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Graduate Student Perspectives on Using Tablet PCs and Associated Technologies

Abstract

The *How People Learn* framework\(^1,2\) was utilized to redesign the course Advanced Food Chemistry (IA-530), which is part of *Universidad de las Américas Puebla* (UDLAP) food engineering master and doctoral programs. Our goal was to improve graduate food chemistry teaching and learning by creating high-quality learning environments that promote an interactive classroom while integrating formative assessments into classroom practices by means of Tablet PCs and associated technologies. In order to examine how students perceived the use of Tablet PCs and associated technologies, we conducted semi-structured interviews with IA-530 graduate students that had completed the course. The analysis indicated a number of themes that consistently appeared within the interview sessions and were addressed by students from different viewpoints. Five overall themes emerged: student participation in class by means of Tablet PCs, impact on learning, potential of Tablet PCs and associated technologies, formative assessments, as well as advantages and disadvantages of using the Tablet PC in IA-530 classroom. This paper reports upon the themes identified in the analysis of the results from the semi-structured interviews.

Context

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.

Course description

The studied course, Advanced Food Chemistry (IA-530) is a first-semester 3 credit required course for the MSc program and also an elective for the PhD program at UDLAP. Approximately 10-15 graduate students are enrolled per semester in IA-530; these graduate students have already earned a BS in food engineering, food science, biology, agricultural engineering, chemistry, or pharmacy. The major goal of the course is to help students think about the way a food chemist does. Thus, students are involved in answering two key questions: i) how the composition, structure and properties (especially in terms of quality and safety) of foods are affected by chemical changes the food go through? And ii) how the understanding of key
chemical and biochemical reactions can be applied to many situations encountered during formulation, processing and storage of food?

The fundamental concepts of the studied courses are, therefore, chemical and biochemical changes of food and its effect on food composition, structure, quality, and safety during formulation, processing and storage, while encouraging students think about and apply food chemistry in the same ways experienced food scientists and engineers do.

**Theoretical background**

The studied course, Advanced Food Chemistry, could be improved taking into account technological advances and recent research on human learning and cognitive processes that underlie expert performances\(^3\).

*Using information about How People Learn*

During the past 30 years, research on human learning has exploded. Although we have a long way to go to fully uncover the mysteries of learning, we know a considerable amount about the cognitive processes that underlie expert performances and about strategies for helping people increase their expertise in a variety of areas\(^1\)\(^-\)\(^4\).\(^7\). Several committees organized by the US National Academy of Sciences have summarized much of this research in reports published by the National Academy Press. A key publication that informs our current discussion is *How People Learn: Brain, Mind, Experience and School*\(^1\).

An organizing structure used in the *How People Learn* volumes (hereafter HPL) is the HPL framework. In particular, it suggests that we ask about the degree to which learning environments are\(^1\)\(^-\)\(^4\):

1. **Knowledge centered.** In the sense of being based on a careful analysis of what we want people to know and be able to do when they finish with our materials or course and providing them with the foundational knowledge, skills, and attitudes needed for successful transfer.
2. **Learner centered.** In the sense of connecting to the strengths, interests, and preconceptions of learners and helping them learn about themselves as learners.
3. **Community centered.** In the sense of providing an environment, both within and outside the classroom, where students feel safe to ask questions, learn to use technology to access resources and work collaboratively, and are supported to develop lifelong learning skills.
4. **Assessment centered.** In the sense of providing multiple opportunities to make students’ thinking visible so they can receive feedback and be given chances to revise.
The HPL framework provides a convenient way to organize a great deal of information about the nature of competent (expert) performance and about ways to help people develop their own competence\(^1\). The framework highlights a set of four overlapping lenses that are useful for analyzing the quality of various learning environments. Balance among the four lenses is particularly important to create high-quality learning environments; since for example, some learning environments can be knowledge centered but not learner centered, and vice versa. In addition, many environments lack frequent opportunities for formative assessment and revision, and many fail to promote a sense of community where learning (which includes admissions of “not knowing”) is welcomed, and therefore are not aligned with HPL framework four lenses\(^1, 2\).

