situation. In particular, it suggests that we ask about the degree to which learning environments are knowledge, learner, community, and assessment centered[1, 2]. The VaNTH Observation System (VOS) is an assessment tool developed to capture qualitative and quantitative classroom observation data from teaching and learning experiences[5-7]. VOS is a four-part system that incorporates HPL framework elements and uses four recurring methods of collecting classroom data: recording student-teacher interactions (CIO), recording student academic engagement (SEO), recording narrative notes of classroom events (NN), and rating specific indicators of effective teaching (GR).

VOS was used to systematically assess HPL framework implementation in EI-100 and IA-332 redesigned classrooms as well as in two "traditional" courses, Material Balances (IQ-210) and Biophysics (FS-320). Observers measured differences in classroom experiences resulting from the innovations and redesigned learning environments as well as in IQ-210 and FS-320. EI-100 and IA-332 redesign significantly ($p<0.05$) increased student participation while formative assessments and feedback were more common[3, 4]. Instructors in these redesigned courses utilized the information gained through real-time formative assessment to tailor instruction and meet student needs. Particularly important were opportunities to make students' thinking visible as well as opportunities for "what if" thinking[3, 4]. VOS captured important differences between redesigned and "traditional" classroom experiences. These differences may be used to measure levels of "HPLness" of a lesson. Moreover VOS clearly captured differences among instructors' teaching styles. In addition, VOS generated detailed feedback that instructors may use to self-assess[3, 4, 7]. Student final grades in redesigned courses were higher than those found in "traditional" courses. Further, fewer students failed the course and the percentage of students who stayed in the course until the end was higher in the redesigned courses.

Introduction

Universidad de las Américas Puebla (UDLAP) is a Mexican private institution of higher learning committed to first-class teaching, public service, research and learning in a wide range of academic disciplines including business administration, the physical and social sciences, engineering, humanities, and the arts. Since 1959, the Commission on Colleges of the Southern Association of Colleges and Schools (SACS) has accredited UDLAP in the United States.

Observed courses

The first course we observed was Introduction to Engineering Design (EI-100), which is a first-semester 3 credit required course for almost every engineering program of UDLAP since spring of 2001. UDLAP's Chemical, Civil, Computer, Electrical, Environmental, Food, Industrial, Mechanical, and Mechatronic engineering students have in EI-100 a great opportunity for a multidisciplinary collaborative experience. EI-100 is a team-taught course that uses active, collaborative and cooperative learning. Course content and classroom activities are divided into three, two-hour sections (Modeling, Concepts, and Laboratory) per week. Students have six different EI-100 facilitators (an instructor and teaching assistant for each section). EI-100 goal is to introduce students to the Engineering Method, this is accomplished by focusing on six course objectives: self-regulation, communication, working cooperatively and collaboratively, problem solving, modeling, and quality. The "Modeling" section initiates students in the process of engineering modeling, using several software including spreadsheets. "Concepts" introduce students to the engineering design process, problem-solving techniques, working in teams, engineering as a profession, and planning for success that students then apply in "Laboratory" on two actual design projects. The "Concepts" section uses quizzes given in nearly every session to ascertain whether students have understood the material in their pre-class reading assignments. In addition, students are encouraged to write brief reflective journal entries to further solidify and reinforce their own understanding, and demonstrate that improved understanding for an improved quiz grade[3].

Food Chemistry (IA-332) is a course that is offered for students of sixth semester of Food Engineering. This course was redesigned following the HPL framework to further promote an interactive classroom while integrating multiple formative assessments by means of Tablet PC technologies[4]. It is a course that uses active and cooperative learning in everyone of its meetings and activities. The grading scheme includes individual and group quizzes, individual and group problem-based exams, journal writing, peer assessments and the development of a semester group project. This observed course had 23 enrolled students, was conducted in two weekly sessions of 75 minutes each. It was held (as EI-100) in a large classroom designed for cooperative learning with 20 tables, each one for 4 students. The classroom has six white boards, two LCD-projectors and two screens. The instructor Tablet PC was wirelessly connected to the projectors, so the instructor was able to move within the classroom with his Tablet PC. The classroom is also equipped with a sound system with a tie clip microphone for the instructor and two wireless microphones for the students. The teacher explained course topics using different schemes, sometimes provides "traditional" instruction, sometimes leaves the students in teams to discuss readings, sometimes students need to watch a video prior to the class in which it is recorded a small lecture of the topic; this allows the teacher to take class time to perform several different types of cooperative learning activities.

Material Balances (IQ-210) is a course offered to students in the second semester of Chemical Engineering and Food Engineering programs. This course follows a "traditional" pattern of teaching and does not use active or cooperative learning methods. The grading scheme includes 4 exams, 12 homework exercises, and a final paper. IQ-210 had 21 enrolled students, classes took place in three weekly sessions of 50 minutes each, which were held in a traditional classroom with 30 individual tables, two boards (of which only one was utilized throughout the

course) and a LCD-projector. The teacher was punctual and delivered all the classes. In almost every class, the teacher explained and solved an example or two on the board, along with the students, and rarely let the students solve exercises first.

Biophysics (FS-320) is a course offered to students in the fourth semester of the Food Engineering program, also follows a "traditional" pattern of teaching and does not use active or cooperative learning methods. The grading scheme includes 4 mid-term exams and a final exam. This observed course had 24 enrolled students, took place in three weekly sessions of 50 minutes each, which were held in a traditional classroom with 40 individual tables and a blackboard. The teacher was punctual and delivered all classes. A typical class consisted of the teacher explaining the topic and then solving one example on the board, rarely letting the students to solve problems before his lecture.

Redesign of Introduction to Engineering Design and Food Chemistry courses

A major issue is to help students develop the kinds of connected knowledge, skills, and attitudes that prepare them for effective lifelong learning[8]. This involves the need to seriously rethink not only how to help students learn about particular isolated topics but to rethink the organization of entire courses and curricula. A model developed by Jenkins[9] highlights important constellations of factors that must be simultaneously considered when attempting to think about issues of teaching and learning. The model illustrates that the appropriateness of using particular types of teaching strategies depends on: (1) the nature of the materials to be learned; (2) the nature of the skills, knowledge, and attitudes that learners bring to the situation; and (3) the goals of the learning situation and the assessments used to measure learning relative to these goals. A particular teaching strategy may flourish or perish depending on the overall characteristics of the ecosystem in which it is placed.

