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Ta-Da! You're a design thinker! Validating the DesignShop as a Model for Teaching Design Thinking to Non-Designers and Achieving Systemic Re-Design in the Education System

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Abstract

"Hackathons" are known for creating unique, collaborative spaces where interested persons voluntarily participate in a marathon of hacking, or coding and tinkering, usually overnight. Only recently have hackathon-type events emerged with a focus on broad, systemic issues, such as education. In our first experiment, the Education Designathon, projects, or hacks, fell short of systemic scope. We identified design thinking as a problem-solving approach that could help in attacking broad, systemic issues while also teaching people new ways to collaborate and form sustainable solutions. A new model was born, The Education DesignShop, with eight key components and a structure around modules that teach design thinking and challenge participants to apply these methods towards their re-designs of the education system.

We compare the results of projects born out of hackathon-type events, such as the Edu Designathon and HGSE (Harvard Graduate School of Education) Hackathon, against those born out of the Education DesignShop. We providing a framework for recognizing how the structure of the DesignShop aids in creating projects with a greater potential for impact and systemic change, as well as projects with stronger design thinking elements embedded into them.

In addition, we tracked participants' problem-solving approach through three 20-minute evaluations given before, after, and a month after the DesignShop. By using Discourse Analysis we are able to code for sophistication levels of the design thinking stages outlined by Stanford's d.School—empathy, define, ideate, prototype, test— that are present in the participant responses over time.

Our results hint at a transformation in the participant's problem-solving approaches as seen by their increased use of design thinking terminology and proposed implementations of the process. We visualize the logic flow in participant responses, and how they converge towards a train of thought that is structured by the design thinking process. By weighing the level of understanding shown at each of these stages by the participants in their responses, we deduce that design thinking was learned to varying degrees during the Education DesignShop and retained over a one-month span.

Introduction

This paper lies at the intersections of two movements. The first, a realization for the untapped problem-solving potential inherent in big, collaborative meetings of passionate people (most commonly seen in hackathons). The second, the realization that design thinking can extend much farther beyond the traditional product design engineering classroom and into the hands of our citizens in order to capacitate them as able problem-solvers in our community.

To understand the first realization is to understand the hacker culture that has expanded across nations and disciplines. Originally used to describe someone who makes furniture with an axe, this makeshift nature reflected onto the first programming-oriented use of the word, one who makes "a quick job that produces what is needed, but not well" and then matured to include [one who makes] "an incredibly good, and perhaps very time-consuming, piece of work that produces exactly what is needed"[1]. Hackathons (or, marathons of hacking) are gatherings of programmers to collaboratively code in an extreme manner over a short period of time on whatever he or she wants[2], and strive to embody the tone of "No Talk, All Action". US Deputy CTO for government innovation Chris Vein commends hackathons as exceptional "sensemaking" tools for government, encouraging agencies to use hackers' talents to solve in creative and imaginative ways that they would never have done themselves[3]. Traditionally, hackathons have had a tangible, or product-based focus, as in the Music HackDay[4] that asks coders to make more apps for the musically inclined.

As hackathons continue to become more and more popular[5], the last 5 or so years has seen a shift to harness the potential of these hackathons and apply them to more cumbersome, more systemic themes that are perhaps not as easily scoped, themes like education[6], clean energy[7], government[8], international development[9], and health[10].

The Education HackDay in Baltimore brought together developers, designers, and educators to create usable applications in the school system. While they claimed to be "prototyping teaching"[11] at the event, the focus remained on product-oriented solutions to aide teacher's daily routine, not on the re-design of our education system.

This paper compares the formats of three events in Table 1: The Designathon, The Education DesignShop (or, design thinking workshop), and the Harvard Graduate School of Education (HGSE) Hackathon.

Experiment Event	Short Description
The Education Designathon	The first hands-on hackathon for education
The Education DesignShop	A two-day workshop for participants to learn and apply design thinking to education
The HGSE Hackathon	A hackathon for education that stressed the importance of using the design thinking process

Table 1: Short descriptions of each experiment in chronological order.

It studies how the different formatting structures in each influenced the resulting projects in at

least two metrics: how systemic the affect of this project will be to the education system, and how well thought out and ”designerly” the project was designed to be. After careful observation of the projects emerging from the first experiment, we incorporated the design-based methodology of design thinking into the structure, effectively teaching it to participants at the DesignShop. The results from this intervention hint at the power of design thinking as a problem-solving approach for such an abstract and complex system as education. Ultimately, we relate this intervention to the power of teaching non-engineers to think like designers under problem-solving approaches structured more deeply in the innovate design methods than in traditional milestone-based or research-based methods2.

First, we walk through the design research that supported the parameters of each of the three experiments. Then we discuss the methods by which the data from the projects and participants of each experiment was analyzed to support our two research claims, that 1) projects emerging from the DesignShop are more systemic than those from the Education Designathon or HGSE Hackathon, and 2) that the DesignShop transformed participants into design thinkers. Finally, we discuss our results and the implications for engineering education curriculum beyond the classroom.

Because this study intends to push the limits of innovation in the field of education, it purposefully does not limit the participants' scope so that they may organically choose a scope and boundary of an education (sub)system that is appropriate for the time of their experiment. That said, guidance of where in the many subsystems to begin work is offered through the various framing questions, such as the EdExperts' Challenges in the Designathon, the Three Topics to choose from in the DesignShop, and the Sponsors' Challenges in the HGSE Hackathon.

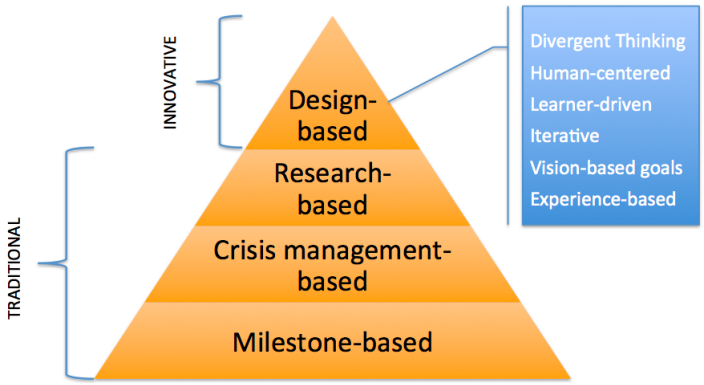

Figure 1: Hierarchy of problem-solving approaches emphasizing the value of a design-based methodology.

The Education Designathon Experiment: Design Background

The Education Designathon began as an investigation to know if there is an optimal investment of our resources (time and money) that yields better solutions for our education system. Assuming we could invent better solutions, where, then, would these stand against the performance of

traditional research ventures on innovation metrics like feasibility, novelty, variety, quantity, and quality, as depicted in Figure 2?

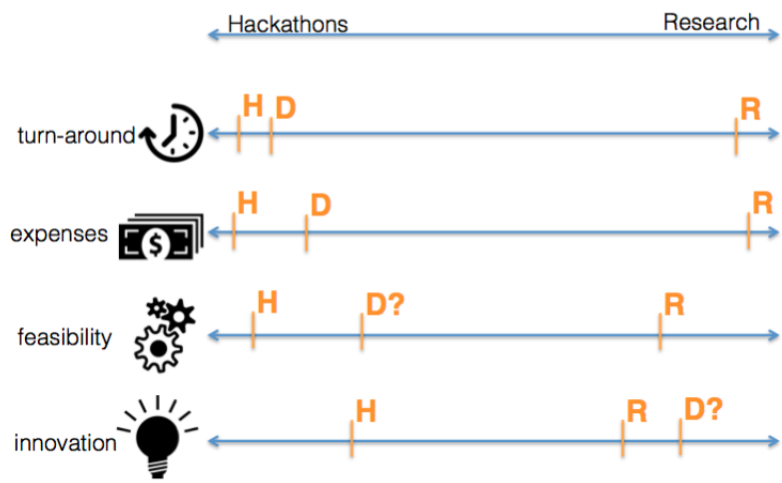

Figure 2: Qualified metrics comparing Hackathons, Research Ventures, and a Designathon.

The sentiment was that of an untapped space sitting in the middle ground between events with long time horizons and big impact (e.g. research ventures) and those with short time horizons and very small impact (e.g. hackathons). The designathon was created as a model to move the results generated from Figure 3's Quadrant III to Quadrant II, toward the quicker and valuable results.

