Design for Standardization:
Standards Education from the Classroom to Everyday Practice

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Identified need and original project goals

The problem that our project identified was that undergraduate students at our university—primarily an engineering-focused institution—were not introduced to standards or the standardization process in a comprehensive or holistic manner. Students would encounter standards in technical courses, but had no robust framework for understanding social significance of standards, processes for their development, their immense strategic importance, or opportunities for getting involved as a career. Our project, Design for Standardization, started with the realization that opportunities existed to introduce students to standards in the context of an elective course that they could take to fulfill a humanities requirement. As a result, we structured the project to develop curricular materials that we could use at Stevens and share with other university faculty.

Our project title, "Design for Standardization," indicated our project's two major goals:

- To teach students about the complexities of standards and standardization that they will need to master if they want to design successful technologies;
- To encourage students to take part in the standards-setting process as a significant and rewarding component of their professional careers.

Our concept of "Design for Standardization" takes its inspiration from the "Values in Design" (or "Design for Values") approach, pioneered by Helen Nissenbaum at NYU and Batya Friedman at the University of Washington. This approach, developed over the past decade through research, publications, and teaching materials, provides designers and engineers with new theories and methods for expressing societal values in technological designs. Because we are following this type of holistic approach—one that conceives of standards and standardization as a broad and far-reaching set of social and technical activities—we believe that our proposal was well positioned to advance NIST's goals to integrate standards and standardization information into existing curricula at the undergraduate and graduate levels, and to strengthen education and learning about standards and standardization.

Our proposal also stated four more specific project goals:

1. The creation of an undergraduate course on "Standards and Society."
2. The creation of content modules that can be adopted and adapted by instructors—both at Stevens and at other educational institutions—who teach subjects such as science, engineering, and business at the undergraduate and graduate levels.
3. Collaboration with groups that are already working to integrate standards into educational curricula.
4. The public dissemination of our teaching materials and the "Design for Standardization" approach, via conference presentations and journal publications.

We believe that we have achieved goals 1, 3, and 4—in fact, we succeeded beyond our expectations, as described below. We did not achieve goal 2. Our initial proposal and significant amount of effort went towards the goal of the creation of content modules. We planned to develop and implement those modules in the "Design Spine," a series of design-focused classes offered for undergraduate engineering majors at Stevens. Our efforts to create customized modules for different departments—including Electrical and Computer Engineering and Systems Engineering—were at first met with enthusiasm. But, over time, the enthusiasm waned and faculty in other departments were less receptive to the types of curricular materials we proposed: we offered multimedia content modules in combination with simulation games, but we heard in response that a simple online quiz was all that was desired. In one other case, a key collaborator left Stevens, thus cutting us off from an opportunity in a different department.

Nevertheless, we believe that the creation of content modules was not the most important curricular innovation we could provide. Once we learned more about the existing content modules and other available resources for standards education that had been created by other NIST awardees, as well as by institutions such as ASTM, IEEE, ANSI, ISO, ICES, and others, we decided that our own creation of content modules (goal 2) was relatively unimportant compared to the other goals. We focused instead on gaining and disseminating our experience with the implementation of case studies and best practices with different groups of students.

The curricular innovation: development, evaluation, and findings.

The major innovation from our project was the creation and delivery of a new undergraduate course.

In the fall 2014 semester, the PIs (Russell and Vinsel) team-taught an undergraduate seminar, Standardization and Society (HST 380), offered through the Program in Science and Technology Studies (STS) in the College of Arts & Letters at Stevens. Like most STS programs, the Stevens STS program offers courses that examine science and technology from the vantage points of the humanities and social sciences. HST 380 is an advanced (junior/senior) course that is open to students of any major and counts toward the advanced Humanities requirements for all majors at Stevens. The course met in 2.5-hour sessions, once a week. Most of the 19 students enrolled in the class were engineering majors, with a minority who major in STS, the arts, or business. The course description reads as follows: "HST 380 provides an interdisciplinary overview of the place of standardization in modern societies. Students will explore how standards play important roles in shaping our lives as consumers and citizens, as well as how they might participate in the development and use of standards in technical and social fields."