The Jenkins model fits well with a proposal by Wiggins and McTighe[10]. They suggest a "working backwards" strategy for creating high-quality learning experiences. In particular, they recommend that educators: (1) begin with a careful analysis of learning goals; (2) explore how to assess students' progress in achieving these goals; and (3) use the results of steps 1 and 2 to choose and continually evaluate teaching methods. (Assumptions about steps 1 and 2 are also continually evaluated.) When using a "working backwards" strategy for EI-100 and IA-332, our choice of teaching strategies derives from a careful analysis of learning goals, rather than vice versa[3, 4].

The ability to design engineering undergraduate courses and corresponding high-quality learning environments require that we move beyond procedural strategies and models. We also need to understand the kinds of skills, attitudes, and knowledge structures that support competent performance. For redesigning EI-100 and IA-332 courses we "worked backwards" taking into account Jenkins model[9] as well as the HPL framework[1-4]. Especially important was knowledge of key concepts and models that provide the kinds of connected, organized knowledge structures and accompanying skills and attitudes that can set the stage for future learning[1]. Our redesigns have been described in detail elsewhere[3, 4].

VaNTH Observation System

The VaNTH Observation System (VOS) is an assessment tool developed to capture qualitative and quantitative classroom observation data from teaching and learning experiences of the bioengineering classroom[5-7]. VOS is a four-part system that incorporates the elements of HPL framework and uses four recurring methods of collecting classroom data: recording student teacher interactions, recording student academic engagement, recording narrative notes of classroom events, and rating specific indicators of effective teaching. VOS was developed from the Stallings Observation System, which consisted of three components that registered the presence and absence of over 600 in-class student and teacher behaviors and activities. Similar to other classroom observation systems, VOS provides information about the types of pedagogy and interactions occurring within a class along with information about levels of student engagement[3]. Unlike previous observation systems, however, VOS contains a category that explicitly measures the presence of the four HPL framework lenses and the interactions of these lenses within observed courses[3, 4].

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The four components of the VOS include the following:

1. The Classroom Interaction Observation (CIO), sampled real-time, which records student and faculty interactions
2. A time-sampled Student Engagement Observation (SEO), which notes whether students are engaged or unengaged with academic tasks
3. Qualitative Narrative Notes (NN) on the lesson content, lesson context, extenuating circumstances, and additional information about the classroom
4. Global Ratings (GR), which provide summative information about major aspects of the pedagogy underlying the class session.

Methods

VOS was used to systematically assess HPL framework implementation in studied classrooms as previously described in deatil[3]. Observations were made over a year, the first course observed during one semester was EI-100; the other three studied courses were observed during the second semester. The two observers achieved a 70 percent inter-rater reliability in using the VOS.

EI-100 was observed in three weekly sessions during two hours each session. Achieving the following number of registrations: using CIO, NN, and GR we recorded a total of 252 observations in each section (504 totally) of the course during one semester, by means of 6 observations per class, three classes per week for 14 weeks. In the case of SEO there were a greater number of observations due to the number of students enrolled in courses, 3360 records for the case of section 01 and 5712 for the case of section 02.

Food Chemistry was also observed during an entire semester in two weekly sessions, each 90 minutes long. This allowed us to obtain the following records: using CIO, NN, and GR a total of 138 observations for each of the three instruments due to a scheme of six observations per class. In the case of SEO we had 3174 observations.

Material Balances was observed during a full semester in the three weekly sessions, each one lasting 50 minutes. Achieving the following number of registrations: using CIO, NN, and GR we recorded a total of 100 observations with each of these three instruments, using a pattern of five observations per class. In the case of SEO we had 2100 observations.

The Biophysics course was observed during a full semester in the three weekly sessions, each lasting 50 minutes, which allowed us to accumulate the following records: using CIO, NN, and GR a total of 70 observations with each of the three instruments due to a scheme of five observations per class. In the case of SEO we had 2400 observations.

Subsequently we performed a statistical analysis that allowed us to establish which courses are HPL-centered and which are "traditional", this analysis also allowed comparisons among the studied courses. Finally we analyzed the final grades and the number of failing and withdrawn students in each of the observed courses.

Results and discussion

Introduction to Engineering Design: EI-100

The use of the CIO allowed us to determine the level of "HPL-ness" (knowledge-, learner-, community-, and assessment-centered) that was present in each of the two sections and three course sessions of EI-100. Here is important to remember that EI-100, as explained above, consists of three sessions: Modeling, Concepts and Laboratory, each one has a different teacher, topics, and learning outcomes; but there is a close relationship between them. Figure 1 shows the differences observed among the two sections and three sessions of EI-100 on the degree of "HPL-ness" present in the classroom.
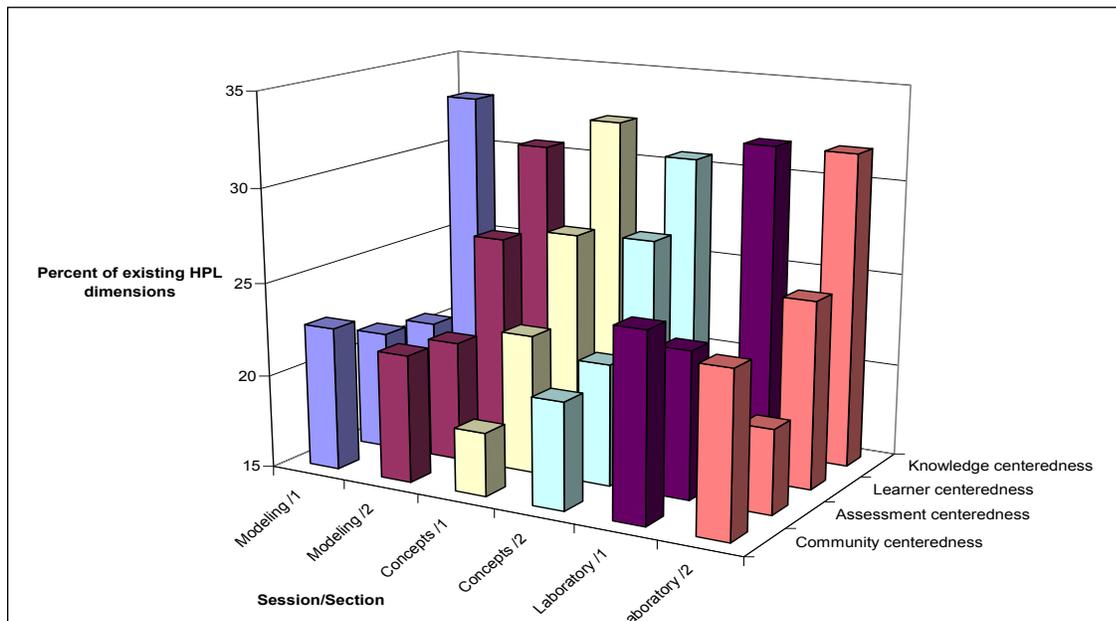