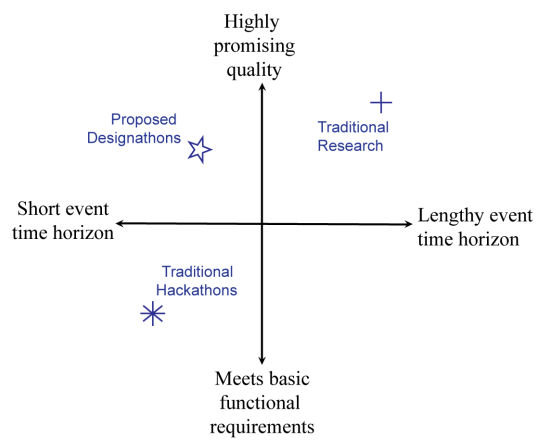

Figure 3: Regimes of results under different problem-solving events.

To characterize the differences in these events is to understand the relationship between Q (the quality of results from the yield of a given event) and t (the time spent working or hacking at that event). Observation suggests that Quality is a function of the log of time, where t_H, t_D, and t_R represent the optimized event time horizons for hackathons, designathons, and traditional research, respectively. As represented by Figure 2, the y-axis marks the expected solutions: a basic solution meets predetermined functional requirements but does not show depth in thought or

sophistication in the idea generated; an advanced solution shows depth of thought in problem identification, well thought-out and researched ideas, and potentially some end-user generated feedback that's led to reiterations of the product; a proven solution would have also tested and evaluated the solution multiple times before releasing a solution[12]. We suspect a logarithmic relationship between the time it takes to the quality of projects and the length it takes to develop the projects as depicted in Figure 4, but we have yet to dive in deeper into this phenomena.

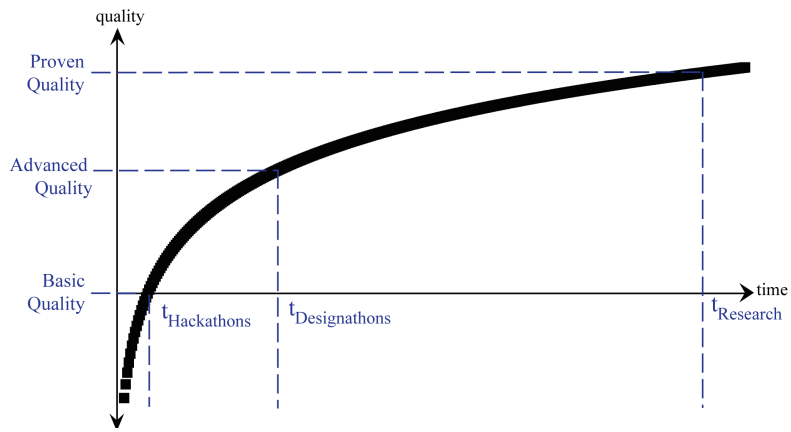

Figure 4: Proposed relationship of quality results and event time horizons for three approaches to problem solving: hackathons, designathons, and research.

The Education Designathon Experiment: Event Parameters

The Designathon was, to date, the only hands-on hackathon for the space of education made to encourage physical hackers, or wherein the focus was expanded for engineers outside of computer science. The structure, like a hackathon, was very free-form, leaving at least 24 hours for hacking. The event was opened by Challenge EdExperts, or organizations doing work in the education fields that challenged participants with their pitches of what was important to their subsystem of education. The schedule budgeted for The Challenge Presentations by EdExperts, for Participant Idea Pitches to rally to teams, for Workshops by EdExperts wherein students could learn more about a specific organization's tools, and for a lab safety training to use the shop tools.

Three topic categories enticed participants: Hands-On Learning, Digital Learning, and Systems Re-Thinking. There were four key design parameters of the event— i) Three topic categories were framed: Hands-On Learning, Digital Learning, and Systems Re-Thinking, ii) Education Experts were brought in to pitch Challenge Presentations, lead workshops, and serve as ad hoc mentors, iii) A laboratory equipped with prototyping materials and a spending budget for each student enabled physical project developments, and iv) Award categories were not matched to the three topic categories but to sponsoring EdExperts.

The event took place in an open space with machine shop access where hackers, or designers, could use power tools and materials to build. Teams were given a 50 dollar budget per person to buy materials or outsource work. After opening remarks by Woodie Flowers, eleven Education Experts (EdExperts) representing all three subtopics gave 5 minute Challenge Presentations.

These Challenge Presentations introduced the challenges and daily work of the EdExperts. After Challenge Presentations, participants were invited up to pitch their own ideas or projects to recruit team members. Twelve half-hour to hour-long workshops by EdExperts took place over the next 2 hours, with some overlap forcing participants to prioritize the topics most interesting to them. The twelfth workshop consisted of teachers, mentors, and faculty from around MIT poised to give feedback to the participants on their ideas and current projects. After lunch, lab safety trainings were offered to all participants who planned on using any machining tools. Little structure followed thereafter. As groups entered the brainstorming phase, some hackers still uncommitted dabbled from project to project before settling in with a team or pursuing their own idea. Some groups wasted no time and directly went out to buy materials from their budgets, some continued strategizing, some enjoying feedback from EdExperts still lingering. Sixteen projects, or hacks, were demoed at the Final Presentations, ranging from a children's book to a rotating table to a Google Chrome browser extension.

The Education DesignShop Experiment: Design Background

Technically speaking, hackers are not problem solving, for they're not given problems, they're just given opportunities to explore, discover, tinker, and hack together. The design constraint in a hackathon is merely the time that they are given. This sharply contrasts with the format of problems used in design challenges. When you instruct a design challenge for a project-based learning activity, for example, the design constraints go beyond the time available in the semester and into the realities of what's feasible, what's appropriate in scope, what is the necessary problem that needs to be solved, etc.

At the Education Designathon, examples of physical hacks included, among others, DynamicTable—a rotating high top table that connects to a computer's monitor such that restless kids would have to walk around the table clockwise to scroll the page up, and counterclockwise to scroll the page down; as well as The Little Book of Circuits— a children's book with integrated circuits that allow for a parent and child reading pair to interact and learn directly from the book.

While design-based approaches are common in physical engineering and design products like DynamicTable and the Little Book of Circuits, they are only now beginning to prove themselves in their application to systemic challenges, like education. In regards to the stipulation that we could move from hacking to designing, some products like EduLinks 5 got closest to the Challenge of System Re-Thinking as it justly reflected the philosophical thinking and background instruction needed for proper system design, and is a tool for educators and planners sitting around a table making policy.

But format— or lack thereof— yielded projects that were a very different kind of systemic, at best, as with the DynamicTable team mentioned above. There seemed to be a lack of scope and preparation to be able to implement ideas that could impact a system of learners and educators.

The analysis of the EduDesignathon projects occurred as the author, Jessica A. Artiles, began her work as a mentor for *2.009 Product Engineering Process*[13], the MIT Mechanical Engineering

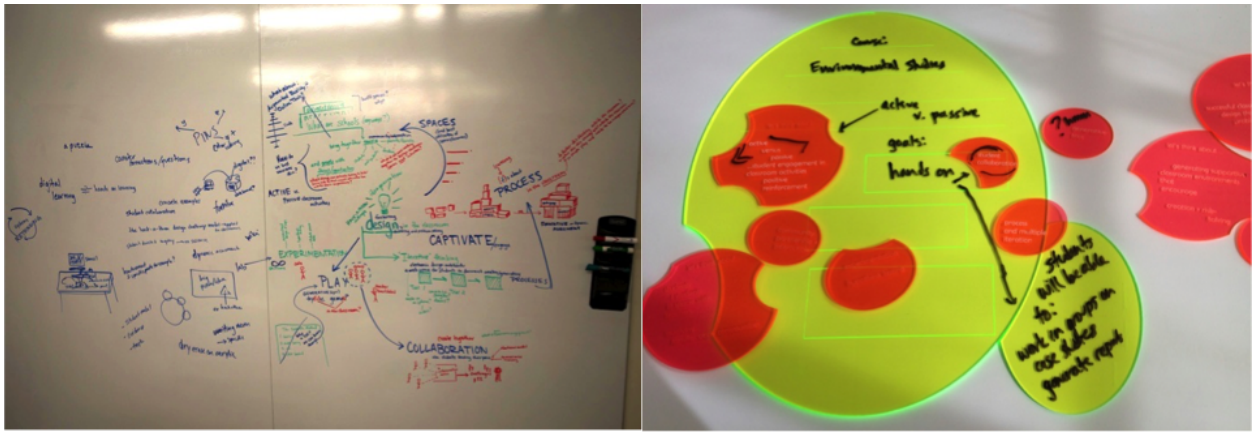

Figure 5: EduLinks, a Designathon hack to capture the direct and indirect influences each player, stakeholder, and theory has within the education system.

