Immersive Experience Impact on Students' Understanding of Design

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education, all from Purdue University. She has served as a lecturer in Purdue's School
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interests include human-centered design learning and assessment, service-learning,
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characterizes learning experiences in engineering such as design and interdisciplinary
learning.

Dr. Monica E Cardella, Purdue University, West Lafayette
Monica Cardella is an Associate Professor of Engineering Education at Purdue
University. She teaches design to first-year engineering students at Purdue as well as

an upper-level design course for seniors and graduate students. Her research focuses on the development of engineering thinking skills (operationalized as design thinking, mathematical thinking, and the interplay between the two) in children as young as 4 years old as well as older "children" (i.e. undergraduate students).

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William (Bill) Oakes is the Director of the EPICS Program and Professor at Purdue University. He is one of the founding faculty members in the School of Engineering Education with courtesy appointments in Mechanical, Environmental and Ecological Engineering as well as Curriculum and Instruction in the College of Education. He has received numerous awards for his efforts at Purdue including being elected as a fellow of the Teaching Academy and listed in the Book of Great Teachers. He was the first engineer to receive the U.S. Campus Compact Thomas Ehrlich Faculty Award for Service-Learning. He was a co-recipient of the U.S. National Academy of Engineering's Bernard Gordon Prize for Innovation in Engineering and Technology Education and the recipient of the ASEE Chester Carlson Award for Innovation in Engineering Education. He is a fellow of ASEE and the National Society of Professional Engineers (NSPE).
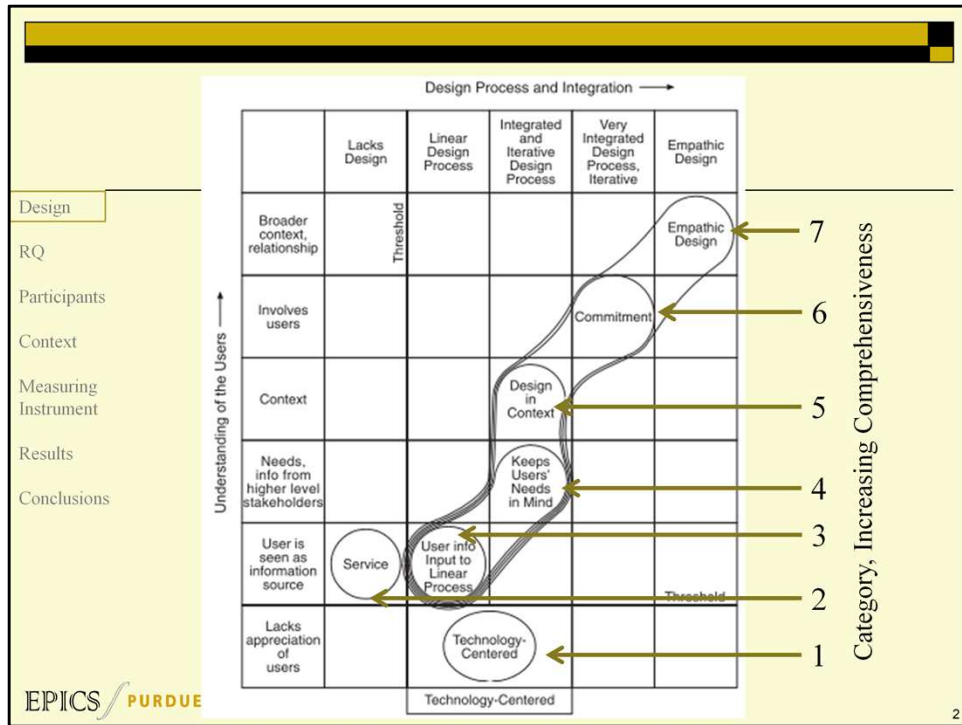
C. B. Zoltowski, W. C. Oakes and M. E. Cardella, "Students' Ways of Experiencing Human-Centered Design," *Journal of Engineering Education,* pp. 28-59, 2012.

We want students to be capable of Category 7 Empathic Design, because it represents broader context and iterative design process thinking.
What kinds of experiences move students to higher categories?

Ideas to Measure "Understanding"

Concept	Definition
Human-centered design	engineering design is an iterative process that is centered on constant communication with the stakeholders of the project
Novice - expert	learning experiences of designers appear to increase both the designers' understanding of design and the designers' understanding of the users and stakeholders simultaneously
Immersion	"[meet] people where they live, work, and socialize… Try to do what your constituents do and talk to them about their experience of life in the moment"

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Not counting vaccinations, cost, or semesters invested in this experience.

Global Engineering program at Purdue
https://engineering.purdue.edu/GEP/Programs/GDT

Locations & distance from Indianapolis:
Yaounde, Cameroon – 6458 mi
Bogota, Colombia – 2535 mi
Quito, Ecuador – 2793 mi
Accra, Ghana – 5762 mi
Amman, Jordan – 5762 mi
Nairobi, Kenya – 7995 mi
Beirut, Lebanon – 6147 mi
Jerusalem (Israel) Palestine – 6240 mi
Dodoma, Tanzania – 8377 mi

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Can a <u>week-long</u>
immersive
design experience impact
students' understanding
of design?