In the first session of the semester, students were thrust immediately into a standards simulation game, where they adopted the roles of different stakeholders in a standards-setting process. The game sparked their thinking about some fundamental questions, such as: Who decides to make something standard? How are standards enforced? What can I do if I don't like a standard? Through their participation in the game, students immediately understood that standards are not lifeless abstractions; they

are conventions and agreements that are made, revised, and sometimes abandoned. In addition to the strategic intrigue that simulations provide, they also help to advance some primary goals of humanities education: for students to hone interpersonal skills of speaking, listening, reasoning, and thinking critically; and for students to develop their capacity for empathy and appreciation for a diversity of perspectives and interests.

In subsequent class sessions, students in HST 380 explored the past, present, and future of standards-setting regimes in industrial, governmental, and international arenas. To reach students with a variety of learning styles, course assignments and activities also featured guest lectures, academic books and articles, videos, student blogs on standardization in everyday life, and further simulation games. Students dove into subjects such as automobile safety standards and regulations; computer "standards wars"; and other standards that they discovered and investigated through group assignments and presentations. By learning about standards for health, aging, and life insurance, they were able to reflect on the human aspects—and human costs—of regimes of standardization that facilitate human differentiation and discrimination.

The course syllabus is available from http://arussell.org/papers/HST380.pdf. We have not tracked how many people have accessed this syllabus, or if they have sought to use it to inform their own course development. In the fall 2014 semester, course textbooks were Andrew L. Russell, *Open Standards and the Digital Age: History, Ideology, and Networks* (Cambridge University Press, 2014); and Martha Lampland and Susan Leigh Star, eds., *Standards and Their Stories: How Quantifying, Classifying, and Formalizing Practices Shape Everyday Life* (Cornell University Press, 2008).

The course concluded with a twist on those familiar end-of-semester rituals: course evaluations and student grades. Everyone in education has experienced how deeply the logic of standardization pervades it—from grades and curriculum requirements to ABET accreditation and US News and Report rankings. Our institutional mandate to conform to a system of evaluation as part of a broader regime of accreditation provides compelling material for revisiting the questions from the first class of the semester: Who decides to make something standard? How are standards enforced? What can I do if I don't like a standard?

HST 380 thus was an interactive and exciting course, deeply engaged with matters of science and technology, and focused on bringing standards to the front and center of classroom discussions and student research projects. We plan to teach the course again soon, and are keen to explore opportunities to bring our students into collaboration with peers from other universities and with standards professionals working in government, industry, and NGOs. Located in Hoboken, New Jersey, we are fortunate to be in close proximity to a rich supply of potential guest speakers, both from the Stevens faculty as well as professionals who work in the New York City area. A guest lecture from ANSI's Lisa Rajchel was a highlight for many students in the fall 2014 semester.

Student response to the course was overwhelmingly positive. Of the 13 students who responded to assessment questionnaires, 100% reported that the course increased their "awareness of the ethical responsibility and societal impact of [their] future profession," that they learned "how standards are created, negotiated, and implemented," that they became "conversant with the strategic and professional aspects of

standardization," and that they could "now identify the great variety of roles that standards play in cultural, political, and economic aspects of daily life." In their anonymous comments, students wrote that the course was "eye opening" and that it was "a vital class that should be required for all engineering and science students." One student wrote, "I really enjoyed the various in-class discussions. The course provided insight into an aspect of science and technology that I wasn't aware of." The student continued, "As an engineer, I feel I learned valuable knowledge about the standardization process for scientific fields." Another student wrote, "I knew standards were important, but I had never considered how much power they actually had."

In summary, we designed HST 380 to reach a diverse group of students who otherwise would not have encountered standards in a critical and rigorous manner. We were especially pleased to see how student work combined technical and humanistic aspects of standardization. We presented the results of this work at the ICES conference in Ottawa in August 2014, as well as at NIST workshops in 2014 and 2015. We also presented some aspects of our research related to "Design for Standardization" to the annual meeting of the Business History Conference, March 13-15 in Frankfurt, Germany, where we appeared on a panel titled "Standardization and its Discontents." Our work appears in the open scientific literature in *IEEE Standards Education e-Magazine* (Volume 4, No. 2, December 2014) and in *Standards Engineering: The Journal of the Standards Engineering Society* (May/June 2015).