Department's senior capstone class, instructed by Professor David R. Wallace, co-author on this paper and Thesis advisor to Jessica. The course takes graduating seniors on an adventure through product design teaching them the virtues of following a deliberate process, and slowly engaging them to think like designers.

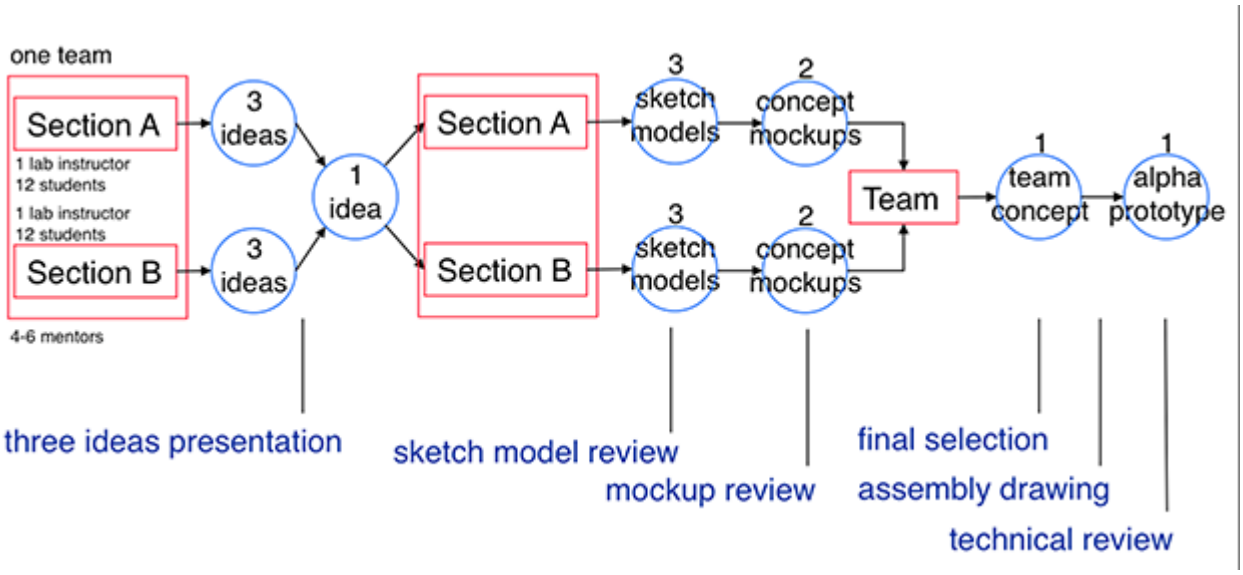

Figure 6: Schematic of the *2.009 Product Engineering Processes* project workflow, delineated by six major milestones.

Curiosity began to set in as to what would happen if these systemic education issues were attacked with the same format and structure of 2.009 seen in Figure 6.

Research into the concept of thinking like a product designer, but solving non-tangible solutions revealed results that pointed to the field of "design thinking".

Design thinking first appeared in Herbert A Simon's 1969 book The Sciences of the Artificial.

Since then, more than four decades of scholars have attempted to define and apply "design thinking" to various systems (product design, architecture, healthcare, etc.) We now call for a reform in the problem-solving approaches of the education system: to move from constraint-based approaches to a design-based approach by infusing Design Thinking into the minds of education stakeholders[14].

Often called 21st century skills, design thinking offers problem-solvers a new departure from traditional standstills in problem-solving, particularly through the stages of problem identification and brainstorming. Non-designers tend to the dynamic of judgmental interference wherein they cut ideas short of their creative potential and do not give it the chance to grow, develop, or even transform into something that might be a suitable, if not great, solution. This truncation can come from endless pre-dispositions that are inherent to the brainstormer's psyche. Among these constraints, the brainstormer can suffer from too much attention to pre-constructed limits (boundary conditions, assumed lack of access or zone of influence, lists of requirements), and/or from pathologically imposed constraints (complacency with the status quo, inherent resistance to change, unyielding preferences, fear of failure, judgment, and unexpected consequences, lacking the impetus for change).

A design thinking mentality, then, is exactly the antithesis of judgment interference with elements such as: a vision-based set of goals, an experience-based specification sheet, comfort with being risk averse, no judgment zones, and the perspiration of not giving up. Figure 7 describes other elements of design thinking seen through the steps of the design process.

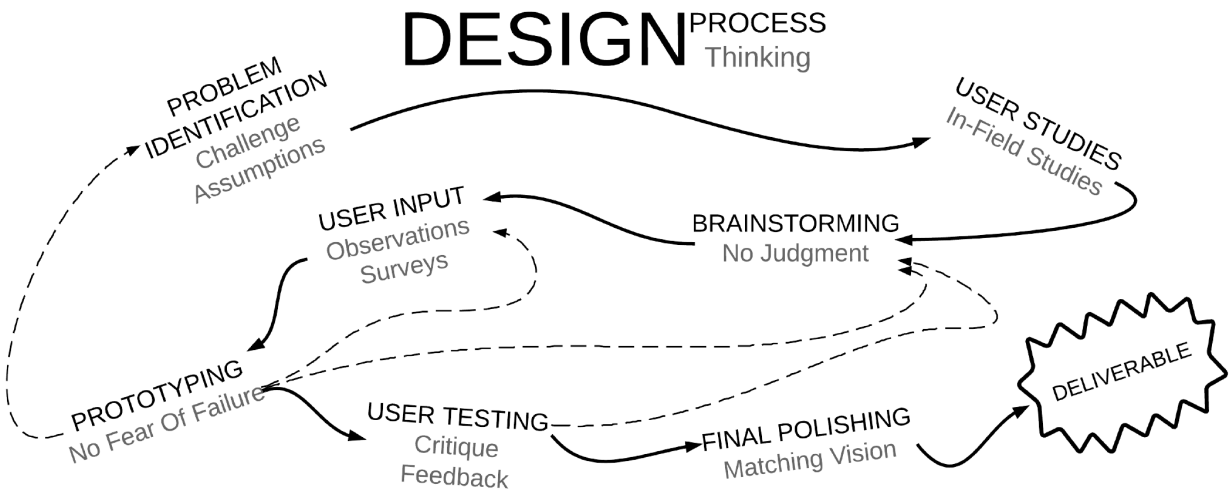

Figure 7: A roadmap of Design Process steps (black) and their inherent elements of Design Thinking (grey), beginning with Problem Identification.

IDEO is an example of a company validating the engagement of using design thinking to tackle systemic issues. They've designed a school system— Innova Schools in Peru– "from the ground up," they've challenged a community's contribution in the transition to renewable energy, and created a birth control support network for young women[15].

At the product level, the Education Designathon in Spring 2013 demonstrated there was space for

creativity and innovation in educational tools if certain education challenges were approached with a design thinking framework. While design-based approaches are common in tangible engineering and design, they are only now beginning to prove themselves in their application to systemic challenges, like education. This next step is imminent. The challenge of using design thinking in education rests in that policy makers—currently the bigger power holders, or stakeholders, in the education space— are trained otherwise. As IDEO explains, "the natural tendency of most organizations is to restrict choices in favor of the obvious and the incremental. Although this tendency may be more efficient in the short run, it tends to make an organization conservative and inflexible in the long run. Divergent thinking is the route, not the obstacle, to innovation."[16]

Design thinking and maker thinking are on their way to being infused into schools with the recent developments in non-traditional educational spaces such as the Art Science Prize, NuVu High Schools, and "Innovation Schools"[17] like the Up Academy and the Boston Green Academy. To drive home change in the education system, however, there needs to be more. In order to fix the education system, design thinking needs to be established as an embedded problems-solving paradigm[14].

