Teaching a Multicultural Perspective in Software Engineering

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Abstract - **Globalization of thought refers to the development of ideas and judgments to accurately account for multiculturalism. Within software engineering, it is important that students understand that when planning a product, designers must keep the scope of the project in mind. Many products have a worldwide effect; product planning must take into account the needs, desires, and cultural mores of societies that will be impacted.**

In the globalization lecture delivered within undergraduate software engineering courses, the students were prompted with different discussion questions involving products that were successful in the American market, yet failed in a foreign market. Students thought mainly of politically correct rationale as a means of explaining why the products were not globally successful. While the students began to develop an understanding of what globalization meant and its effect on product design during the lecture, afterwards they failed to incorporate this knowledge into their subsequent software designs.

To help students develop an appropriate understanding, the pedagogical theory of backward design was used to develop a curriculum that helped pupils build an understanding of multiculturalism and apply it to product design.

Index Terms - Backward Design, Expert Learners, Facets of Understanding, Knowledge Domains, Knowledge Schemas, Software Engineering.

INTRODUCTION

Software engineering is a discipline that is not limited to one culture or client base; product development must consider who the customer base is and what that customer base requires. Therefore, when teaching software engineering principles, variations amongst clients must be considered when making product development judgments and idea developments.

This consideration of a variety of needs of multiple types of customers can be summed up by the term "multiculturalism." Multiculturalism is, "of or relating to a social or educational theory that encourages interest in many cultures within a society rather than in only a mainstream culture," or "of, relating to, or including several cultures." [10]

Helping students develop a sense of multiculturalism is a very difficult task because students come to the classroom with information schemas, or webs, that contain ideas and relationships between those ideas about customer needs and software implementations, since they themselves are customers in the marketplace. Unfortunately, a subset of students thinks their ideas are globally accepted. This notion limits their understanding about how other societies work and what those customers may require of products. Therefore, instructors must break down these expert learners' data schemas to permit the development of Affective domain skills that allow for recognizing the perspectives of a variety of clients. By using backward design to recognize these understanding goals, an instructor can create instructional methods and assessments that can help meet these goals.

To try and accomplish this necessary breakdown of inaccurate ideas and to help students recognize the needs of various cultures which must be met by software products, we administer a globalization lecture within both our undergraduate Software Engineering course and our undergraduate Engineering Product Design course. By definition, globalization means to, "to make global or worldwide in scope or application." [10] By administering a globalization lecture, we attempt to ensure that the multicultural nature of end user needs is met.

This paper addresses the concerns instructors have about breaking down these schemas to make room for the global nature of multiculturalism in product design. It begins with a background discussion on the different domains of learning, expert learners and data schemas, and both backward design and facets of understanding. A case study is presented, which explains the development of an undergraduate level globalization lecture that stresses the importance of multiculturalism in product design. We then present an analysis of our case study, which highlights the need for the instructor to make instructional methods personal to the student to break down incorrect informational schemas to allow for the recreation of new ones that recognize the importance of multiculturalism in the global process of product design.

BACKGROUND

I. Levels of Knowledge Gained – Bloom's Taxonomy

As defined by Benjamin Bloom, there are three different domains, or categories, of educational understandings: cognitive, affective, and psychomotor. [1] Cognitive understandings deal with the development of factual

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knowledge and analytical thinking skills. Memorization of dates, analysis of data, and creation of reports fall into this domain category. Affective understandings deal with the development of emotional intelligence. Recognizing social mores, responding appropriately to situations, and valuing work fall into this domain category. Lastly, psychomotor understandings deal with the development of physical abilities. Of concern in this study are the Cognitive and Affective Domains:

Cognitive Domain: [1]

- *Knowledge*: basic memorization of facts and figures;
- *Comprehension*: interpretation of problems and situations;
- *Application*: applying basic facts and theories to new situations;
- *Analysis*: dissection of a situation into specific parts;
- *Synthesis*: taking parts of a pattern or situation and creating a new situation or interpretation;
- *Evaluation*: making value judgments.

Affective Domain: [1]

- *Receiving Phenomena*: acknowledging a situation;
- *Responding to Phenomena*: interacts with the conditions of a situation;
- *Valuing*: attaching worth to an element;
- *Organization*: comparing and weighing values;
- *Internalizing Values*: development of a value system.

An instructor may require a student develop knowledge in any combination of those domains. For instance, a pupil may be challenged with responding to an international economic problem that requires Cognitive Knowledge (economic formulas), Cognitive Application (applying those formulas to the specific situation) and Affective Valuing (determining which situational specifics are germane to the problem).