Figure 1. Percentage of "HPL-ness" observed in EI-100 three sessions (Modeling, Concepts, and Laboratory) and two sections (1 and 2). Adapted from Gazca et al.[3]

In a pattern common to studied sections and sessions, the highest percentage was found in knowledge-centered activities, with a percentage of approximately 30% in the six groups observed. The Modeling and Laboratory sessions of both sections displayed their second-highest percentages in community-centered activities. These results are logical if one considers that in these two sessions most problems and projects are solved in teams and most of them are related to the real world. On the other hand, the Concepts sessions, which comprise the theoretical portion of the EI-100 course, have their second-highest percentage in learner-centered activities, followed by assessment-centered activities. It is important to point out that even though there are differences between the percentages of HPL-centered activities, all six groups are working in alignment with the four HPL lenses (Figure 1).

There are some opportunities for improvement for certain teachers and sessions as can be seen in Figure 1. In the Concepts sessions, it would be desirable to increase the percentage of community-centered activities, while the Laboratory sessions need to work on increasing the amount of learner-centered activities. The results also clearly show the difference among teachers who have more experience with the EI-100 course, and especially with the HPL framework. Thus, the Laboratory session of section 2 presented the lowest percentages of HPL in all the lenses since it was only the second time she taught the course and is a junior faculty, while the Concepts sessions of section 2 and the Laboratory session of section 1 obtained the highest percentages in the four lenses since both professors have taught EI-100 at least 8 times and both are senior faculty[3].

When the percentages of the combinations of activities centered on the HPL lenses were analyzed, section 2 exhibited higher average values for the activities centered on the four lenses. However, statistical results (t test for independent groups) show no significant ($p > 0.05$) difference between the two sections in the percentages of activities centered on each one of the four lenses. Despite not having found significant differences between the results from the two sections, observations demonstrate that there is a high proportion of activities centered on each of the four lenses of the HPL framework in the six groups (Figure 1); thus EI-100 is aligned with the HPL framework and the course redesign was successful in that regard[3].

A series of characteristics should be present in a classroom aligned on the HPL framework. Four of them were selected from the NN instrument. According to Figure 2, the six studied groups (the two sections in their three respective sessions) worked in such a way so that the four selected characteristics of the HPL framework are present in the classroom. Every one of class sessions involved students working in a cooperative group to solve problems, which is an expected result given course learning outcomes. EI-100 was redesigned so that students work more collaborating with others than individually on problem solving. This is true for Modeling, Concepts, and Laboratory sessions. It is also important to point out the fact that the highest percentages in cooperative work were in the Concepts sessions and the lowest in Laboratory.

A second important characteristic that should be observed in an HPL-centered classroom is that the professor guides HPL-centered questions and answers. The six groups displayed this characteristic throughout the semester, although with a lower percentage than the one for cooperative work. Concepts (sections 1 and 2) and Laboratory (section 1) sessions displayed the highest percentages of HPL-centered questions and answers during the observation. This may be

explained by the fact that they were the sessions in which the professors were senior faculty and the ones most familiar with the HPL framework and therefore implemented it the most in their classrooms[3]. Another of the characteristics that should be present in an HPL-centered classroom is the design of environments in which students are motivated to show how they solved a given problem. This explanation may be given individually or in groups. In this sense, the six groups showed low percentages, with the highest percentages in the Modeling sessions (an important learning outcome of this session) and the lowest in the Concepts sessions (for both sections).