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Age	Gender	Major	Previously Enrolled*
Senior	Male	Computer Science	0
Junior	Female	Mechanical Engineering	0
Senior	Male	Multidisciplinary Engineering	0
Senior	Male	Atmospheric Science	0
Graduate	Female	Industrial Design	0
Senior	Female	Multidisciplinary Engineering & Health and Human Sciences	5
Senior	Male	Biomedical Engineering	4
Sophomore	Male	Biomedical Engineering	0
Junior	Female	Biomedical Engineering	0
Senior	Female	Biomedical Engineering	0
Sophomore	Female	Speech Language Audiology	0
Junior	Female	Biomedical Engineering	0
Senior	Female	Biomedical Engineering	0
	Female: 8	Engineering: 9	New: 11
	Male: 5	Other: 4	Returning: 2

Common thread: a desire to serve the community

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Mis-identified gender of 1 participant in conference paper. Corrected here.

EPICS– Summer Session

Week	Activities
	Design Task (Pre-camp)
1	introduction to the human-centered design process and skill development
2	immersion in a different culture, a summer camp environment dedicated to and entirely populated with children with disabilities who are encouraged to challenge themselves in an outdoor setting
3	developing and refining designs for their respective projects; presented their work to the administrators and donors and proposed future work
	Design Task (Post-camp)

The three week, three credit-hour course in the summer consisted of three distinct phases: introduction to the human-centered design process and skill development; a week of staying at the camp to observe and interact with campers ages 8 to 13, counselors, administrators, architects, a doctor affiliated with the camp, and donors; and a week of continuing design work to present to the same stakeholders. It is noteworthy that camp was about a two hour drive from campus, so that the students stayed at camp, away from familiar surroundings, but it was not so far away as to introduce complexity and high cost in arranging travel.

In the second week, the participants of the course were immersed in a different culture, a summer camp environment dedicated to and entirely populated with children with disabilities who are encouraged to challenge themselves in an outdoor setting.

C. B. Zoltowski, A. Cummings and W. C. Oakes, "Immersive Community Engagement Experience," in *2014 Annual ASEE Conference Proceedings*, Indianapolis, IN, 2014.

Design Task – Soapbox Derby Car

Scenario & Table of Tasks

List the *activities* to be completed during the semester. (List activities individually).	What *resources* and/or *people* would be involved?	*How* would those resources and/or people be involved?	*Why* is the activity being done? What is the purpose of doing the activity?

Open-ended Questions

□ What is important

□ Measure success

□ Stakeholders

□ Input from stakeholders

□ Previous design experiences

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As a designer, what do you feel is important to consider when doing design, and why? What does it mean to do design well? How do you measure success?
List all the people who would have a role in the design process. For each, describe why they would be involved.
If you had unlimited access to children, parents, experts etc., how would you include each in the design process and what information would you want to learn from each?
Describe any design experiences that influenced how you approached this design, and how it influenced you.

R. B. Melton, M. E. Cardella, W. C. Oakes and C. B. Zoltowski, "Development of a Design Task to Assess Students' Understanding of Human-Centered Design," in *2012 Frontiers in Education Conference Proceedings*, Seattle, WA, 2012.

12 Pairs of Design Task Responses Categorized

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Conclusions

Wilcoxson Signed Rank Test: paired data; $\alpha = 0.006$

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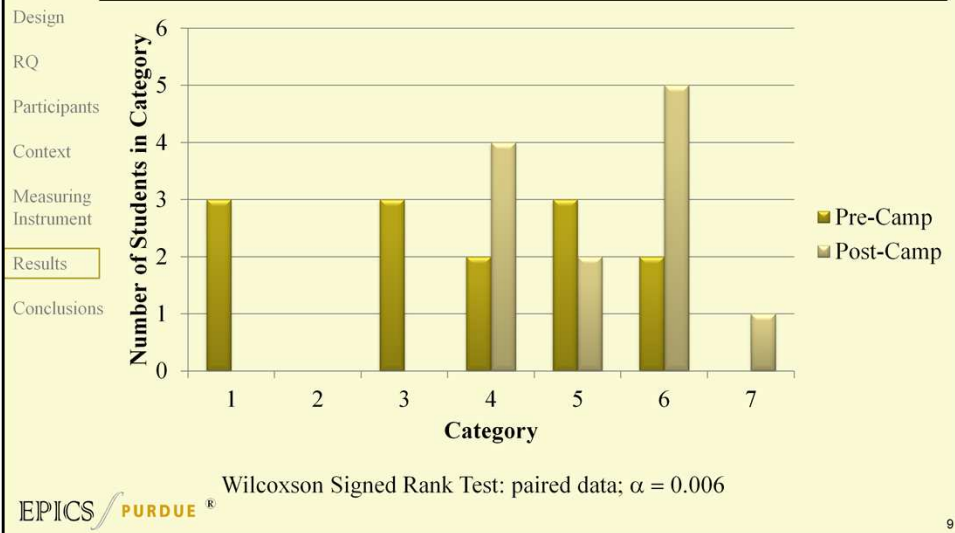
In order to determine a statistically significant difference between the pre-camp and post-camp categorizations, we used the Wilcoxson Signed Rank Test [20]. It is similar to a t-test because of operating on a small sample size. This is appropriate because of the following assumptions and characteristics that differ from a t-test: the data are paired values that are independently drawn; the values are on an ordinal scale; and there may not be a normal distribution around the mean value (non-parametric). This test allows for the use of the normal distribution table for determining significance. The Wilcoxson Signed Rank Test for the paired data shows an α significance of 0.006. For this calculation, we include the 12 pairs of data and exclude the participant who did not complete a post-camp design task. The analysis shows a statistically significant difference between the pre-camp and post-camp categories of the participants.