II. Familiarity with Material – Expert Learners

A student's familiarity with subject material influences how she may digest course curriculum contents and respond to both formative and summative assessment in a subject-specific classroom. These 'expert students' exhibit specific academic characteristics that influence how learning occurs and determines the effectiveness of the teacher's instructional methodology and delivery.

For our purpose, an academic expert student is a person who has developed topical insights due to exposure to ideas within a specific field. These insights positively influence how the pupil thinks, feels, and responds to a variety of subject material. [2] This is caused by an alteration in how the student perceives situational information, analyzes the data, and responds to the academic scenario. She is able to more efficiently weed out extraneous information and focus on germane data, organize information in a practical manner, and both quantify and qualify the situation. Since the expert student can effectively evaluate an academic problem or situation, she can more effectively absorb information and respond to the condition.

The Commission on Behavioral and Social Science and Education has outlined several key characteristics of academic expert students, which positively affect those pupils' learning and corresponding effective instructional methods for usage with such students. One attribute of the expert student is that she can decipher sequences and patterns within an informational scenario. [2] A pupil's response to a scenario will differ depending on the student's previous experiences. An expert student will have stored knowledge in her memory bank, which has been portioned and categorized into various organizational hierarchies that are easily accessible for situational analysis and application.

To apply her highly-organized data to new situations (a high-level, advanced method of thinking), the student expert draws from her "schemas." Schemas are her informational skeletons; they are representative of different situations that can help the pupil determine how best to relate to a new problem situation. [3] By extracting from her pre-developed schemas, the student expert can better understand and respond to new academic problem scenarios.

Moreover, these expert students do not memorize subject-specific facts; relationships, characteristics, and information applications are the focus of an expert student's knowledge base. Her mind is similar to a library's card catalog organizational system; information is stored in portions, and these portions are defined according to attributes, applicable concepts, dependencies, and routine utilization of the data. [4]

Expert students are able to successfully transfer catalogued, mastered, subject-specific understandings to new learning situations. Current researchers and educators stress the importance of the successful matching of expert student transfer abilities (and practice of those skills) with instructional methods that consider pupil learning profiles and corresponding needs. [2]

III. Facets of Understanding and Backward Design

To author and implement effective instruction, a teacher must determine for what understandings he is training. Wiggins and McTighe pioneered the development of Backward Design, in which the designer of instruction must examine his material and determine with what concepts are worth being recognized, which ideas are important to distinguish and practice, and what the major, "enduring" subject understandings are that he wants his pupils to develop. [9] This 'importance hierarchy of knowledge' guides the designer in the appropriate development of formative and summative assessment, which then leads to the authoring and implementing of appropriate instructional methods.

Concepts that are worth recognizing are those that are worth mentioning for low-level understanding mastery. These ideas are oftentimes memorized facts, and may or may not be pivotal to the overall message of the course. Examples of such concepts include historical dates and basic mathematical facts.

Ideas that are important to distinguish and practice are those that mid-level understandings; they may require deeper thought on the part of the pupil. Oftentimes a student may have to grapple with some of these understandings. She may have to examine an idea, analyze it for worth, or think critically about its existence. An instructor may ask the student to respond to the idea in a novel manner.

Enduring topical understandings are the huge notions that teachers hope every pupil will remember after the conclusion of the course. Oftentimes these enduring ideas are complex and multi-idea. They may have value in various scenarios or serve as the crux of many key concepts.

After determining what levels of concepts are important and how they relate, the designer can analyze for which facets of understanding he will teach. The six facets of understanding are:

- Explanation of information: the pupil can explicate situational details, fact attributes, and data;
- Interpretation of scenarios: the pupil can translate ideas, model scenarios, and detail multiple facets about an idea;
- Application of data: the pupil can utilize data in multiple contexts;
- Perspective about the situation: the pupil can provide a critical analysis about a scenario from numerous viewpoints;
- Having empathy: the pupil can discover worth within the context of a situation, based either on character, circumstance, or ethics;
- Development of self-knowledge and metacognition: the pupil can determine why knowledge development is difficult and analyze strengths and weaknesses in her personal learning journey. [9]

The instructor must determine which levels of comprehension are important, and for which facets of understanding he wants to guide his pupils to explore and develop. This focus must be developed before instructional design and assessment creation occur, so the teacher knows for what levels and types of understanding he is trying to train. Once the instructor knows the class focal points, he can better create tools and instruction that spotlight those educational understanding goals.