These results have enabled us to emphasize, in the feedback provided to the professors, the need to design learning environments in which all four characteristics are considered, pointing out to them that higher-order discussion is of great importance when one wants to promote the HPL framework. It may be stated that there are differences between the six observed groups in terms of the presence of the four characteristics. However, the presence of the four characteristics in every one of the six groups leads us to affirm that EI-100 is oriented towards the HPL framework, even though some sessions are better designed and implemented than others[3].
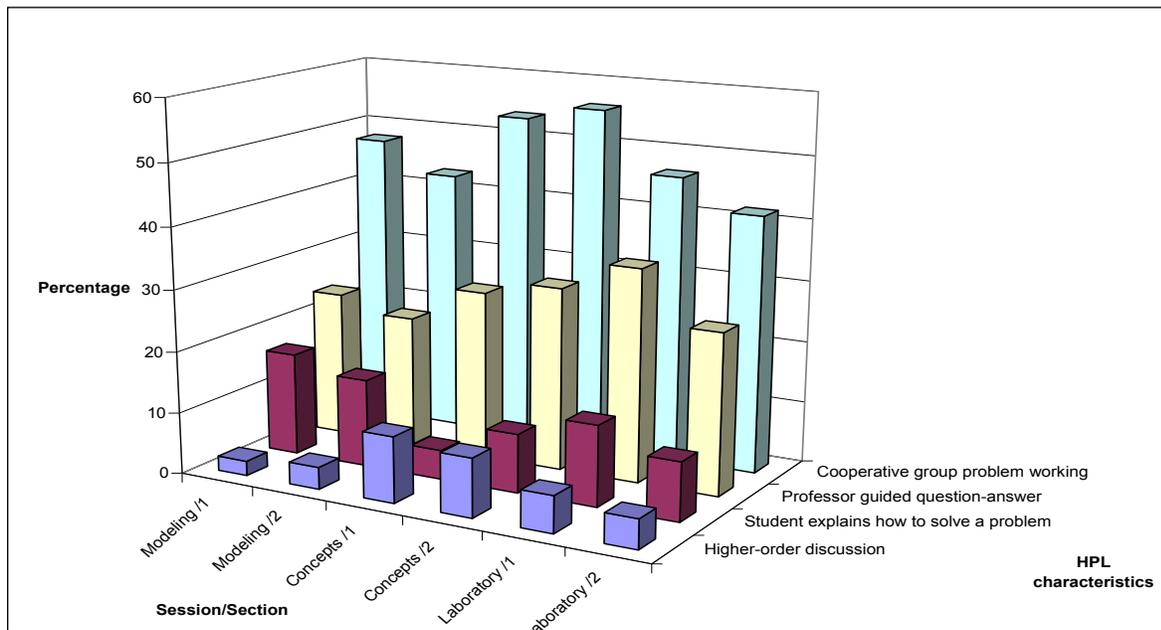

Figure 2. Percentage of HPL framework characteristics observed in EI-100 three sessions (Modeling, Concepts, and Laboratory) and two sections (1 and 2). Adapted from Gazca *et al*.[3]

In order to complement the information, a series of characteristics that every professor should promote in an HPL-centered classroom were selected from the GR instrument. Table 1 presents the results obtained from the related observations in the two sections of the EI-100 course.

It is important to remember that GR, the fourth instrument of the VOS uses a Likert scale related to the presence of different actions by the professor, assigning a 0 score when the behavior was never observed and 3 when the behavior was always observed. For analysis purposes, the observation modes were considered. In both sections observed, professors revealed the seven observed activities. The highest observed modes were for those related to providing students

with HPL challenges and employing appropriate visual aids for instruction. Connecting to prior learning was observed in lesser frequency than the other activities, while formative assessment during, and at the end of class was carried out in all six groups observed[3]. Especially low modes were observed in pre-assessment (in Modeling session, section 1), connecting with prior learning (in Laboratory session, section 2), asking hypothetical questions (in Modeling session, section 2 and Laboratory session, section 2).

Only in three sessions were observed the seven characteristics: Concepts (sections 1 and 2) and Laboratory (section 1); both sessions are taught by professors with plenty of experience in the course and the HPL framework. The results obtained from the observation of these activities enabled us to provide a more accurate feedback to different professors, showing them the importance of each of the activities and the opportunities for improvement they contained for future courses[3].

Table 1. Mode of observed[a] HPL characteristics in EI-100 three sessions (Modeling, Concepts, and Laboratory) and two sections (01 and 02). From Gazca *et al.*[3]

	Modeling		Concepts		Laboratory	
	Section 01	Section 02	Section 01	Section 02	Section 01	Section 02
Providing an HPL challenge	3	3	3	3	3	3
Making connections to prior learning	2	1	2	2	2	0
Pre-assessment of students understanding of a concept	0	1	1	3	1	1
Ongoing assessment of students understanding during a lesson	2	1	2	2	2	2
Post-assessment of students understanding after a lesson	1	2	2	2	2	2
Using appropriate visual aids to explain the lesson	3	3	3	3	3	3
Professor asking hypothetical questions	0	0	1	1	2	0

[a] 0: never observed, 1: a few times observed, 2: regularly observed, 3: always observed

Based on the use of the first three VOS instruments (CIO, NN and GR), it may be concluded that the Introduction to Engineering Design course is aligned with the HPL framework. In the six groups observed (two sections and its three corresponding sessions), a great deal of knowledge-, learner-, assessment- and community-centered activities were observed, as well as characteristics that should be present in an HPL-centered classroom such as students explain how to solve a problem, cooperative learning takes place in the classroom, the professor guides higher-order discussions, and the professor leads an HPL-based question and answer session. Further, several characteristics that should be promoted by a professor conducting an HPL-oriented class were also observed, for instance offering HPL challenges; connecting with prior learning; formatively assessing at the beginning, during, and at the end of class; using appropriate visual aids; and asking hypothetical questions[3].

However, some important differences were found from one session and section to the next. It is important to point out that the use of the three instruments allowed us to observe in each session the type of activity for which it was designed. For example, there were a higher percentage of assessment- and community-oriented activities in the Laboratory sessions, because that was precisely how that portion of the course was designed. Likewise, use of the three instruments allowed us to discern important differences among professors. What stood out was that the sessions with the highest percentages of HPL-oriented activities were those taught by facilitators who had more experience with the course and the HPL framework. This demonstrates the need that exists, on the one hand, to train professors on the HPL framework so that they can develop an in-depth knowledge of it and then apply it in the classroom, and on the other hand, the importance of the professor's experience in using HPL[3].

Use of the SEO instrument enabled us to determine the percentage of students engaged in both desirable and non-desirable activities in each of EI-100 two sections and their corresponding three sessions as can be seen in Table 2.

Analysis of the results for desirable and undesirable activities exhibited a higher percentage of desirable than undesirable activities in only two of the six groups observed (Concepts sections1 and 2). Laboratory sessions (sections 1 and 2) presented a higher percentage of undesirable activities, along with the Modeling session of section 1. The fact that in the Concepts session there is a greater percentage of students in desirable activities can be explained by the context of the course. The Concepts session comprises the theoretical portion of the course, and in it student achievement is mainly assessed through individual examinations, while in Modeling and Laboratory is through team-based assessments. If we recall that EI-100 is a course for first-semester engineering students, it is reasonable to conclude that students are more concerned with "paying attention" in courses in which they know that they will be assessed individually. Furthermore, they are accustomed to high school, in which theoretical subjects are the "most important" to their courses of study[3].