The Education DesignShop: Event Parameters

Four central principles for successful innovation guided the design parameters of the event[18]. First, we build up from the premise that design thinking leads to innovative solutions, as is underlined in the many case studies Tim Brown provides in Change by Design.[19] Secondly, as Tim Brown points out, an underlying theme to innovative individuals is that they have built the creative confidence be think they are able and capable of producing new, never before seen solutions. Thirdly, innovators need more than the experience or the want to create change, they need the toolsets (both material resources and mental skills) to innovate. Among these, prototyping materials and an expansive capacity to see beyond the obstacles before you, are critical. Finally, the ideal innovator is a "T-person", one that combines depth of experience (the vertical line) with a breadth of knowledge (the horizontal line). The event hosted 100 participants with a median age of 28 years old. The youngest was 9 years old and oldest 63 years old.

The DesignShop model features cycles of iterative learning by doing modules for participants to learn design thinking and apply it on their projects that re-design the education system. This model includes key features, such as:

- Three topics were used to frame the event's challenge, as well as to attract similar-minded participants into pre-assembled teams with shared interests from the start.
- An open online community forum was provided before the event to normalize the relatable experience of the attendees. Participant were asked to read and comment through at least two of the 21 transcribed interviews with education experts that were posted on the site.
- Interdisciplinary teams were pre-assembled to ensure that every team had at least one of each user-type—student/learner, teacher/educator, policymaker/administrator, industry representative—, a low Residual Sum of Squares from the Team mean Design Score— a

portfolio of each person's five self-reported design thinking skills including Rapid Prototyping, Sketching, Using Post-its, Brainstorming in Groups, and Expressing Ideas Through Lego's—, and that those four participants had chosen interest in the same of three topics.

- Hands-on learning modules fostered quicker adoption of design thinking principles. Tutorials on "Visual Thinking Sketching" and "The Power of Prototyping" gave participants tangible skills for development, and deliverable-based team activities gave participants a project-based learning opportunity to apply their newly acquired concepts.
- A flat hierarchy of mentorship throughout kept a democratized learning environment where our youngest 10 year old participants felt as relevant and able to contribute as our 62 year-old more experienced participant. Each team of four had a Team Facilitator (identified by a sequined bow tie) to moderate the interpersonal dynamics and to introduce design thinking strategies to facilitate team activities. Mentors (identified by a neon fedora hat) floated in and out of teams, who had a permanent empty 6th chair at their table to invite the interaction.
- Physical materials for prototyping were available throughout the event in order for teams to bring their ideas to life, regardless of how abstract they were. A base of arts and crafts supplies were supplemented with blue foam and foam core, and thinking tools like a bowl of Lego's at the table center.
- The event ultimately resulted in a competition-based format wherein teams competed for top prizes that would jumpstart the continuation and execution of their developed ideas. These rewards included three prizes for $ 1000 as reimbursable stipend, three prizes for $ 500 as reimbursable stipend, and three prizes in the form of 1-hour consultations with prominent organizations in the space.
- Inspired by the active engagements invested into the students' learning experience in 2.009, encouraging easter-eggs throughout the event rounded out the experience for participants to feel that this was really for them and their learning. Details like small and quirky prizes after answering a mini-quiz correctly, and an upside down encouraging statement on each nametag, set the bar of attention and detail.

The following deliverables were requested of each team of participants during each of the modules.

The Harvard Education Hackathon: Design Background and Parameters

The HGSE Hackathon occurred months later, in October 2014, and was inspired in part by the EduDesignathon and in part by the Edu DesignShop, resulting in a hybrid event that straddled between a hackathon and a workshop. The presentations of the resulting projects from this event were also studied in order to provide more data to be statistically compared. The Education Hackathon was co-presented by HGSE, Google, and edX as a three-day event to "propose, design, and test solutions to educaitonal challenges in online learning."[20]

Team Activity	Sessions Deliverable
Team Meet-up	Team name and logo
Empathize and Reveal Presumptions	Association map of team motivation gathered from user interviews
Identifying the Problem	50+ ideas from group brainstorming; 1 chosen central problem direction
Research and Ideation	Association maps of root causes to central problem; decided root cause of problem to fix; top 2-3 ideas moving forward
Refine Ideas and Prototype	Narrowing to central innovation; exploratory physical prototypes
Feedback Session Prep	2 Posters, one explaining innovation, one asking questions for improvement
Feedback Session	Suggestions for each team reviewed
Iteration	Presentation and Prototype of Innovation

Table 2: Deliverables expected after each Team Activity

Similarly, mentors and workshop leaders helped participants through the stages of ideation and prototyping and testing. However, the teams were not given clear structure as to where they should be in the process throughout their idea's development, nor were they required to submit certain deliverables to keep their teams on track. Additionally, it was not budgeted for teams to spend the night hacking away.

Measuring Systemic Projects: Methods for Data Analysis

Each of these experiments brought together a variety of different people to focus on a similar goal - developing ideas to help make education better. These events, however, differed in structure that, we argue, led to differences in team project outcomes (and participant transformations, as discussed in the second methods section). Events like the Designathon and HGSE Hackathon encouraged weekend-long tinkering projects with no expected thought of how to scale or implement project longevity. Contrastingly, the DesignShop gave the explicit requirement that projects should consider the ability to affect systemic change. By stating this goal for the DesignShop in conjunction with supporting workshops centered around design thinking and the eight key DesignShop elements, projects that emerged from the DesignShop showed a greater thought detail afforded towards affecting a system.

To evaluate this claim, we identify six components below that we would expect to find present in the presentations of each of these projects performing at this level:

- **R2.1** Teams consider all aspects of the problem
- **R2.2** Teams consider the many people involved in creating change
- **R2.3** Teams consider the many processes involved in creating change

- **R2.4** Teams consider system inter-dependencies
- **R2.5** Teams focus on the user and how the user can help invoke systemic change
- **R2.6** Team project shows transformation at systemic level

Both authors engaged in this qualification by watching each of the recorded project presentations at all three expeirments and coding them for a binary expression of each of the six systems signals.

This is not the only qualitative difference between projects, however. Research has been done on the classification of the stages of systemic change. According to Anderson's analysis, there is a continuum of systemic change that can be mapped in a 2D space structured by six developmental stages and six key elements of change[21]. We coded each team presentation and located them as they would place on Andreson's continuum matrix.

Measuring Systemic Projects: Results

Results of coding project presentations by the six aforementioned systemic signals are presented in Table 3.

Research Claim	Cohen Kappa
2.1 Teams consider all aspects of the problem	0.68
2.2 Teams consider the many people involved in creating change	0.72
2.3 Teams consider the many processes involved in creating change	0.74
2.4 Teams consider system inter-dependencies	0.7
2.5 Teams focus on the user and how the user can help invoke systemic change	0.42
2.6 Team project shows transformation at systemic level	0.62

Table 3: Inter-rater reliability agreement percentages of six systemic signals coded in projects.

The agreement across readers shows a promising understanding of team's projects, but the low score of agreement on Research Claim 2.5 highlights the difficulty with interpreting a project that can "invoke systemic change." These areas demonstrated that projects produced by participants had much more focus on how to subsequently take the ideas they had developed over the weekend and put them into production. They also showed that they were much more focused on the systems that their projects could potentially disrupt and create change within. As you can see from Figure 9 and Figure 10 (representations of one reader's coding), the projects from the DesignShop showed a considerably higher percentage of awareness that projects needed to focus on the many people and processes that work together to entice change. Similarly, projects from the Designshop showed significant success at developing projects that showed transformation at the systemic level (meaning that they were not one-off hackathon type products) and that there was obvious focus on the user that would be ultimately interacting with their work (see Figure 13 and Figure 12).