**Tablet PCs**

In an increasingly collaborative, mobile and globally inter-connected environment, UDLAP envisions ubiquitous computing as a natural, empowering component of every teaching, learning, and research activity. Tablet PCs combine a standard notebook computer with a digitizing screen and a pen-like stylus device to produce a computer that allows ease of input of natural writing and drawing. Pedagogically, applications for the Tablet PC include lecture/presentation enhancement, problem-solving demonstrations, active learning support, guided brainstorming, reading, commenting, marking-up (providing feedback), and grading of student work.

A review of the current literature supports the following advantages in using a Tablet PC\(^3, 6-11\):

1. Digital ink enables instructors to write “on the fly” during class as one would write on a chalkboard or on a transparency. This is especially meaningful for engineering and chemistry courses where examples and explanations are often mathematically and graphically intensive.
2. The freedom of marking-up significantly changes the way students and teachers interact. It facilitates bidirectional sharing of information, moving students beyond merely observing presentations to interacting with the material, the teacher, and each other.
3. The use of Tablet PCs supports more efficient management of information. Dynamic working notes can be saved in a searchable format, while lecture notes with vivid annotations become available for students’ online viewing.

**Redesign of the course**

A major issue is to help students develop the kinds of connected knowledge, skills, and attitudes that prepare them for effective lifelong learning\(^3, 4\). 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. The ability to design 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. Thus, for the redesigning of IA-530 similarly as previously described\textsuperscript{3,6} we “worked backwards” as suggested by Wiggins and McTighe\textsuperscript{12} taking into account Jenkins model\textsuperscript{13} as well as the HPL framework\textsuperscript{1,2}. Our redesigns involved a transformation of IA-530 from a lecture-based format to a challenge-based format. We use the term “challenge-based” as a general term for a variety of approaches to instruction that many have studied:

- case-based instruction
- problem-based learning
- learning by design
- inquiry learning,
- anchored instruction

There are important differences among these approaches, but important commonalities as well. We used the HPL framework as a set of lenses for guiding the redesign of the lessons, development of our challenges but also the overall instruction that surrounded the challenges\textsuperscript{1-4,6}. Particularly important were opportunities to make students’ thinking visible and give them chances to revise. We also noted the importance of provided opportunities for “what if” thinking, given variations on the challenge and for new problems that also involved the lesson’s concepts.

**Methodology**

The *How People Learn* framework\textsuperscript{1,2} was used to redesign the course Advanced Food Chemistry (IA-530). Our goal was to improve graduate food chemistry teaching and learning by creating high-quality learning environments that promote an interactive classroom while integrating formative assessments into classroom practices by means of Tablet PCs and associated technologies\textsuperscript{3,6}.

We mainly utilized two Tablet PC associated technologies, *InkSurvey*\textsuperscript{4} and *Classroom Presenter*\textsuperscript{5}, to gauge student learning in real time, provide immediate feedback, and make real-time pedagogical adjustments as needed. Detailed information is available elsewhere\textsuperscript{3,6}.

In order to examine how students perceived the use of Tablet PCs and associated technologies, we conducted semi-structured interviews (lasting on average 20 min each) with IA-530 graduate students (four men and eight women) that had completed the course. These students were selected from a pool of potential participants using maximum variation, trying to choose them in order to represent IA-530 demographics.

**Results and discussion**

As reported previously\textsuperscript{3,6}, the redesign of IA-530 significantly (p<0.05) increased student participation and formative assessments. Instructors utilized the information gained through real-
time formative assessment to tailor instruction to meet student needs. Particularly important were opportunities to make students’ thinking visible and give them chances to revise, as well as opportunities for “what if” thinking. Attempts to help students reflect on their own processes as learners were also emphasized. The VaNTH Observation System (VOS, an assessment tool developed to capture qualitative and quantitative classroom observation data from teaching and learning) was used to systematically assess HPL framework implementation in the redesigned classroom and results are reported elsewhere. Observers measured differences in classroom experiences resulting from the innovations and redesigned learning environments. VOS captured important differences between redesigned and “traditional” classroom experiences. These differences may be used to measure levels of “HPLness” of a lesson. In addition, VOS generated detailed feedback that instructors may use to self-assess.