In analyzing the different categories of desirable activities for the six groups, the highest percentages were found in the instruction and discussion categories, although there were some differences among the six groups. It is important to point out that there is a great opportunity for improvement for every one of the professors observed. Through feedback, we showed them that there are other desirable activities (besides instruction and discussion) in the classroom that

would be worthwhile to foster in students. Analyzing the percentages of students engaged in undesirable categories, some differences among sessions stand out. For example, the Modeling session displayed the highest percentages in social interaction for both sections. In the Concepts session, in section 1 the highest percentage was in the uninvolved category; in section 2, it was in social interaction. In the Laboratory sessions, the highest percentage category in both sections was social interaction[3].

Statistical results (t test for independent groups) showed no significant ($p > 0.05$) difference in the percentage of students engaged in desirable activities between the two sections of either Modeling, Concepts, and Laboratory sessions. Similarly, there is no significant ($p > 0.05$) difference in the percentage of students engaged in undesirable activities between the two sections of the three EI-100 sessions. However, for section 1 the Concepts session displayed a significantly ($p < 0.05$) higher percentage of students engaged in desirable activities than did the Laboratory session. Additionally, the Concepts session showed a significantly ($p < 0.05$) lower percentage of undesirable activities than the Laboratory session. When comparing the three sessions (Modeling, Concepts and Laboratory) for section 2, the results were similar as the above mentioned[3].

Table 2. Percentage of undesirable and desirable observations in EI-100 three sessions (Modeling, Concepts, and Laboratory) and two sections (1 and 2). From Gazca *et al.*[3]

		Modeling		Concepts		Laboratory	
		01	02	01	02	01	02
Undesirable categories	Discipline	0.0	0.0	0.0	0.1	0.0	0.9
	Sleeping	0.3	0.9	0.7	0.2	0.4	0.4
	Personal needs	5.5	8.7	5.2	5.6	6.9	7.4
	Uninvolved	15.8	12.5	15.2	11.2	14.6	13.5
	Social interaction	16.9	18.4	13.6	16.3	18.2	17.1
	Absence	15.4	9.2	12.1	9.8	16.0	16.3
	Collaboration	0.1	0.0	0.0	0.0	0.0	0.0
Desirable categories	Seatwork	0.3	1.1	0.0	0.0	0.0	0.0
	Organization	0.0	0.2	3.0	0.7	0.0	0.0
	Test-quiz	3.9	0.0	0.0	2.2	0.0	0.0
	Discussion	19.4	24.0	20.3	25.5	24.1	29.9
	Instruction	22.4	25.0	29.9	28.6	19.8	14.6

In conclusion, VOS captured differences in EI-100 classroom experiences. These differences may be used to measure levels of "HPLness" of a lesson. Moreover VOS clearly captured differences among facilitators' teaching styles and identified the effects of EI-100 three different sessions. In addition, VOS generated detailed feedback that facilitators may use to self-assess and further refine EI-100 redesign[3].

Material Balances: IQ -210, Biophysics: FS-320, and Food Chemistry: IA-332

Taking advantage of the CIO we determined the level at which these courses are centered on each of the four HPL lenses. Figure 3 exhibits the percentage of "HPL-ness" observed in these three courses. As can be seen IQ-210 and FS-320 are courses almost entirely knowledge- and learner-centered, while their assessment-centeredness is of little concern and their community-centeredness is hardly taken into account, as expected in "traditional" courses. Instead, IA-332 takes into account the four lenses of the HPL framework, and although knowledge is still the predominant centeredness, an HPL-aligned course is developing.
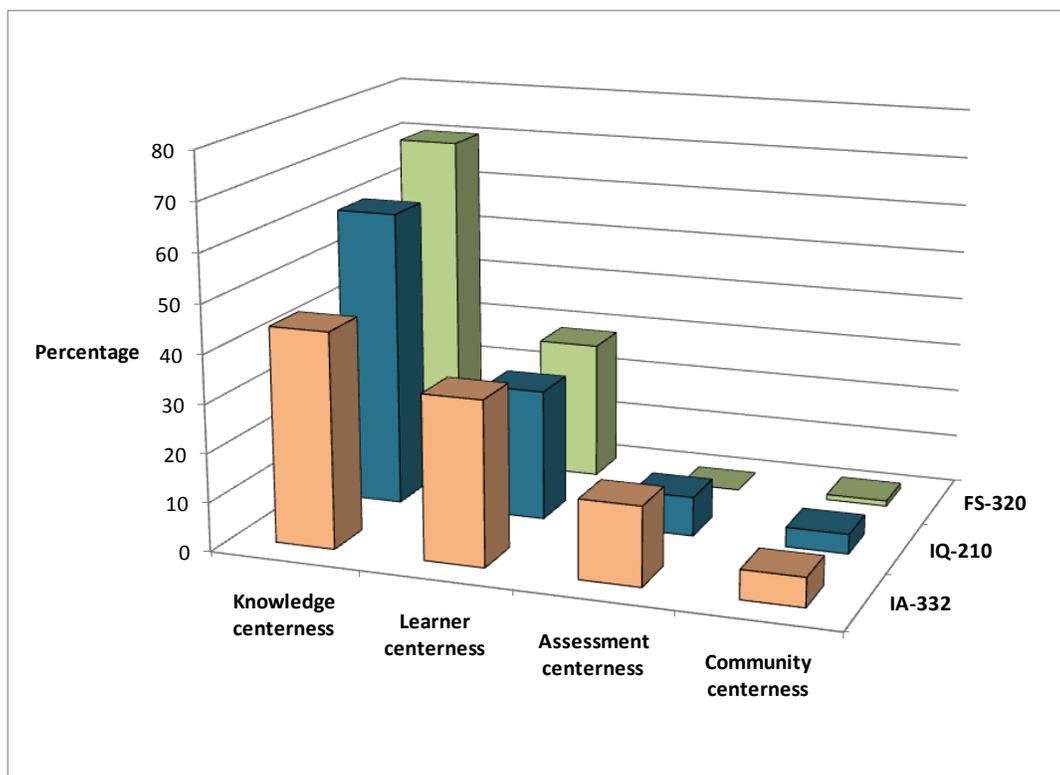
Figure 3. Percentage of "HPL-ness" observed in Material Balances (IQ-210), Biophysics (FS-320), and Food Chemistry (IA-332) courses.