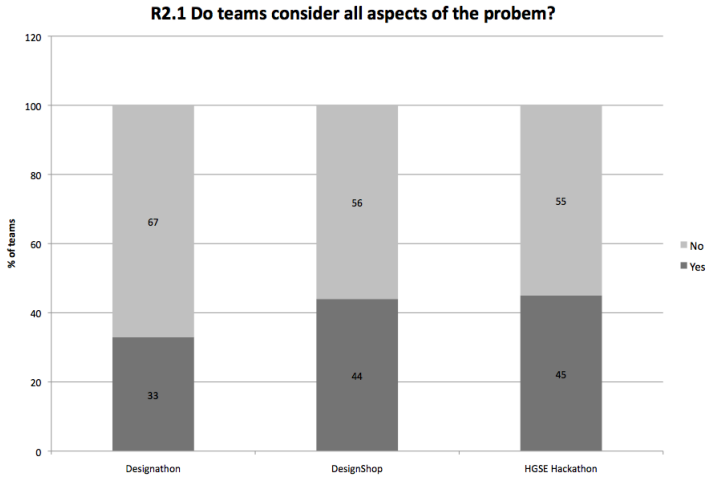

Figure 8: Percent comparison of teams that did and did not **consider all aspects of the problem**

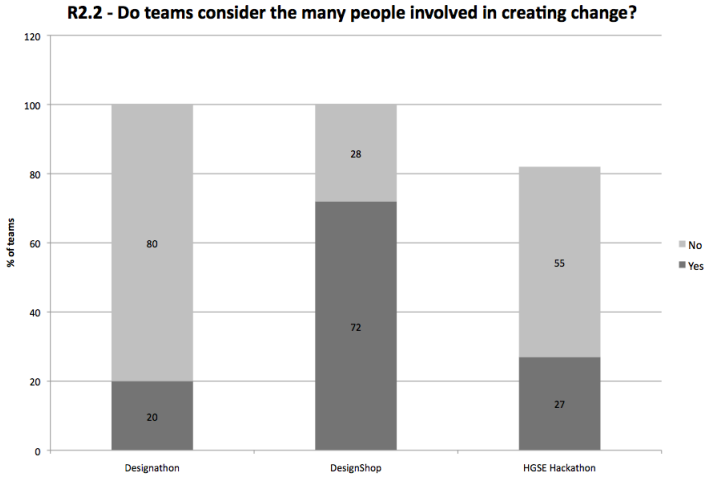

Figure 9: Percent comparison of teams that did and did not **consider the many people involved in creating change**

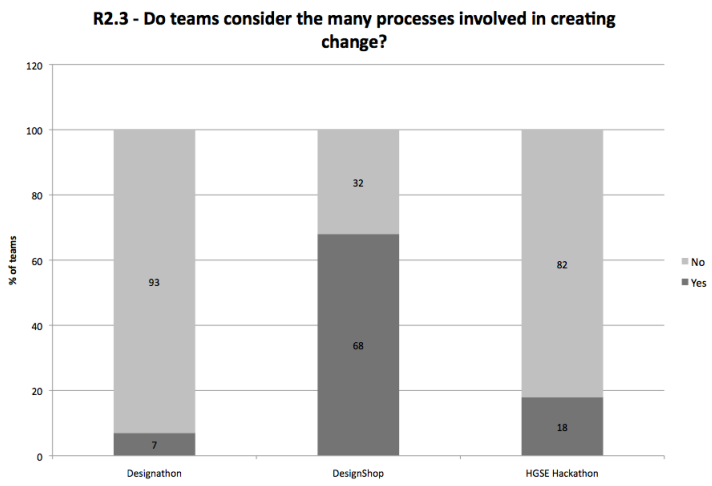

Figure 10: Percent comparison of teams that did and did not **consider the many processes involved in creating change**

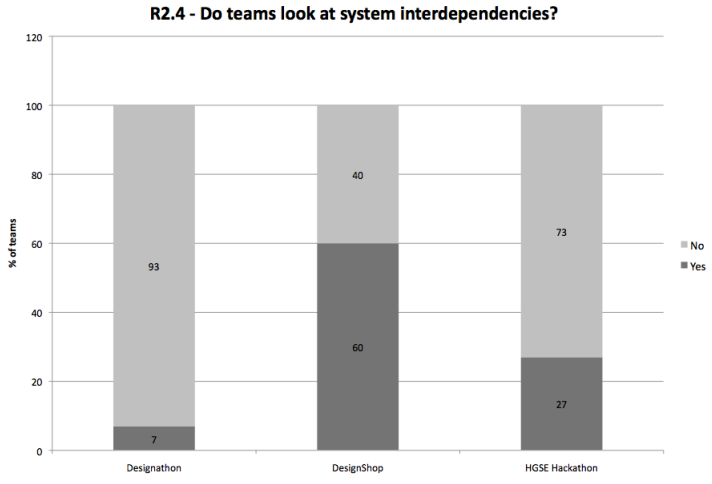

Figure 11: Percent comparison of teams that looked at system interdependencies

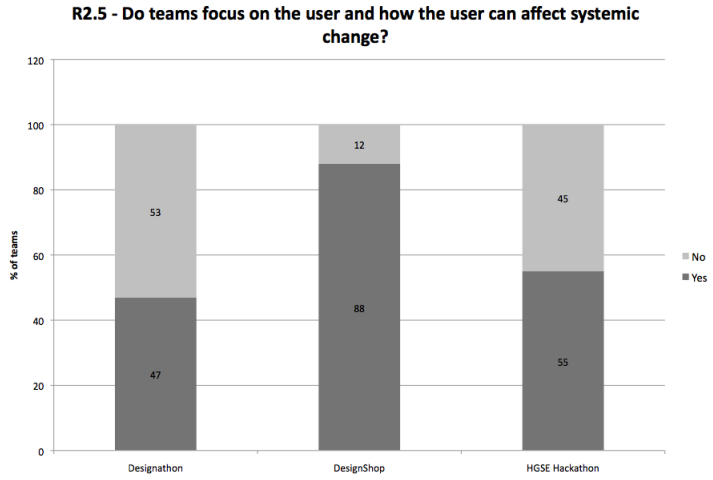

Figure 12: Percent comparison of teams whose **project focused on the user and how the user can affect systematic change**

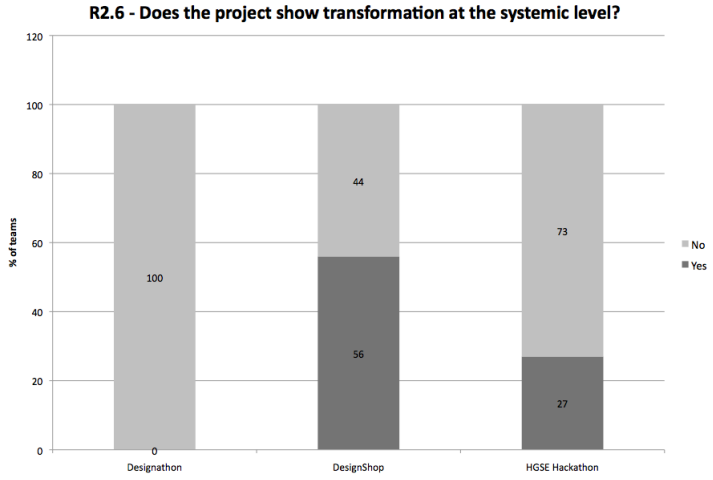

Figure 13: Percent comparison of teams that showed **transformation at system level**

In Anderson's continuum, "better projects," or, projects that are more sophisticated in their thoroughness to affect systemic change lie on the bottom right of the matrix as these would have thought of the policy alignment that would enable the predominance of a new system. Upon reviewing the final projects of the teams across the three separate events and evaluating them on the breadth and depth that their projects took, it is apparent that the DesignShop brought out a greater number of teams that exhibit higher sophistication for instituting change with their projects. Compared to the DesignShop (see Figure 15), both the Designathon and the HGSE Hackathon (see Figure 14 and Figure 16, respectively) contained projects that had lower developmental stages than those of the DesignShop.

You can see the differences in thinking supported at these events by taking a look at the difference in deliverables. One project that came out of the DesignShop, the PlayLab, was an idea to create a modular shared space to bring back play and exploration to the school day. This team discussed the implications that this type of space would have on students, teachers, administrators, and possibly the state. The team was sure to be aware of accomodations that may need to be made for different learning or accessibility styles as well as fitting within the constraints of a school day. The idea of the PlayLab showed thinking that affected a system rather than a single product that solved a possible problem. This holds a stark comparison against some projects from the HGSE Hackathon. At the HGSE Hacakthon, InstaCourse, a team that aimed at making it easier for anyone to create an online course faster, paid little attention to the current issues surrounding online course building or the impediments that stood in the way. This team focused only on the person who would be building the course but not the possible students that would be using it or the administrators that may need to get on board.

The differences in these projects show that it is possible for a group of people to come together and develop ideas that can create real change for the problems our society currently faces and do so with scale and longevity as a crucial aspect of it.