Semi-structured interviews (lasting on average 20 min each) were conducted with IA-530 graduate students (four men and eight women) that had completed the course. Of the selected and invited students, none refused to participate. Audio recordings were transcribed and then analyzed. We developed codes inductively through the data and based on relevant literature.

The qualitative analysis indicated a number of themes that consistently appeared within the interview sessions and were addressed by students from different viewpoints. Five overall themes emerged: student participation in class by means of Tablet PCs, impact on learning, potential of Tablet PCs and associated technologies, formative assessments, as well as advantages and disadvantages of using the Tablet PC in IA-530 classroom.

**Student Participation**

Students noted that the use of a Tablet PC in class leads to greater participation, due to the interaction with the teacher and the tablet itself. Using the Tablet PC encourages participation in the classroom because the students can manipulate and control the data presented by the instructor and ask questions at the same time without losing the information. Also, the Tablet PC allows them anonymity and that gives security to respond without fear of being shamed for not giving a correct answer. Students mentioned that the tablet itself is a tool that encourages participation by being interactive and allows sharing ideas among peers, generating more participation to be working in teams. Selected quotes follow:

“The fact that you have the slides in your hands lets you have more vision because you’re seeing the information and while the instructor continues with his class, and you just fall behind on something, but you may return the slide and you can ask a question, then if there is more participation, and the fact you have the information in your hands is more useful and you can manipulate the same time.”
“There is more participation by the anonymity that allows you the Tablet PC because somehow when assessments are made and sent to a professor without a name you feel more confident and secure.”

“Definitely, there is more participation because there are students who feel a little embarrassed at the time to express their views and a Tablet PC gives you more security, and you're not mentioned, but also much interest also causes everything electronic and computer and for the sake of manipulating the Tablet is an emotion more to participate and not just the course itself, but by the tool.”

“I think there is more participation because I think it keeps the attention of students if the teacher only speaks and you’re standing and sitting as a student listening and writing down what you said, I do not learn the same way, for I have learned, and so much more visual, the teacher will explain you go paying attention, you're scoring, is more dynamic and I like it because there just are sitting listening to what the teacher says.”

“There is more participation, because everyone has their own pace in the Tablets, then you'll scoring, you go checking and if you have any questions, you obviously tell it to the teacher.”

“There is more participation, especially when using Classroom Presenter and InkSurvey because the dynamics are given in the questions and dialogue with classmates is to choose the correct answer or answers, more participation and teamwork.”

“There is a greater participation because the class becomes so active that motivates you to participate, to do more questions and you're not distracted all the time, because there you're writing, you're storing everything in a computer and how is also something else you do not use in every class, that makes you have more motivation to go to the class, because you're using another type of material motives and that's going to use them more with the teacher.”

Impact on Learning

Students commented that using the Tablet PC affected how they managed and obtained information during class to use in their learning. Using the Tablet PC in the classroom has an impact on learning. The ability to take notes on the teacher's presentations and exercises conducted in Classroom Presenter and InkSurvey facilitated the understanding of the topics discussed in class when they studying at home. They mentioned that taking notes in addition to the information provided by the instructor supplemented the ideas that were then easier to remember because it became important cues that help them learn. Selected quotes follow:

“During the classes I could scroll each of the slides that were explained, so if it was easier to digest information and learn more.”
“I learned more and going according to the teacher to make the structures then it was of great help.”

“Had a positive impact and it was faster, more agile when doing exercises in class”

“Nevertheless of the presentation on the blackboard, the fact that I had my personal Tablet PC I had the opportunity making my notes. Also what I liked is that when the teacher did some questions and we sent responses we could see the results of our answers in real-time and know if the exercises had been successful, i.e. if you had learned.”

“Using a pen with different colors, presentations were made and to score right there, I feel my learning was favored because also I could check my notes later and it's easier when you write down in a notebook as you do not know exactly where the instructor explain why you get lost when studying.”

“I found it very useful to have the teacher's slides while scoring and thus get no ideas and recovering lost when studying.”