Following concept identification, the instructor can begin to build instructional methods and lesson plans that foster knowledge-centered environments. Knowledge-centered environments are organized around data and concepts that are ordered by the teacher in a manner that encourages tactical, practical thinking. [2] Various exercises, lecture, projects, and assessments push pupils to develop appropriate subject-specific facets of understanding; the teacher delivers instruction that links main concepts through explanation and example to encourage knowledge transfer. Such lesson planning encourages student understanding transfer because the teacher is trying to create links between what a pupil knows and what she does not know, and what is being presented within the current lesson and what lesson is planned next. Smooth transitioning, accompanied with examples and guidance, help the student think in a logical way, which encourages appropriate subject understanding development.

Knowledge-centered environments and understanding-driven instruction are most effective when applied via instructional methodology that takes into consideration student learning profiles for an expert student classroom.

CASE STUDY

I. Course, Lecture Development, and Pre & Post Assessment Background Discussion

Information regarding the globalization of products is especially important for software applications, especially web-based systems. Such systems can be easily delivered to and accessed by people in a variety of countries due to the ease of use the Internet provides. Within this paper, we will discuss the evolution of the undergraduate level globalization lecture that stresses the importance of this fact and the intricate nature of the pedagogy required to adequately convey this message to students.

We taught the concept of the necessity of global thinking within the topic of product design to meet the needs of various cultures in both an undergraduate Software Engineering course and an undergraduate Engineering Product Design course at Indiana University of Pennsylvania and Carnegie Mellon University. The student population in these classes was primarily junior and senior computer science and engineering students.

The globalization lecture delivered within both classes was extracted from early teaching experience of product design concepts.

When it was delivered in the Software Engineering course, the focus of the class was centered on the software to be delivered to the client. When the lecture was administered in the Engineering Product Design class, the focus of the class was on the general concept of products.

Both courses were team, project-based courses. Students were grouped in teams consisting of 3 to 5 pupils, and each team was asked to design a software or engineering product. Typically, there are 4 to 6 teams per course administration.

The globalization lecture is delivered two-thirds of the way through the semester. The student teams would have developed a significant portion of their product by the time the lecture was presented. At this point in the semester they would have iterated upon their design at least twice, which would have overcome any reluctance to modification of their design based on new information.

The globalization lecture has been developed through a variety of iterations of delivery (each to be referred to as phases). The instructor used qualitative discussions with the student teams to pre-assess their background knowledge with respect to design for a multicultural world. No student team expressed any background understanding of multiculturalism.

The students in these classes are primarily (less than one student per course section) middle to upper class Caucasian students from the same (overwhelmingly rural) geographic region. A qualitative assessment of the student's understanding was done after each phase of instruction on multiculturalism. The assessment was conducted by review of their current product designs done by each student group.

II. Phase I - Description

Phase I consisted of a series of examples or discussions about how software should be adapted for other countries' citizens' usage; this was not related to an in-depth study of culturalism or values systems but to demographic information gathered in other geographic locations.

For instance, during one lecture, the instructor led the class in a discussion about the concept of postal codes verses zip codes and states verses provinces. A simple example of this concept provided to students during Phase I of the globalization lecture was the task of writing software for those in the Canadian market – instead of states there are provinces and instead of zip codes there are postal codes.

The impact of alternative character sets of customers was another example discussion presented during Phase I of the development of the globalization lecture. During the design reviews, the instructor did not tell the students to be aware of alternative character sets. Alternative character sets refer to the different characters used within a written language for expression (e.g.: French letters, Chinese letters).

III. Phase I - Observations

When the class was implementing these postal codes within a product, the students were able to adapt the specific, collected demographic addressing information in software but the general concept was not reflected when discussing the concept of postal code verses zip code in general class discussion. While the students made appropriate changes to zip codes, they could not grasp the Canadian idea of a province (as opposed to an American state). Instead of developing a higher level of understanding about the concept of a global market, the students were actually looking for a laundry list of specific modifications to be made to their software to be successful in the product implementation. They did not understand the concept of cultural differences and values, and the adaptations to software development that this may require.

Additionally, the alternative character sets example further stresses the need for student understanding of globalization of product design to meet multicultural needs. The students' reaction to inquires about alternative character sets was that the instructor did not tell the class to be aware of this important cultural facet, and therefore it was neglected by student software development.