Open-Ended Responses Shifted

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Q1: What is important			Q3: Stakeholders		
Category 1	**Category 3-4**	**Category 5+**	**Category 1**	**Category 3-4**	**Category 5+**
Safety Reliability Quality Cost	Stakeholder needs User needs	Stakeholder *feedback*	Design team	Design team Project partners Experts Advisors	Children Parents Drivers Race organizers Spectators Donors Government agencies Mechanics Materials suppliers

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Question 1 of the design task questionnaire is "as a designer, what do you feel is important to consider when doing design, and why?" The most common answer here for the students who have participated in our community engagement program is "consider the stakeholders" or "stakeholder needs" or "user needs". The other common answers are safety, reliability, quality, and cost. However, respondents often neglect to list engagement with stakeholders in the B1 table of activities. Because of the lack of stakeholder engagement in the table of activities, we rated these responses as lower categories 1 and 3.

Question 3 of the design task questionnaire is "list all the people who would have a role in the design process. For each, describe why they would be involved". Category 1 individuals listed just the design team in this question. Category 3 and 4 individuals listed project partners, experts, and advisors in addition to the design team. The data suggests that most of the postcamp respondents can now provide detailed lists of stakeholders, including children, parents, drivers, race organizers, spectators, donors, government agencies, mechanics, and materials suppliers. The longer list of stakeholders indicates an increased awareness of the larger social context of design.

Expectations for Post-Camp Responses

Expectation	Met?
Increased understanding of human-centered design, measured by higher Category	✓
Increased engagement with stakeholders at the beginning of the design process	✓
Increased iteration with users in prototyping and testing	✓
Inclusion of interaction with stakeholders informally and in social situations	✗*

* Close alignment between Design Task and Immersive experience; participants' new knowledge is now tacit?

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This analysis of design task responses shows that an immersive experience with users increases the student designers' awareness of users' needs, reduces designers' propensity for making assumptions, and increases designers' use of a rigorous iterative design process. This confirms the expectations of increasing involvement of the stakeholders and simultaneous increasing understanding of design. However, we did not find that students generally listed observation and interaction with stakeholders in informal settings as part of the design process, which is what the students did at camp. While only one student made an impressive five category leap from Category 1 to 6 in only three weeks, it is encouraging that the students generally moved up as a result of this immersive experience.

An alternative explanation for the apparent lack of Category 7 evidence is that the soapbox derby design task aligns so well with the treehouse and sailboat projects of the immersive course that the respondents may feel that they already know the users and do not have to include the step of understanding the user in this design task. A second alternative explanation for the apparent lack of Category 7 evidence is that the soapbox derby design task as a measurement tool is limited in its ability to elicit Category 7 thinking. The responses to the reflection questions B6 and B7 from the students have indications of Category 7 understanding of design as acknowledged by the participants themselves; however, we did not include qualitative analysis of the reflection questions in this paper. Further evidence is included in another publication, however, that the students are moving toward empathic design thinking.

C. B. Zoltowski, A. Cummings and W. C. Oakes, "Immersive Community Engagement Experience," in *2014 Annual ASEE Conference Proceedings*, Indianapolis, IN, 2014.

Future Use – Design Task + Rubric*

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Category	Evidence
3	Table: *design – build – test – deliver*
4	Table: *prototype – test with user – refine – deliver*
5	Q3 Stakeholders: diverse group beyond design team
6	Q5 Prior experiences: specific stories of confronting one's assumptions about stakeholders
7	Table: observation and interaction with users and stakeholders in informal settings

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*For non-research users to categorize and measure students' understanding of design

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A rubric is in development to evaluate the soapbox derby design task based on the phenomenographic framework. Characteristics such as whether and how the users and stakeholders are engaged, types of information about users considered by the designers, and the level of iteration in the design process gave indication to which Category the design task fits. The higher Category design task data from this work will also inform this rubric. This may assist future non-research users of the design task in categorizing students' understanding of design.

Our findings suggest that even short immersive experiences can have a large impact on students' understanding of design. This short immersive experience showed significant increase in student understanding of design and the role of users and stakeholders. The impact may compare in impact to longer-term design experiences such as global design teams or internships that are available in limited quantities to undergraduate students. Internships and global design experiences can and do move participants toward empathic design [15]. Immersive experiences can be added to the portfolio of options available to students to allow a greater participation in such transformational experiences.

C. B. Zoltowski, "Students' ways of experiencing human-centered design (doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Database. (3413917).," 2010.