“Using a Tablet PC in my class had an impact in terms of matter, I think it favored, more than anything streamlined.”

“Learning was better, the sort that might seem a bit tedious for so long, two and half hours but did not feel were sitting in one place, then moved the Tablet, you saw the professor writing, commanding things, then gave me concerned that does not feel tedious class and little chance of interaction with the teacher as not interrupting and raising his hand and the information that you can take it to your house.”

“Tablet PC favored me and I like too much because I was following the teacher and I could write what he said a note you could use it, then save it, then when you wanted to study entry had that maybe something by issues, not was then recorded and then there was you had the great advantage, they were like small keys these keys are important for the study also help.”

“With a Tablet is a different way of learning and assume that things should be noted that sometimes you have to put in your notebook the general idea but suppose on a Tablet and if they are putting a slide specifically the issue and features or key points that can help you later when studying.”

Potential of Tablet PCs

Students noted that the use of the Tablet PC in the classroom increases motivation and participation, however, have not been "exploited" enough, so they consider the potential of the Tablet PC is great, as long as maximum use and implemented in most courses. In class, students had the opportunity to manipulate the information that was provided by the instructor and class
exercises to receive feedback in real time. After these experiences, students said it would be more useful if all applications are considered as being able to write, take photos, take up other programs and the sharing of information between peers in real time, not only with the teacher. They mentioned the communication and collaborative work is much more streamlined using the Tablet PCs and associated technologies. Selected quotes follow:

“The Tablets have much potential as the deal also depends on everyone, but I personally think it takes up very well if a Tablet has much potential in so many ways, as well as speeding up the class could be a database much larger recordings could be because that I think helps a lot, have a recording, and then return to hear what the teacher is saying I think I could share more files, and could save many more things are not just notes, simple images, photos or other things and generally have a record of everything.”

“Has great potential in the classroom, I could share my information with my classmates, i.e. the notes I took, maybe my partner did not take it with or vice versa. So if, as we can share information, notes or details that are important for the class, not just for you, but the information go to the Tablet of the student to the teacher but also between peers can be sent as a network, more collaborative work with peers, not just student-teacher, but between partners.”

“It could work better together as a class, not only could see what was making the teacher if you could not see what your peers are doing.”

“The experience was very good because we had communication with the teacher, it was much faster.”

“It could have more activities in the Tablet e.g. solve more problems and peer review them, not only the teacher could give you your answer or feedback.”

“I should work doing more exercises. I imagine in a chemistry course, for example, along with my students that is the stuff that I am, asking everyone to put their name and asking formulas to quickly check whether the knowledge of a formula is, example, something as simple is the formula of water or the structure of methane and see quickly if the knowledge that I teach was learned, to see if knowledge has been acquired as you think you were, because traditionally it is the ask them to write it on a paper, and then to review both your sheet and you visualize faster, faster I would say to see if the knowledge was acquired.”

“I believe that we used only a small part of the Tablet PC and I think it still has many more uses, because according what we have been heard there are universities where they now use them too, I think if there were other classes would be much easier learning because you would be fully connected with the teacher, with the subject and with the whole class.”
“I feel that should be used more the Tablet PC for other classes in the university, because I have understood that they are like 3 or 4 courses around throughout the degree and only in the engineering department, its use is very low, and if you used more would be better. Teachers will be prepared, would have more information, classes would be more interesting, have more activities, you can ask more, you can do maybe a consideration at that time to see how much you understand, the student may have many uses.”

Formative Assessment

Students commented that the Tablet PC offers the possibility of real-time feedback and this allows them to make their thinking visible and have the opportunity to revise their ideas immediately. The real-time feedback on the exercises done in class was very helpful for them. The ability to see almost immediately the results of their formative assessments or tests (that didn’t had an impact on their grades) before summative assessments (which had an impact on course grades) helped resolve doubts and clarify them with the instructor. Being able to develop formulas, make notes, solve cases, exercise, etc., in any of the software used in class (InkSurvey and Classroom Presenter) both individually and in teams, allowed for a greater understanding of the topics discussed in class. Students mentioned that the feedback should be not only by the instructor but may occur between themselves (students) and can be anonymous, which gives them more confidence to participate in the process of formative assessment. Selected quotes follow:

“You can assess the degree of knowledge that you had in the questions, I think that is good, also when the instructor gave us team exercises, the fact that you get the answers of all the teams and you can see each of the responses of other teams, feeds you more because you can take information from these answers to your notes.”