IV. Phase II - Description

Phase II of the development of the globalization lecture involved a recognition that the problem that had to be addressed to students involved culturalism and not just specific adaptation of demographic software information related to the end-user of the software. Phase II built on Phase I by adding additional examples to class lecture. Building on the zip code / postal code discussion, the problems of cultural differences was explained to students in lecture and assessments. The first example provided to students was the famous failed case of Gerber Baby Foods being marketed in Africa. The problem with the product was that the baby jars depicted a famous American, chubby baby on the label. However, in Africa, due to the high illiteracy rate of its people, products in Africa usually depict a picture of what is contained in the packaging on the front of the label.

The second example provided during Phase II of the lecture was another famous failed product case. For this example we used the marketing of Maytag washing machines in India.

V. Phase II - Observations

Initial reactions of students when presented with the failed Gerber Baby Foods African product was that the pupils believed the overall problem was that there was a white baby, rather than a black baby, on the front label. Other student-conceived issues included that it was a chubby baby rather than a smaller baby, and another guess was that perhaps babies in Africa did not eat baby food. When presented with the actual rationale, the students found it amusing that another culture could be so "naïve." However the students did concede that the African customers most likely did not actually believe that there was chopped up babies in the jar of Gerber Baby Foods!

The student explanations as to why conventional washing machines failed in India were that perhaps there was no electricity available for the washing machines to function or that perhaps the customers had no running water for the machines to wash clothing. However, the actual rationale was to why these conventional machines failed in India was that the traditional dress of Indian women is the sari, a very long piece of fabric. This fabric would get wound around the agitation spindle and burn the motor out.

Unfortunately, the reaction of the students to these examples presented within Phase I and Phase II of the globalization lecture was that the pupils' software had to be protected from the needs of such "naïve" cultures. The students could not understand the multi-cultural base of customers available worldwide, and therefore the students were not able to focus on the vast, varying needs of their potential customer base.

VI. Phase III - Description

Phase III of the development of the globalization lecture involved challenging the students' cultural beliefs and values. Both Phases I and II were still included within Phase III's contents; examples were still the primary vehicle of information delivery and no examples were tossed out from lecture content. The first Phase III example was a hypothesized example in which students purchased produce at

a grocery store, but the produce was contained within cans, as opposed to the American convention of having live produce available for inspection and bagging. This was presented with the recognition that the students would still be able to purchase produce as they normally would (personally selecting goods for a cash-and-carry purchase), but that the experience would be "odd" or "unnatural" due to a change in packaging.

The second Phase III example provided to students was a hypothesized website that first asked customers to self-identify race / ethnicity. The rationale given for such a product delivery was that the software could provide a user-centric experience tailored to each visitor. Such a user-centric experience as described to students included pictures of people that looked just like the user.

VII. Phase III - Observations

The pupils' reaction to the first Phase III example regarding grocery shopping was strong; the students did not just simply believe the situation was unnatural, but they could not fathom a culture that would ever do such a thing regarding produce packaging because the situation was so foreign to them. It was important to point out to the class that the potential rational for doing such a packaging; the reason given was that perhaps this other culture that packaged produce in cans did not believe it to be good that random strangers could touch and handle your food during private inspection and potential bagging for purchase. Given a reasonable rational, the student acknowledged why another culture might do this, but they still considered the potential experience to be very unnatural and had a very difficult time trying to identify with this "naïve" culture.

The second example regarding the website customization really disturbed the students because while they could visualize, or understand, that it would be easy to develop such a system, they believed that nobody ever would because they believed political correctness (which determines that asking a person's race and developing a specific tool for that race is inappropriate) is a universal cultural trait, as opposed to simply being an American cultural artifact.

ANALYSIS

I. Phase III - Success

We defined the success of Phase III because the students learned what we aimed to teach them – they grew to understand the importance of recognizing the global nature of software development to meet the varying needs of a multicultural marketplace. Phase III was actually successful in that it did challenge the students' understanding of, and need for, multicultural approaches to designing software. The class discussions, initiated by the students, were questions of how they could actually design their software for a global market.

So, for instance, in web-based systems, there is a separation between the model, view, and control (MVC), the view being the user interface and experience. The students then began to recognize that while changing the view, much of the programming and data system, the model and control of the MVC system, did not have to change. Designing software for a global system and object reuse were complimentary concepts because the model and control of a MVC system would be reused in different cultural interfaces.

II. Pedagogy Analysis

We knew what we wanted to teach within this globalization lecture; students had to develop the understanding that political correctness or American values do not always equate to the reality of a global customer base. Each project has a vast reach, and developing a sense of cultural pluralism is important to the success of the product.