Measuring Participants' Transformations: Methods for Data Analysis

The data gathered here looked for evidence that participants that attended transformed into design thinkers, as evidenced by an increase in their choice of problem-solving methodology. A 20-minute evaluation of each participants' problem-solving ability was conducted at three different points: Pre-event (before the event began), Post-event (in the immediate moment the event was over while the judges deliberated the winning teams), and Post-Post-event (in the 2-3 month timeframe after the DesignShop). These surveys asked three general questions and gave a box nearly the size of an entire 8.5"x11" sheet for the answer. The three questions are below, in the order they appeared in the evaluations:

- **Pre-Event Survey** You have been tasked to reverse an emergent trend of persons throwing trash away in the recycling bins. When these items are mixed, they are no longer recyclable. Please describe the steps you would follow to address this task.
  Remember, there is no wrong answer, but you only have 20 minutes for this activity.
- **Post-Event Survey** You work for a Fitness Center that has interested members, but they're just not meeting their health goals and it is your job to keep them as customers.

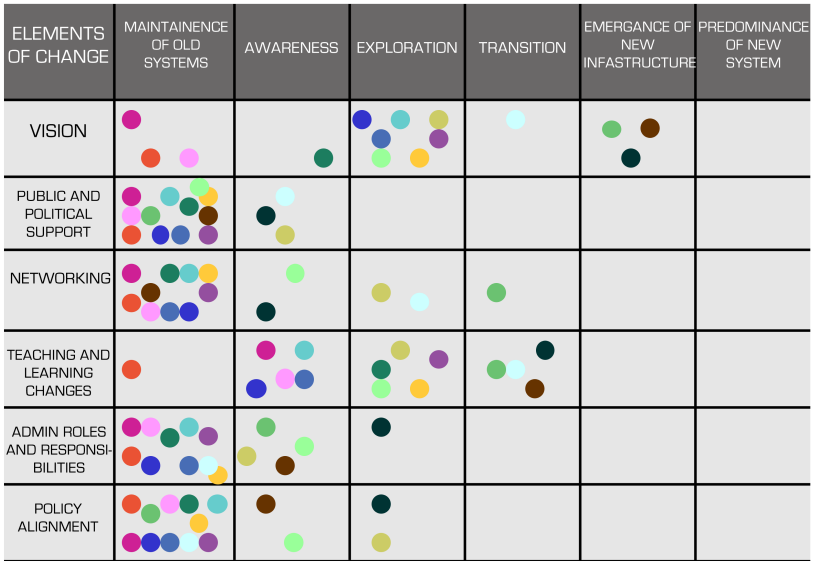

Figure 14: Matrix of systematic project dependencies of Designathon teams

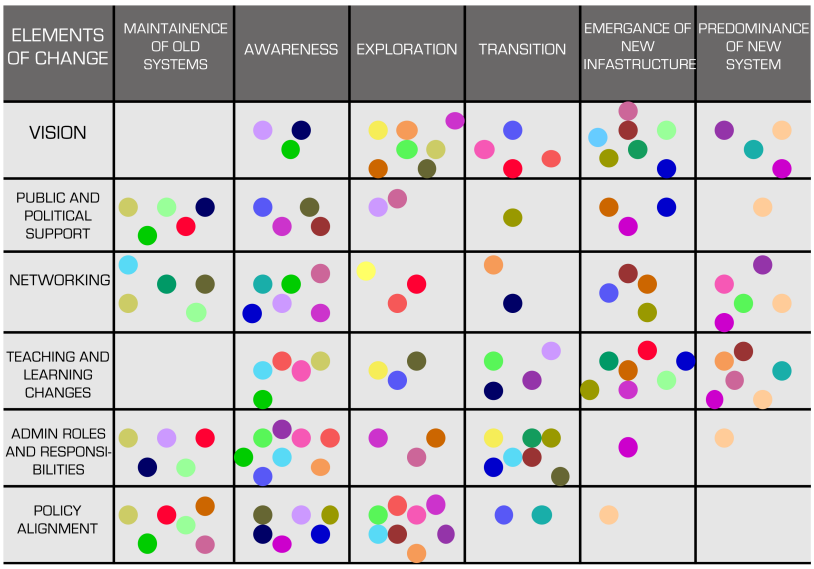

Figure 15: Matrix of systematic project dependencies of DesignShop teams

Figure 16: Matrix of systematic project dependencies of Harvard Graduate School of Education Hackathon teams

Please describe the steps you would follow to address this task.
Remember, there is no wrong answer, but you only have 20 minutes for this activity.

- **Post-Post-Event Survey** You have been asked to stop the spread of mosquito-spread malaria in West Africa.
  Please describe the steps you would follow to address this task. Remember, there is no wrong answer, but you only have 20 minutes for this activity.

These responses were analyzed and coded for the five core design thinking steps of the d.School and IDEO process: Empathy, Define, Ideate, Prototype, Test. First, the evaluations are read over and each step the participant suggests is logged, in chronological order, with a designated weight, or depth of appreciation for that step. This depth is reported on a scale of 0-3 where a 0 is a no mention, a 1 reports a slight mention, almost as if to check off a box that mentions the step in the process; a 2 reports a significant mention of the process, it's importance, and/or how it might be executed; and a 3 reflects a deep appreciation of the step, some potential methods of execution, or even reasons why it is important and warranted at the moment.

After this chronological log was made, a global representation of the respondents' appreciation for the design thinking step was coded. This recorded the overall depths of appreciation shown for each step of the process, at some point or another throughout the response. In our coding protocol, if a response simply mentioned the design thinking process step as if to check off a box, they simply received a 1 whereas if they cited specific methods they would use to build empathy, for example, they'd receive a 3.

Data was collected to understand how the eight key components worked to effectively support non-designers into Design Thinkers.

From evaluation of participant feedback we found that 79% of participants at the DesignShop said that they agreed or strongly agreed that their team benefited from being interdisciplinary. We also found that participants reported a perceived increase in ability to brainstorm in groups and use tactile visuals to help express their ideas as well as an increase in ability to empathize with others.

Measuring Participants' Transformations: Results

Below you can see a time-lapse view of the chronological flow through the entire set of participants' evaluations, comparing their answers in the Pre-Event Surveys (Figure 22), in the Post-Event Surveys (Figure 23), and in the Post-Post-Event Surveys (Figure 24). In this matrix layout, each bubble represents a node in the survey response where each number denotes how many participants mentioned that process in that order. The columns represent the chronological step over time. The rows represent one of the five steps in the process. In this representation, an ideal response that follows the design thinking process in perfect order (Empathy first, Define second, Ideate third, Prototype fourth, and Test fifth) would be shown in the diagonal form of an Identity Matrix, moving from Empathy in the top left corner denoting their first step, and ending with Test in the last bubble, row five, column five. The circle graph around each node overlays a gradient of the weights of each of those responses. That is, of the 32 participants in the Pre-Event Survey (Figure 22 that responded first with Empathy, 29.2 percent answered with such few examples that they were categorized at a weight, or depth, of 1 (represented by the light color), another 29.2 percent answered a bit more thoroughly and were categorized at a weight of 2 (the intermediate color), and 41.7 percent responded with sufficient examples and proficiency that they ewre given a depth of 3 (the darkest color).

As illustrated in Figure 23, there is a clear gravitation of participants answering their problem-solving exercises using design thinking in the Post-Event Surveys right after the DesignShop. It is even more validating to see this trend line in the Post-Post-Event Surveys conducted months after the DesignShop. This suggest that the methods captured a transformation that occurred in the long-term understanding of the person, and not in the short-term memory of the participant.

Our weighted charts in Figures 17 through 21 illustrate the depth of appreciation that participants used when referencing each step in their survey responses. In example, there were 4 persons in the Post-Event Evaluations that showed Empathy at a level of 0 (not ever mentioned) whereas there were 36 persons in the Pre-Event Evaluations that did not mention Empathy. The general move towards the right side of the plots (and into the higher and deeper levels of usage for each step), suggest that not only did our participants increasingly reference the design thinking process as their problem-solving method of choice, but they also more deeply understood each part of the process and were able to use convincing examples of methods they might employ when implementing each of the parts.

As depicted here, many participants were strong in the area of ideation - or coming up with ideas.

Before the Designshop, most participants just gave solutions long before they understood the situation, context, or reasons there even exists a problem. It is important to note that people are not lacking creativity to find solutions, but the creativity to find the right problem. The DesignShop in comparison to other hackathon models gives participants a framework to think within a framework and to then go out and ask the right questions to solve real challenges. This coding was also done by two readers coding each response to identify what step of the design thinking process the participant was engaging in, and at what level. Table 4 denotes the percent of agreement in the averaged weights of each step for each set of participant data.