“I find it very important because then you could find out if had a knowledge, or what we were seeing in class you understood clearly or definitely or maybe you had misunderstood then the time to give real time feedback then that you ask again and allowed the teacher to explain again without losing the sequence of the subject because it also sometimes happens that you give the class or the class is given, you get to your house, study your notes and obviously the next day must resume at the time but as you are with it now the feedback is more dynamic and understandable.”

“When the teacher works a case, we answered either individually or in teams, and then he was telling us our answers and if they were good or whether they were wrong and if they were poorly explained to us why.”

“That part of doing the exercise and at the same time see the feedback I think is very important.”
“Always seek to improve learning. In a Tablet you can write about everything in the areas where you have to write formulas such as chemistry, you write the formula and you can send it to the teacher, he will review it and feedbacks you, and it is something that is very supportive.”

“I think it's much better to work with the Tablet PC, with this technology, to work on a sheet and give it to the teacher, it's much better for the teacher to provide feedback to the students, if there are doubts that perhaps someone worth asking he/she can type and send it anonymously.”

“Many times ourselves reviewed our exercises in the class, if the teacher took a note and wrote in the Tablet and viewed all, not just my own notes, but of all student notes, or the professor stressed something and I saw i. We also made exercise voting anonymously and that helps the student to join the course by that which they are ashamed of being wrong, that can help you to participate because often not involved or to recognize that if you know because sometimes you do not know if you know or something you're embarrassed to ask the teacher.”

Advantages and Disadvantages

Students believe that a Tablet PC has the advantage of the stylus pen to take notes on the teacher’s slides and the screen can rotate more comfortable to take notes. The Internet connection must function properly to avoid wasting time during class. However, among the disadvantages, students mentioned that in some cases, being connected to the network can divert attention and check their email, keep checking social networks, etc., losing sight of the class teacher. Selected quotes follow:

“The fact that you have the information in your hands, maybe you can trust that you have the notes of the instructor and do not take your own notes.”

“It is very easy for example to be in social networks or being on the Internet or checking the email, I think you can generate a disadvantage because now if instead of sharing or get closer to the teacher and students, you move away.”

“The Internet connection sometimes failed and that is a problem if you don’t have a good support.”

“I believe that for a presentation is very useful because you can take notes that the teacher says during your presentation, and also consider the fact that it can rotate, moreover, makes it more comfortable and more simple because you do not feel that the keyboard is disturbing you, then I think also that it is as harmonically very, very good choice for taking notes.”
The fact that you have a pen and taking notes is great because if you do not have to print the slides before coming to class and take notes on paper with a pen in hand and with it, take notes with the stylus and then send them to your email and already studying and you have the information on the slide without having printed before taking the class.”

“I see advantages from the point of view that one can stay connected with the teacher, who can send you some answers to your questions, etc.”

Carney\textsuperscript{15} identified goals and sub-goals of each lens of the HPL framework as well as classroom practices associated with each of them. As many practices can serve multiple goals, she further described their possible relationships. We will try to explicitly tie the HPL framework with the results of student interviews:

\textit{Learner-centered classroom}

The goal of learner-centered instruction is to help students build on the conceptual and cultural knowledge that they already have and to help them develop better skills and practices for future learning. The first learner-centered sub-goal is to develop a model of the student’s existing: knowledge and conceptions, including misconceptions; skills, attitudes and beliefs; as well as communicative practices. This sub-goal is consistent with an assessment-centered classroom as well\textsuperscript{15}. This was evident in the interviews through a variety of specific learner-centered classroom practices (that also served the purpose of formative assessment) fostered by the use of Tablet PCs and associated technologies: observation, questioning, conversation, and reflection on student activities and products. This results are in accordance with the quantitative study previously published\textsuperscript{3}.