Beyond the rewards that came with course offering as planned, the experience of teaching the course—and developing it within the community of educators nurtured by NIST's curriculum development program—created many unanticipated benefits:

- Incorporation of standards education materials into the Stevens Summer Program for high school students during the summer 2014 and 2015 sessions;
- Meaningful collaboration with IEEE Standards Association, including publications in IEEE-SA web and print materials; Russell's participation in the IEEE Standards University; and Russell's well-received lecture on the history of standards at the December 2015 meeting of the IEEE SA Board of Governors;
- Student submissions to the ANSI student paper competition in 2015. We were delighted to learn that one of our students, Shane Quinlan Arlington, was awarded first place in the competition. Arlington and Vinsel traveled to Washington DC in the fall of 2015 to accept the award;
- Significant collaboration with other individuals and institutions in standards education, including:
    - ANSI Committee on Education (Russell and Vinsel are now members);
    - United Knowledge (UK provided simulation exercises for our course, and Vinsel has worked as a moderator for UK exercises outside of Stevens over the past year);
    - Drexel University (Vinsel was a guest speaker at Drexel's NIST-funded summer 2015 workshop for graduate students, and we are in regular contact with Profs. Amy Slaton and Scott Knowles about future collaborations that might include another application for NIST's support);
    - The Maintainers, a conference to be held at Stevens on April 7-9, 2016. This conference will host over 40 speakers who responded to a call for

papers on the subject of maintenance, standardization, repair, and other aspects of labor in infrastructural or other technological systems.

We attribute the success of all of these initiatives directly to the support that NIST provided for this project. We believe it is fair to conclude that the impact of NIST's funding far outpaced our expectations, and will continue to be a catalyst for collaboration well beyond the term of the funding.

Lessons learned through the activity and suitability for adoption in other educational organizations, communities, or fields of practice.

We see five lessons that are particularly important to highlight, particularly for professionals who seek to learn from our experience or who will adopt or adapt the materials we produced.

1. *Classroom discussions are most effective when student interest is engaged on a personal level*.

   Standards education has long suffered under the label of being "boring" or too heavily laden with acronyms. The best way to overcome these problems is to replace abstract concepts and examples with examples that matter more to students: education, sports, entertainment, personal electronics, and so on.

2. *Simulation games are very effective teaching tools*.

   In our experience, the most significant leaps in student understanding and student engagement came through simulation exercises. We note that colleagues in other

fields—including history, anthropology, and political science—also have been utilizing simulation games in their teaching, and are equally impressed with the results.

3. *Local conditions are decisive*.

   We observed that educational materials that work well at one university or for one instructor may not necessarily work well in another setting. This observation, if accurate, is at odds with efforts to create materials that "scale" efficiently. Perhaps one factor at play here is the level of tacit knowledge embedded in course materials that is difficult to transfer along with the materials themselves.

4. *It is a risk to propose curricular innovations that are under another department's control.*

   We were enthusiastic about the prospect of creating content modules that our colleagues in engineering could adopt for their own "Design Spine" courses. Unfortunately, we encountered difficulties finding collaborators who would implement the modules we proposed. The lesson here is that it is a risk to propose curricular innovations that are under another department's control. We think this risk would be worth taking again, but the safer path is to develop courses and materials that one can control more directly, as we did with HST 380.

5. *High quality videos would be helpful*.

   Existing course materials are primarily in the form of readings, lecture notes and

slides, and exercises. These can be effective (with the caveat of #3 above), but we believe that an additional type of instructional material—namely, high quality videos—would be even more effective. We do not have any concrete suggestions for such videos, beyond the conclusion stated above, that any videos should seek to present material in a way that is first and foremost engaging for students.