Working within the confines of backward design, we identified these educational understanding goals to develop our formative and summative assessments and instructional methods to achieve those goals. Students had to develop both Cognitive and Affective domain knowledge. Within the Cognitive domain, students had to develop basic knowledge about the software development process and apply that knowledge to specific situations. Additionally, pupils had to identify specific geographic and demographic knowledge to the specific product design in question. Within the Affective domain, students had to evaluate specific cultural mores and values and respond to them appropriately when designing an implementation of a product.

When examining the various facets of understanding, we wanted the students to work on developing their perspectives about the particular cultural position of their customer base and having empathy regarding what those customers need to function appropriately.

The development of the globalization lecture within our software engineering course utilized the concept of backward design to attempt to achieve all of these understanding goals. As defined by the idea of backward design, we first identified the goals of the lecture (both Cognitive and Affective domain understanding development and multi-faceted knowledge development) and then created both formative and summative assessments to help students form these levels of understanding. Recall that formative assessments are those activities and evaluations that help pupils develop identified knowledge and summative assessments are those activities and evaluations that conclude lesson activities, which determine the success rate of the lesson itself. Such assessments for our classes included class discussions and a continuous term product development effort in which they had to participate continuously. The instructional methods that we used within all three phases of the development of the globalization lectures included the presentation and discussion of various multi-cultural product implementations that were both failures and successes.

The caveat that made this lecture tricky was the fact that our students could all be considered expert learners for this particular topic. Recall that an expert learner is a student that has studied a particular area previously and has pre-

conceived information webs, or schemas, of data within his mind. These information webs, or schemas, contain both information and relations between this data, and when a student attempts to learn new information he tries to add this new information to his already-defined schemas. For this lecture topic, each of our American students had preconceived idea webs about the perspectives and values of software clients. Our students believed that software clients were similar to themselves; social mores, values, and interactions should be the same.

The difficult task of our globalization lecture is that we had to break down the information schemas of our expert learners to open up their minds to the different ideas, perspectives, values, and actions of different cultures. An expert learner is not an accurate learner but one that has a deep-seated information schema about a particular subject or area of learning. The biggest problem with this task was destroying the pupils' limited perspectives because their perspectives were firmly planted in the concepts of political correctness and ethnic stereotyping. Each pupil examined each of the situations from a specific viewpoint, grounded in predefined knowledge schemas or webs.

During Phase I, when examining the concepts of provinces and postal codes, students did not break down their concepts of political states or addressing system; they simply tried to accumulate a rote-memorization laundry list that impacted lower levels of Cognitive domain thinking but did not impact Affective domain thinking types or the perspective facet of understanding.

During Phase II the students did not branch out when evaluating the Gerber Baby Foods or Maytag failed product implementations. Rather than breaking down their preconceived notions about other cultures contained within their information schemas, the pupils tried to use those misguided information schemas to figure out an Americanized excuse as to why an American product would not fit with a foreign culture. When presented with the real reasons why the products failed, the pupils heard the reasoning but could not integrate it into their already-existing, politically correct information schemas.

Phase III, on the other hand, was successful. The additional examples in which the students had to think through basic situations in which the roles were reversed – the students' products had been changed, or designed, by foreign product designers – forced the pupils to consider what it is like when software producers do not consider who their clients are. When the students' shopping and Internet needs were not considered when a product was implemented, the students' information schemas about how things should be were broken down and they could begin to develop the facet of understandings of perspective and empathy, which further developed their Affective domain skills.

Students are expert learners in the area of product usage, arriving in the classroom with predefined information schemas about how product consumers function and their viewpoints. By using backward design to identify that we want students to develop Cognitive and Affective knowledge about product design and recognize the perspective of a global marketplace, we were able to develop assessments and instructional methods that broke down those preconceived, Americanized information schemas to open their minds to the multicultural dimension of product development and usage.

CONCLUSION

In this paper we discussed the importance of globalization in product design; multiculturalism demands that software engineers take into account who their customers are, including social mores, personal values, and client needs shaped by location and beliefs. When teaching software engineering students about globalization, the instructor must recognize that his students are expert learners in terms of software usage and what they believe to be customer requirements based on his social experiences. Expert learners are those students who have learned specific knowledge about a topic and formed those ideas into data schemas, or webs, that contain information and relationships between that information. By using backward design to acknowledge that we want students to learn the Cognitive skills regarding the rules of product design, Affective skills regarding customer needs and situation, and the facets of understandings perspective and empathy, a teacher can design specific assessments and instructional tactics to break down preconceived data schemas about the topic and build accurate (and not necessarily politically correct) understandings about these software engineering ideas.

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