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Instructables.com as a Tool to Improve Student Outcomes and Promote Community Engagement (Work-in-Progress)

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Abstract
Project-based Learning (PBL) has become a popular pedagogical tool in Engineering. Projects force students to put theory learned in lecture into practice, exposes students to some of the non-idealities of real systems (imperfect instruments, uncooperative systems, etc.) that are difficult to convey in lecture or homework, and ideally motivates students by showing how course material is related real-world engineering problems. This work discusses my preliminary and ongoing research into using Instructables.com—a user-content generated website of "Do It Yourself" tutorials—as a tool to help amplify the benefits students derive from PBL. Specifically, I require students to document their projects in an Instructable in lieu of a final report, and I encourage students to post their Instructable to Instructables.com. This work discusses three ways in which the use of instructables.com may improve PBL outcomes. First, instructables.com may improve students' motivation for pursuing further study in the field of engineering. This belief is rooted in the framework of Self Determination Theory, which stresses the importance of a task's "Relatedness" for developing intrinsic motivation. By using instructables.com as a motivation for project ideas and as a publication venue for project results, students can see how their work relates to work being done outside of academia. Second, by requiring students to write a step-by-step tutorial of their final project, the use of the "Instructable" format encourages students to reflect on their designs and design decisions, potentially improving student outcomes. Finally, this work briefly touches on how encouraging students to document their designs on instructables.com may lead to more interaction between the "maker" and engineering communities, thereby enhancing public awareness of the Engineering Profession.

Introduction
Project-based learning (PBL) is a well-established tool in Engineering Curricula. Many programs incorporate senior or capstone design courses to give students realistic design experiences, and an increasing number of programs offer "cornerstone" design experiences at the freshman levels (Dym, Agogino, Eris, Frey, & Leifer, 2005). Among other considerations, Project Based Learning is thought to help improve motivation and retention rates among students (Atadero, Balgopal, Rambo-Hernandez, & Casper, 2014; National Academy of Engineering, 2005), and the National Academy of Engineering recommends early exposure to design practice, including PBL, to improve engineering education (2005).

While by itself PBL offers enormous benefits to student learning, it is likely that how a project is administered can serve to amplify or diminish these effects. This work explores the use of Instructables.com as a tool to help maximize the benefits students glean from project-based learning. Instructables.com is a user-content generated "Do-it-yourself" (DIY) site. Any user can submit an Instructable—a step by step tutorial for completing a project—and the site contains

Instructables for over 100,000 projects (Instructables.com, 2016) on a variety of topics. All Instructables are visible to the entire Instructables.com community, where other users are able to view, "favorite," and comment on the project. Comments left on a specific Instructable are subject to a "Be Nice" comment policy, that instructs users to be positive and constructive in their feedback.

This paper first analyzes the use of Instructables.com through the framework of Self-Determination Theory (SDT) (Ryan & Deci, 2000) to explore in detail how it can theoretically aid student motivation and retention. I then touch on the use of Instructables.com as a tool that helps foster student reflection and increases interaction between Engineering students and the broader Maker/Hobbyist community. In these discussions, I primarily focus on the use Instructables.com as a medium for students to document their designs, but also discuss how Instructables can be used to help students appropriately scope open-ended projects.

Self-Determination Theory and PBL-Based Motivation

Self-Determination Theory explores the concept of motivation in individuals. At a basic level, SDT differentiates between two types of motivation, autonomous—completing tasks because one finds them fulfilling and worth doing—and controlled—completing tasks because one feels pressured to do them. People operating under controlled motivation are less likely to persist in a task once the external pressures are lifted. Therefore, to effectively promote retention in engineering, it is important that instances of PBL promote autonomous motivation in students. Self-Determination Theory states that there are three needs that must be met to foster autonomous motivation: competence, autonomy, and relatability (Gagné & Deci, 2005). I believe that Instructables.com and its affiliated user community can help a course project to meet these needs.