With SEO we determined the percentage of students engaged in desirable and undesirable activities in IA-332, IQ-210, and FS-320 courses. Figures 4 and 5 show the results of observations made in the studied courses. The desirable activity best promoted by the teacher of IQ-210 is the "instruction" category. In this course there was a low percentage of observations regarding the "work organization" and "individual work" categories. At the same time, it is a course in which there were almost no "discussion", "test-quiz" or "teamwork" activities. In FS-320, the only desirable activity in which students were involved was instruction; there were almost no collaborative work to solve problems or tests or high-level discussions. Figure 4 also exhibits HPL-centered instructional activities promoted in IA-332 and in which students were involved including individual seatwork, high-level discussions, and collaborative work to solve problems.
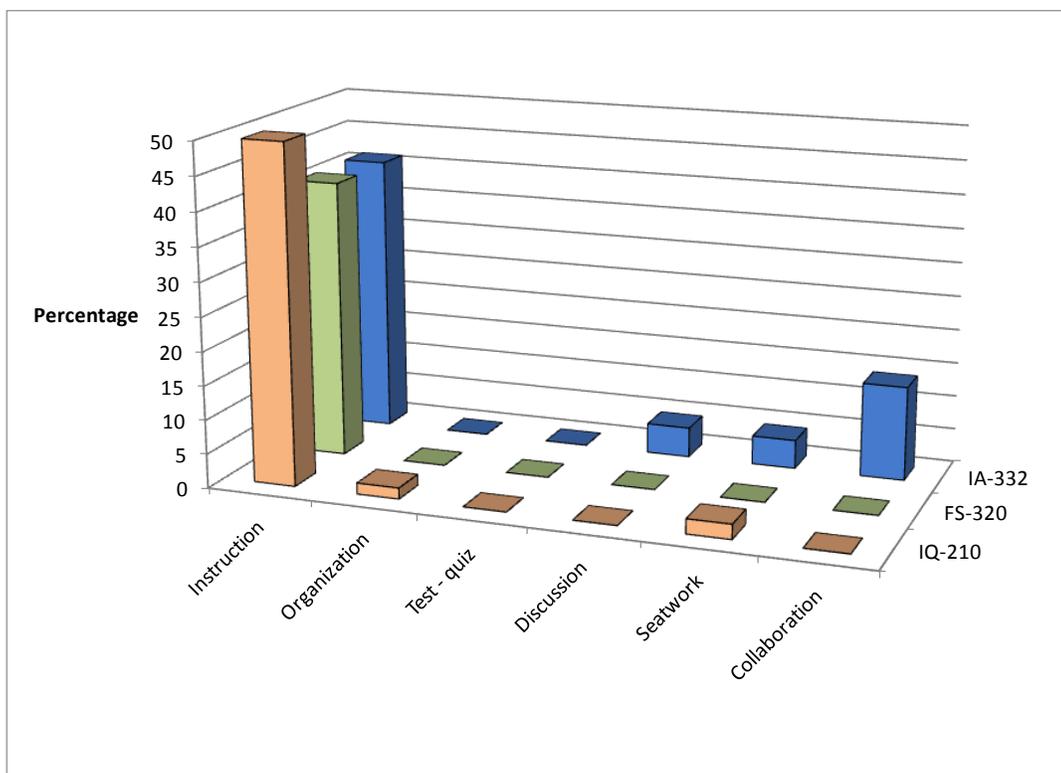
Figure 4. Percentage of students engaged in desirable activities at Material Balances (IQ-210), Biophysics (FS-320), and Food Chemistry (IA-332) courses.
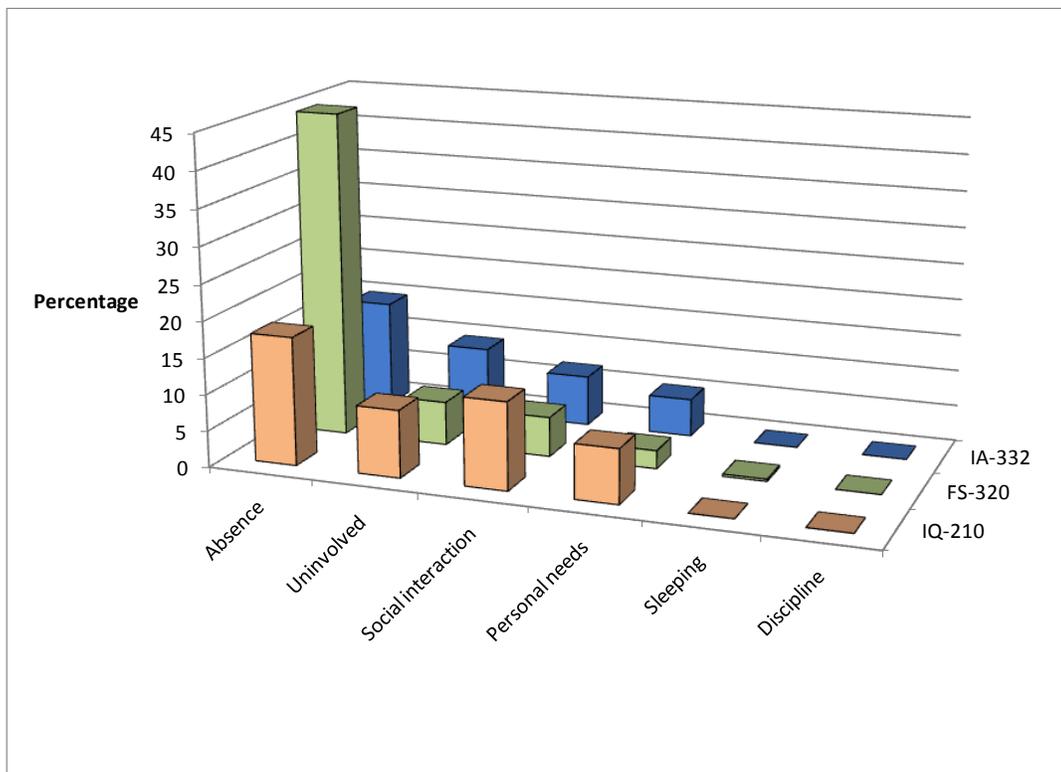

Figure 5. Percentage of students engaged in undesirable activities at Material Balances (IQ-210), Biophysics (FS-320), and Food Chemistry (IA-332) courses.