A second sub-goal of a learner-centered classroom is to give students ample time, tools and opportunities to construct knowledge. This can be done through a variety of specific learner-centered classroom practices that support knowledge-building as well\textsuperscript{15}. The practices evident from the interviews include: open-ended long-term problem solving activities that force students to deeply examine a phenomenon, discussing misconceptions, presenting situations/problems that will provide cognitive conflict, and enabling students to readjust their thinking. Sometimes students were given an opportunity to do this in a social or learning community context. Under these circumstances, these practices can be learner-, knowledge- and community-centered\textsuperscript{15}, thus will be further encouraged in the next semesters.

A third sub-goal of a learner-centered classroom is to give students an understanding of their own knowledge and learning processes, that is to foster metacognition\textsuperscript{15}. This was done through a variety of specific learner-centered classroom practices evident from the interviews, including: fostering student reflection on their own understandings and thinking, self-assessment, reflection
on own growth and change over time, and discussing the nature of misconceptions and their role in understanding. Many of these practices can also serve an assessment-centered goal or sub-goal as well\textsuperscript{15}; therefore they will be additionally promoted by means of Tablet PCs and associated technologies.

\textit{Knowledge-centered classroom}

A goal of a knowledge-centered classroom is to create flexible, adaptive understandings of the ideas, skills and important information of a given domain. One sub-goal of a classroom that is knowledge-centered is the construction of conceptual knowledge and competencies that allow flexible, adaptive reasoning. Specific practices to meet this sub-goal might include: instruction or activities focused on conceptual knowledge (rather than facts), relating specific knowledge presented to concepts, relating skills to concepts or the work done in the larger domain, and introduction of new content in response to student confusion or need\textsuperscript{15}. From the interviews, the following practices that meet this sub-goal, but were not evident to students are: experimental, hands-on learning situations where the activity is related to larger concepts, classroom activity that emphasizes non-scripted exploration and sense-making by students, as well as student creation and design of experiments or other hands-on learning activities. Although the following practices that meet this sub-goal, but can also support learners and be used for assessment were clearly identified by students in the interviews: encouraging students to formulate questions about their understanding, classroom activities that help students practice reasoning with concepts, classroom activity that relates facts to concepts, practicing transfer or extension to other problem contexts or kinds of activities, as well as classroom activities that call for students to articulate their explanations or reasoning\textsuperscript{15}.

A second sub-goal of a classroom that is knowledge-centered is to help students to understand how the knowledge is used in a larger context or community of practice. Specific practices that support knowledge-building but are also community-centered may include: activities that lead to an understanding of the discipline. Any of the following knowledge-building practices help students understand context or community of practice, but also take seriously the learner’s knowledge construction processes: students participate in investigations or other domain-authentic activity, and students are asked to reflect on how their work relates to domain or professional activities\textsuperscript{15}. These practices were not evident in the interviews, thus will be included in the new re-design of the course.

\textit{Assessment-centered classroom}

The goal of assessment-centered instruction is to provide ongoing insight into students’ knowledge construction so that classroom activities can be tuned. One sub-goal of assessment-centered instruction is to help the instructor monitor students’ understanding as it evolves\textsuperscript{15}. 
Specific practices relating to this goal that were evident from the interviews and fostered by the use of Tablet PCs and associated technologies include: designing activities that can be used to make student thinking visible, using day-to-day student activities and work to provide formative assessment feedback continually (rather than one shot-high stakes summative testing), i.e., assessments are integrated with instruction rather than separate from it. A specific practice related to this sub-goal that is also knowledge-centered and less evident in the interviews is: assessing the student’s ability to discern whether and when to apply concepts, facts or procedures to novel situations (transfer)\(^\text{15}\), thus will be further encouraged in the next semesters.

A second sub-goal of assessment-centered instruction is to help the instructor constantly refine instructional practice in light of their students’ understanding. Specific practices are: development of a model of desired learning and activity, reflection on the practices and products of students, as compared to this model, and revision of this model as appropriate\(^\text{15}\). Although these practices were not evident in the interviews, they were present in the course as previously reported in the quantitative study\(^3\).