Feelings of competence can be impacted by both the perceived difficulty of a project, and by the feedback (s)he receives for completing a project. The literature often refers to "optimally challenging tasks" (Gagné & Deci, 2005, p. 332), or tasks that are scoped to encourage "stretching of one's capacities" (Deci & Ryan, 1985, p. 27) as beneficial for improving autonomous motivation. Unfortunately, different students in the same class often have different levels of understanding of the material: To maximize students' autonomous motivation, each group might need a slightly different project. For reasons of fairness and time, it would not be feasible for the professor to create custom project assignments for each group. An open-ended assignment that allows groups to choose their own projects within some guidelines helps mitigate these issues while providing students an increased sense of autonomy. In introductory courses, though, not all students may be familiar enough with the material to scope an appropriate project proposal. This is an area where Instructables.com can help: by showing students write-ups of a myriad of example projects, students can get an idea of how much effort is required to implement different types of systems. They can then use this information to scope a project appropriate for their level, setting them up for increased feelings of competence once the project is concluded. As an example of this, in the Fall of 2014, I required students in my

introductory Digital Design course to build an electronic game on their FPGA. By looking through past projects on Instructables.com, students found an Instructable describing an FPGA implementation of Pong (Raja, 2014), which gave them critical insights both into the challenges involved with interfacing an FPGA to a VGA monitor, and the inspiration that they could actually make a video-game on an FPGA using concepts they already knew from class.

Studies show that praise and social approval can also increase feelings of competence (Deci E. L., Effects of Externally Mediated Rewards on Intrinsic Motivation, 1971): to maximize student motivation, good work must be rewarded with recognition. In a class setting, however, the desire for recognition may be difficult to meet. If a project assignment is narrowly scoped, there may not be much room for project differentiation among individual groups, so individual praise from a professor may be less impactful. If the project is open-ended, it may be the case that a few standout projects grab the attention of the professor and classmates, leaving many other very good projects unrecognized. Once again, Instructables.com can help mitigate this issue. If a student publishes their completed project to Instructables.com, they have the opportunity to receive feedback on their designs from the large Instructables community. Given Instructables.com's "Be Nice" comment policy, and its active group of moderators, in my experience, students have always received positive, competence enhancing feedback.

Finally, while some students might find a given class project intrinsically interesting, many are engaging in the project due to external motivation—namely the project grade. To get students to internalize motivation for the type of work featured in a final project, the task needs to promote a sense of relatedness, or belonging within a broader social context (Deci E. L., et al., 2001). While some of this need may be met by the professor and the cohort of classmates, these sources of relatedness are limited. Students may only have a given professor for one quarter, so any relatedness-promoting social relationship between student and professor may be too transient to affect student motivation. As class sizes and enrollments swell, there may be less of a cohesive social structure around a particular major's cohort, stymying the ability of this group to support relatedness. Additionally, some students in "required" courses may find the course and project subject matter outside of their area of interest, potentially meaning that the "social context" of the cohort places less value on a successful project. With its large community of active hobbyists, tinkerers, and makers, Instructables.com provides a social context where engineering students can talk about and find support for their creative, project-based efforts. In fact, students report that community members occasionally reach out to them to ask about their projects: "putting the final projects from CPE439 on Instructables was a pretty cool idea. It was overall more satisfying than most of my other final projects because now other people message me because they're interested in the project and want to recreate it, compared to my other projects that just live in my drawer and collect dust." This sort of continuous engagement from a community allows a course project to have a positive impact on students long after the quarter ends.

Combined, I believe that the joint effects of boosting feelings of competence and relatedness that come from having students interact with the Instructables.com community has the potential to leave students more autonomously motivated for completing digital design and embedded system-type projects, and persisting in these fields of study. The next step in this research will be to use survey instruments to attempt to quantify the extent to which Instructables.com really does elicit this effect in students.

Additional Benefits of Instructables.com as a Pedagogical Tool

In addition to improving student motivation, the use of Instructables.com in PBL may have the potential to improve student learning through reflection. Whether or not students choose to post their project to Instructables.com, they must still complete a step-by-step write-up that teaches an interested technical audience how to reproduce the system. This process causes students to look back over their design and clearly explain how and why they built their system the way they did, and also requires them to justify any assumptions they have made in constructing the system. Since engaging in critical reflection can improve learning (Boaud, Keogh, & Walker, 2013; Moon, 2013), it stands to reason that using Instructables.com in PBL similarly improves student learning. It is important to note, however, that students would only get the full benefits of reflection if they take Instructable writing seriously. To ensure that they do, I generally weight the final written Instructable as 30-40% of the overall project grade.