Material Balances had a high percentage of students involved in undesirable activities and a high percentage of absent students. The percentages observed in the categories of "social interaction", "not involved" and "personal needs" were also important in IQ-210 (Figure 5). The percentage of students involved in undesirable activities in Biophysics was also noteworthy; there was a high percentage of absent students, followed by students not involved, or involved in personal needs or social interaction. In general, i the HPL-aligned courses (IA-332: Figure 5; EI-100: Table 2) the percentage of students involved in undesirable activities was lower than the observed in "traditional" courses (IQ-210 and FS-320: Figure 5).

The NN is a third instrument of the VOS, with which we can detect the presence of many features that should be present in every HPL-aligned classroom. Figure 6 presents the results for four selected characteristics that were observed in the studied courses. At IQ-210 and FS-320 the only observed characteristic was "professor guided question-answer". These teachers didn't promote high-order discussions, cooperative work to solve a problem, nor allowed the students to explain how they solved the problems. The Food Chemistry teacher guided questions and answers, but also carried out collaborative work to solve problems; students were enabled to explain how they solved problems, and also held high level discussions some times.
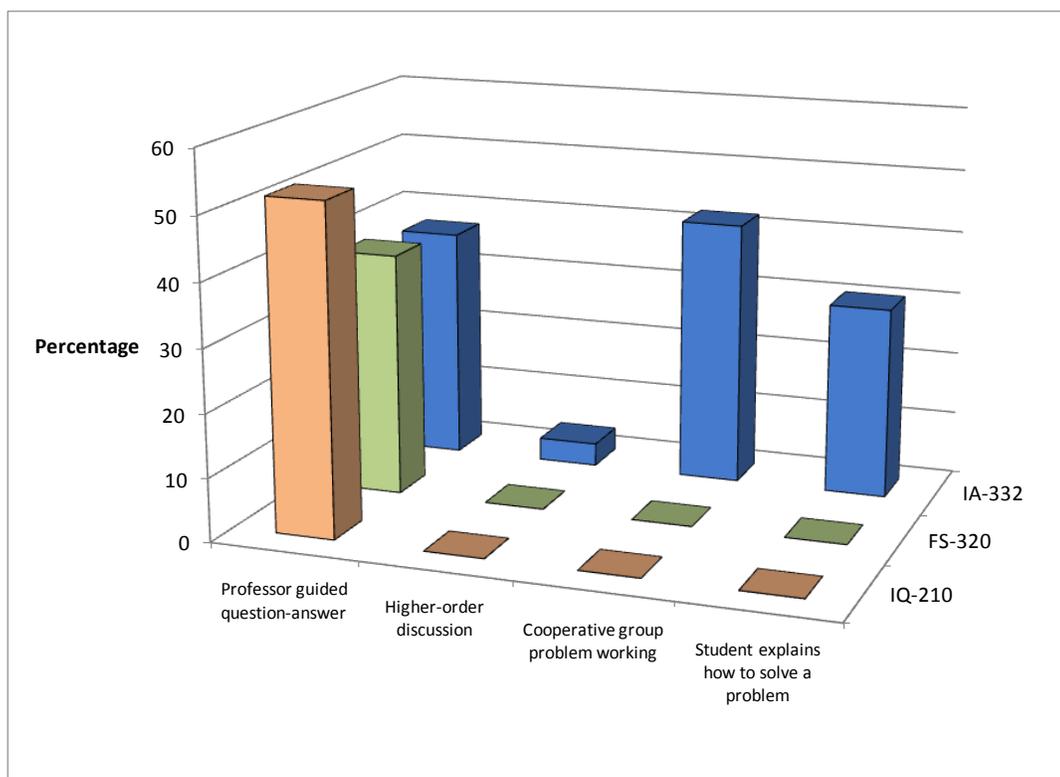

Figure 6. Percentage of HPL characteristics observed at Material Balances (IQ-210), Biophysics (FS-320), and Food Chemistry (IA-332) courses.

In an HPL-aligned course many actions by the teacher should be observed by the GR instrument. As exhibited in Figure 7, the IQ-210 teacher took assessed student understanding during class and at the end of it. But there are other actions as the assessment of student understanding at the beginning of the class, asking hypothetical questions, or making connections to prior learning