A third sub-goal of assessment-centered instruction that is also learner-centered is to provide appropriate formative assessment to individuals. A specific practice relating to this sub-goal not evident in the interviews was assessing the student’s ability to discern whether and when to apply facts or procedures, therefore will be included in the new re-design of the course.

A specific assessment-centered practice relating to this sub-goal that is knowledge-centered and also learner-centered and clearly evident in the interviews is: assess students’ abilities to relate content to other parts of the curriculum and their life experiences while feedback given encourages and helps students to revise their thinking\(^\text{15}\). The latter was clearly fostered by the use of Tablet PCs and associated technologies as stated in the interviews.

A fourth sub-goal of assessment-centered instruction that is also learner-centered is to help students to learn to assess their own learning and understanding. Specific practices leading to that goal clearly evident in the interviews include: providing formal and informal feedback, provide feedback about how the student does tasks in addition to whether he or she does them correctly, while more needs to be done in the course with regards to supporting students in learning how to self-assess or assess peers’ work. Since as stated by Carney\(^\text{15}\), this sub-goal can be achieved in a community-centered way, by teaching students how to assess each other’s work providing opportunities for groups to work collaboratively and assess each other’s work.

A fifth sub-goal of assessment-centered instruction that is also community-centered is to help students to assess their ability to work in a group or contribute to the community. Specific practices leading to this goal include feedback as to how the student works in the group\(^\text{15}\). Therefore these practices should be further promoted in the new re-design of the course.
Community-centered classroom

The goal of community-centered instruction is to connect students’ knowledge construction to the multiple community contexts in which the knowledge is situated. These contexts include the school and classroom community, the student’s larger social community, and a community of practice in which the knowledge is used. One sub-goal of community-centered instruction evident in the interviews is the creation of a learning community in the classroom in which all students feel that they have a stake in the knowledge construction process. Also evident specific knowledge- and community-centered practices fostered by the use of Tablet PCs and associated technologies that lead to this sub-goal include: establishing social norms of the school or classroom that value the search for understanding; learner- and community-centered practices that lead to this sub-goal are: establishing a classroom climate in which students have freedom to make mistakes, as well as establishing a classroom climate in which students feel free to ask questions, explore new questions and hypotheses. Community centered practices that can lead to this sub-goal that can also serve assessment and were not evident in the interviews include: class construction/negotiation of standards for student work and peer to peer feedback on work, while it were evident classroom work practices that value student sharing and critique of each others’ work.

A second, and learner-based sub-goal of community centered-instruction is to help students to connect their knowledge construction activities to the larger community they live in. Specific practices that can lead to this sub-goal that were not evident in the interviews are: establishment of relationships between classrooms and the community in which the University is settled, classroom tasks in which students are explicitly asked to report on or reflect on the relationships between their home life and classroom activity, activities in which persons from the community share their practices or knowledge with the students, activities in which students share their work to persons from the community, curricular focus that encourages making connections between outside and in-school learning, and classroom norms are congruous with those of the larger culture. Therefore, these practices need to be included in the new re-design of the course.

A third, community-centered sub-goal, which is also knowledge-centered is to help students understand the community of practice in which any knowledge is used. Specific practices that lead to this sub-goal are: outside expert practitioners are consulted in order to help students understand the community of practice in which the knowledge is used, tasks engaged in are similar to those practiced in by experts, and experts are a resource for students. These practices were not clearly evident in the interviews, thus will be included in the new re-design of the course.
Final remarks

Our findings demonstrated that graduate students think that using Tablet PCs and associated technologies: increased their motivation to participate in class as well as their scores in graded work-products; made the classroom more active and them constantly thinking, thus learning with understanding increased; that the university should implement it into other classes; the teacher provided a great deal of real-time feedback to students that made their thinking visible and gave them chances to revise. Among the disadvantages, students think that teachers should be advised the chance students have of being able to check their e-mail and social networks while using the Tablet PCs. Furthermore, a new re-design of the course guided by the How People Learn framework should ask with more detail what would the new learning environments look like if they operate at the intersection of the four lenses of the framework?

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References