The other benefit of using Instructables.com to enhance Project Based Learning is that it increases the interaction between engineering students and the broader population. As an open community Instructables.com attracts hobbyists and "Do-it-Yourselfers" from a wide-range of backgrounds, including those with no formal training in engineering disciplines. Currently, as I am in the initial stages of experimenting with the use of Instructables.com as a teaching tool, I am relying on outreach from the existing Instructables.com community to help motivate my students. As more engineering students join Instructables.com as a result of PBL, however, these roles may start to reverse. With an increase in the number of engineering students posting projects, there will be a much broader set of ideas for hobbyists to emulate and build from. Also, students who join and become active in the Instructables.com community will be in a prime position to provide encouragement, feedback, and advice to hobbyists and "Makers" who post projects to the site. This symbiotic relationship has the potential for bringing the engineering and maker communities closer together, and may eventually help to recruit tinkerers into formal engineering programs.

Conclusions

As part of my efforts to maximize the benefits my students derive from project based learning, I have been exploring the use of Instructables.com as a means for students to get inspiration for their final projects, and as a way for students to document their project designs. In this work, I have discussed the theoretical basis for why Instructables.com may be beneficial, and the anecdotal evidence I have received that leads me to believe that Instructables.com could be a powerful tool for improving student motivation and outcomes. I recognize, however, that

anecdotal evidence can be misleading. Therefore, for my next steps in this research, I intend to use quantitative survey instruments based off of the validated questionnaires provided by the founders of Self Determination Theory (selfdeterminationtheory.org, 2016) to try to quantify the effects of using Instructables.com during final projects on my students' learning.

References

Atadero, R. A., Balgopal, M. M., Rambo-Hernandez, K. E., & Casper, A. M. (2014). Project-Based Learning in Statics: Curriculum, Student Outcomes, and Ongoing Questions. *121st ASEE Anual Conference & Exposition.* Indianapolis: ASEE.

Boaud, D., Keogh, R., & Walker, D. (2013). *Reflection: Turning Experience into Learning.* Routledge.

Deci, E. L. (1971). Effects of Externally Mediated Rewards on Intrinsic Motivation. *Journal of Personality and Social Psychology, 18*(1), 105-115.

Deci, E. L., Ryan, R. M., Gagne, M., Leone, D. R., Usunov, J., & Kornazheva, B. P. (2001). Need satisfaction, motivation, and well-being in the work organizations of a former Eastern Bloc country. *Personality and Social Psychology Bulletin, 27*(8), 930-942.

Deci, E., & Ryan, R. M. (1985). *Intrinsic Motivation and Self-Determination in Human Behavior.* Springer Science & Business Media.

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering Design Thinking, Teaching, and Learning. *Journal of Engineering Education, 94*(1), 103-120.

Gagné, M., & Deci, E. L. (2005). Self-determination theory and work motivation. *Journal of Organizational behavior, 26*(4), 331-362.

Instructables.com. (2016, January 31). *About Instructables*. Retrieved from Instructables: Share What You Make: http://www.instructables.com/about/

Moon, J. A. (2013). *Reflection in Learning and Professional Development: Theory and Practice.* Routledge.

National Academy of Engineering. (2005). *Educating the Engineer of 2020: Adapting Engineering Education to the New Century.* Washington D.C.: National Academies Press.

Raja, V. (2014, August 14). *Pong game using fpga kit*. Retrieved from Instructables: Share What You Make: http://www.instructables.com/id/Pong-game-using-fpga-kit/

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American psychologist, 55*(1), 68-78.

selfdeterminationtheory.org. (2016). *Questionnaires*. Retrieved from SDT: Self-Determination Theory: http://selfdeterminationtheory.org/questionnaires/