that were less important for this teacher. In fact it was a course that provided few HPL challenges to students. In FS-320, ongoing assessment of student understanding was regularly observed as well as teacher's enthusiasm. Results were lower in the categories of assessment of student understanding at the beginning and en of class, and also in making connections with prior learning. Even smaller ratings were observed for asking hypothetical questions and the use of appropriate visual aids. FS-320 didn't provide any HPL challenge. Food Chemistry is a course redesigned following the HPL framework and everyone of the expected actions were captured by the GR instrument of the VOS (Figure 6).
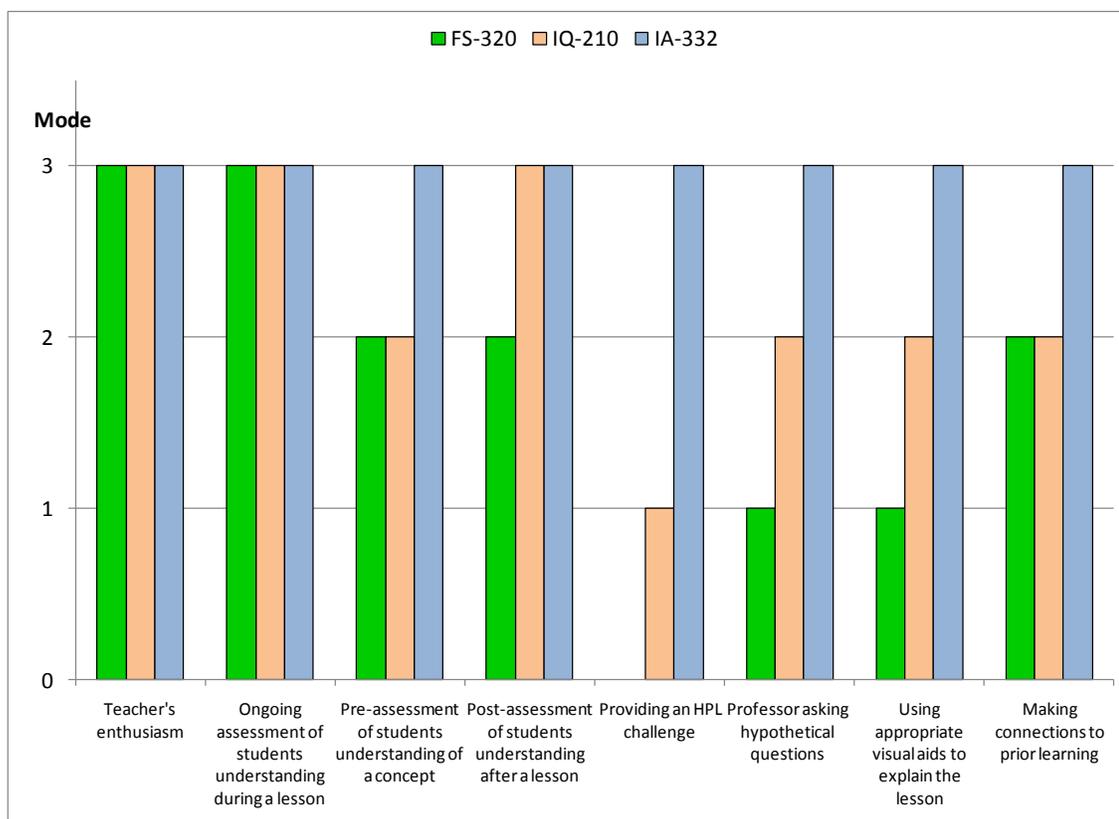

Figure 7. Mode (0: never observed, 1: a few times observed, 2: regularly observed, 3: always observed) of selected HPL characteristics at Material Balances (IQ-210), Biophysics (FS-320), and Food Chemistry (IA-332) courses.

Based on the use of the first three VOS instruments (CIO, NN and GR), it may be concluded that the Food Chemistry course is aligned with the HPL framework. In the group observed, a great deal of knowledge-, learner-, assessment- and community-centered activities were observed, as well as characteristics that should be present in an HPL-centered classroom such as students explaining how to solve a problem, cooperative learning takes place in the classroom, and the professor guides higher-order discussions and leads HPL-based question and answer sessions. Further, several characteristics that should be promoted by a professor conducting an HPL-oriented class were also observed, for instance offering HPL challenges; connecting with prior learning; formatively assessing at the beginning, during, and at the end of class; using appropriate visual aids; and asking hypothetical questions.

Comparison among studied courses

Table 3 summarizes some statistics of the observed courses, two of these courses (EI-100 and IA-332) can be considered as HPL-centered courses and the other two (IQ-210 and FS-320) as "traditional". It is important to note the high percentage of students who completed most courses; it is also noteworthy the great percentages (80%) of daily attendance in EI-100; a fact that differs importantly from what happened in FS-320.

Table 3. Comparison among courses: Introduction to Engineering Design (EI-100, sections 01 and 02), Material Balances (IQ-210), Biophysics (FS-320), and Food Chemistry (IA-332).

	EI-100		IQ-210	FS- 320	IA-332
	01	02			
Students enrolled	N= 43	N = 68	N=21	N=24	N=23
Students who completed the course	34 (79.1%)	60 (88.2%)	18 (85.7%)	17 (70.8%)	23 (100%)
Average daily attendance	36 (87.8%)	58 (89.2%)	17 (80.9%)	12 (50%)	20 (86.9%)
Average final grade	8.03 ± 2.40	8.64 ± 0.81	7.72 ± 2.09	ND	8.79 ± 0.38
Number of students who failed the course or withdrawn from it	7 (16.2%)	8 (11.7%)	3 (14.3%)	7 (29.2%)	0 (0%)

We realize how poor can be a comparison between studied courses with the final grades obtained, since a large number of factors affect the final grades, such as the semester in the program, the number of students enrolled, the teachers involved, etc. However, and since there is no other means of comparison, the final average was used to try to compare the observed courses. The final grades were higher in courses aligned to the HPL framework than in the "traditional" courses. Furthermore, the percentage of students who withdrawn or failed the course was higher in "traditional" courses.

Final remarks

The VaNTH Observation System captured important differences among redesigned and "traditional" classroom experiences. These differences may be used to measure levels of "HPLness" of a lesson. Moreover VOS clearly captured differences among instructors' teaching styles. In addition, VOS generated detailed feedback that instructors may use to self-assess.

The use of VOS allowed us to observe the presence of several HPL characteristics in the courses IA-332 and EI-100, features that were not observed in the other two studied courses. Therefore Food Chemistry and Introduction to Engineering Design are both courses aligned the HPL framework, they are knowledge-, learner-, assessment-, and community-centered. In contrast, Material Balances and Biophysics are "traditional" courses not aligned to the HPL-framework mainly knowledge-centered.

Student final grades in redesigned courses were higher than those found in "traditional" courses. Further, fewer students failed or withdraw from the HPL-centered courses. In every studied course students were involved in desirable and undesirable activities. However, the number of students involved in undesirable activities is higher in "traditional" courses than in the HPL-aligned courses. Further, the number of students performing desirable activities is higher in HPL-aligned courses than in the "traditional" courses.

Acknowledgments

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