Survey Response	Empathy	Ideate	Define	Prototype	Test
Pre-Event	62.3	70.1	51.2	94.4	66.2
Post-Event	92.4	65.4	46.1	63.2	69.4
Post-Post-Event	59.8	74.4	66.5	68.6	82.4

Table 4: Inter-rater reliability percentage of agreement for averaged depth of understanding in each of the five process steps referenced in participant responses, across all three sets of data.

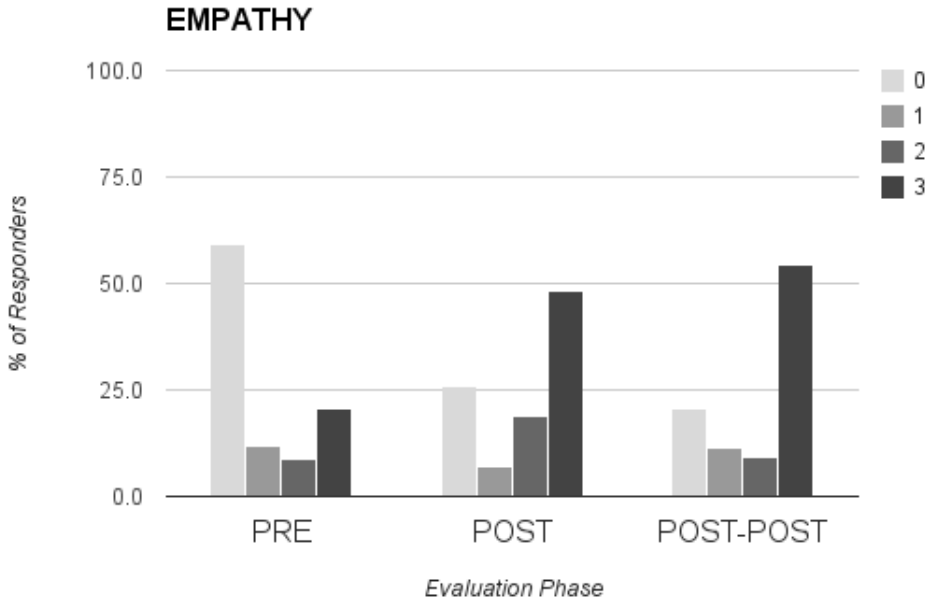

Figure 17: Comparison of number of participants at each depth of implementation for the design thinking process step of Empathy.

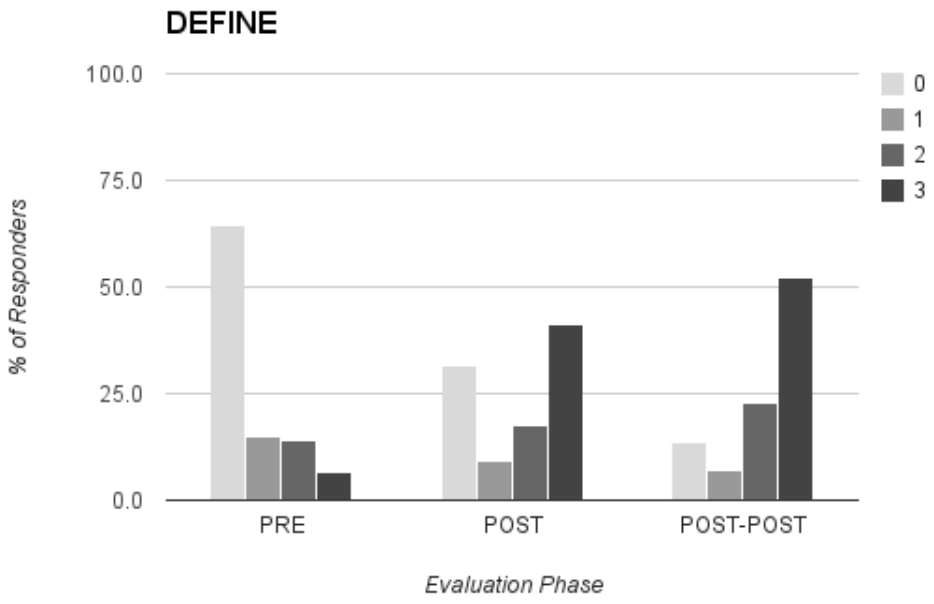

Figure 18: Comparison of number of participants at each depth of implementation for the design thinking process step of Define.

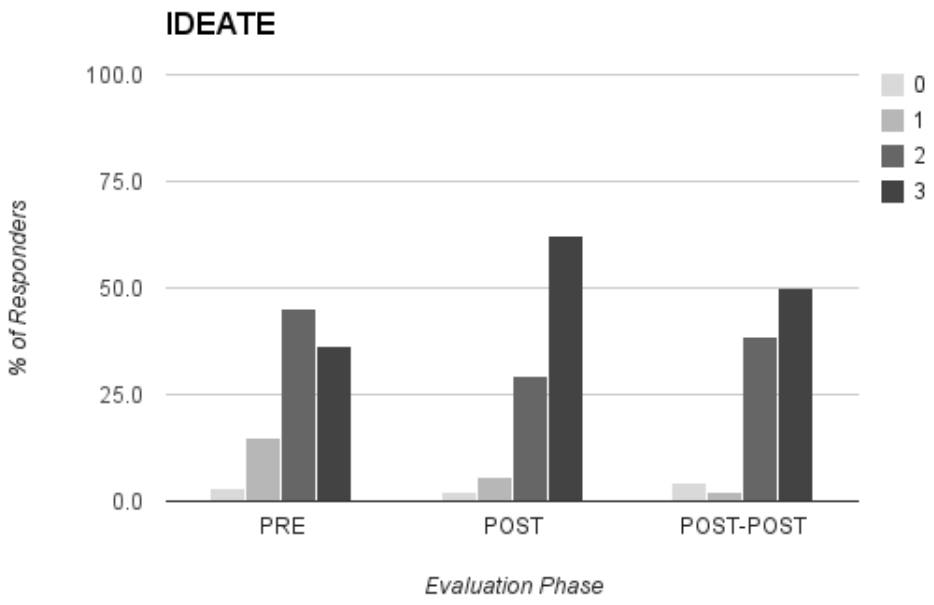

Figure 19: Comparison of number of participants at each depth of implementation for the design thinking process step of Ideate.

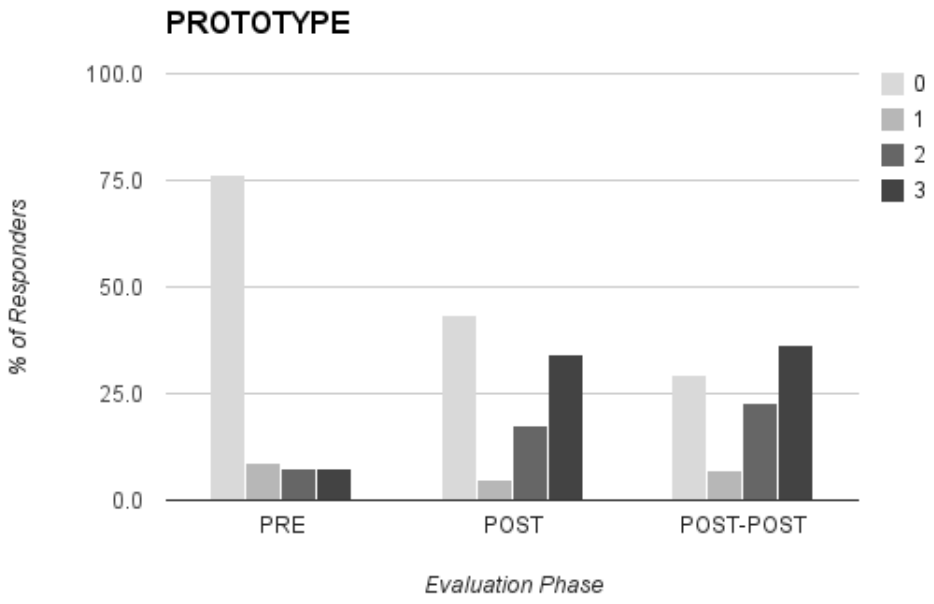

Figure 20: Comparison of number of participants at each depth of implementation for the design thinking process step of Prototype.

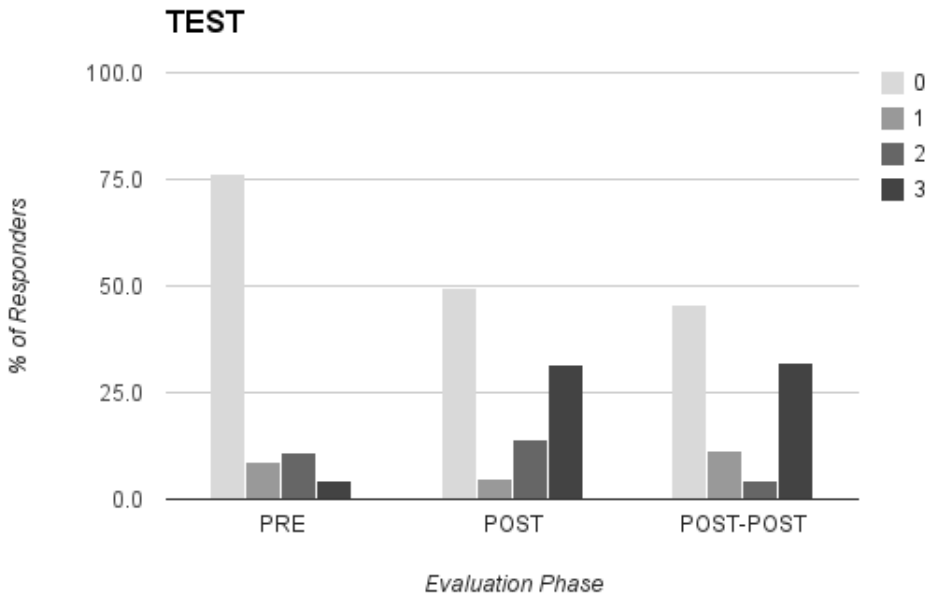

Figure 21: Comparison of number of participants at each depth of implementation for the design thinking process step of Test.

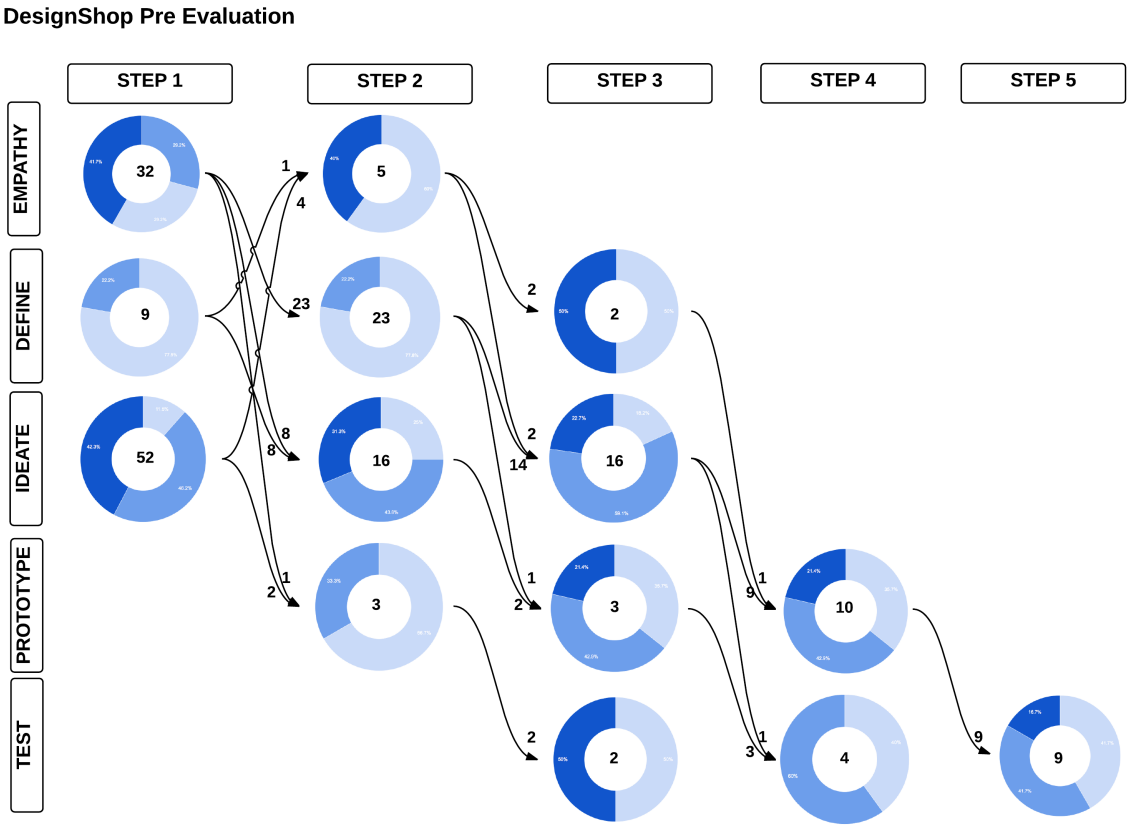

Figure 22: Chronological flow of design thinking process within participants' responses in the Pre-Event Survey; n=93 participants

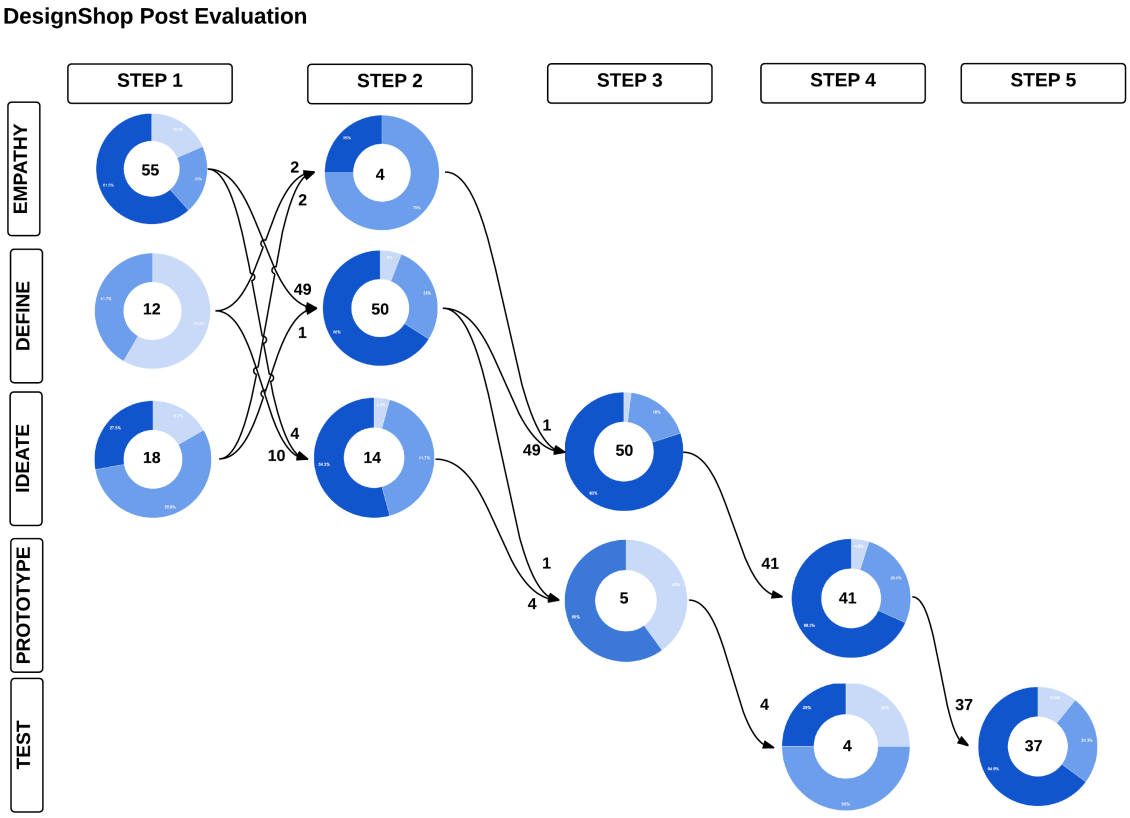

Figure 23: Chronological flow of design thinking process within participants' responses in the Post-Event Survey; n=85 participants

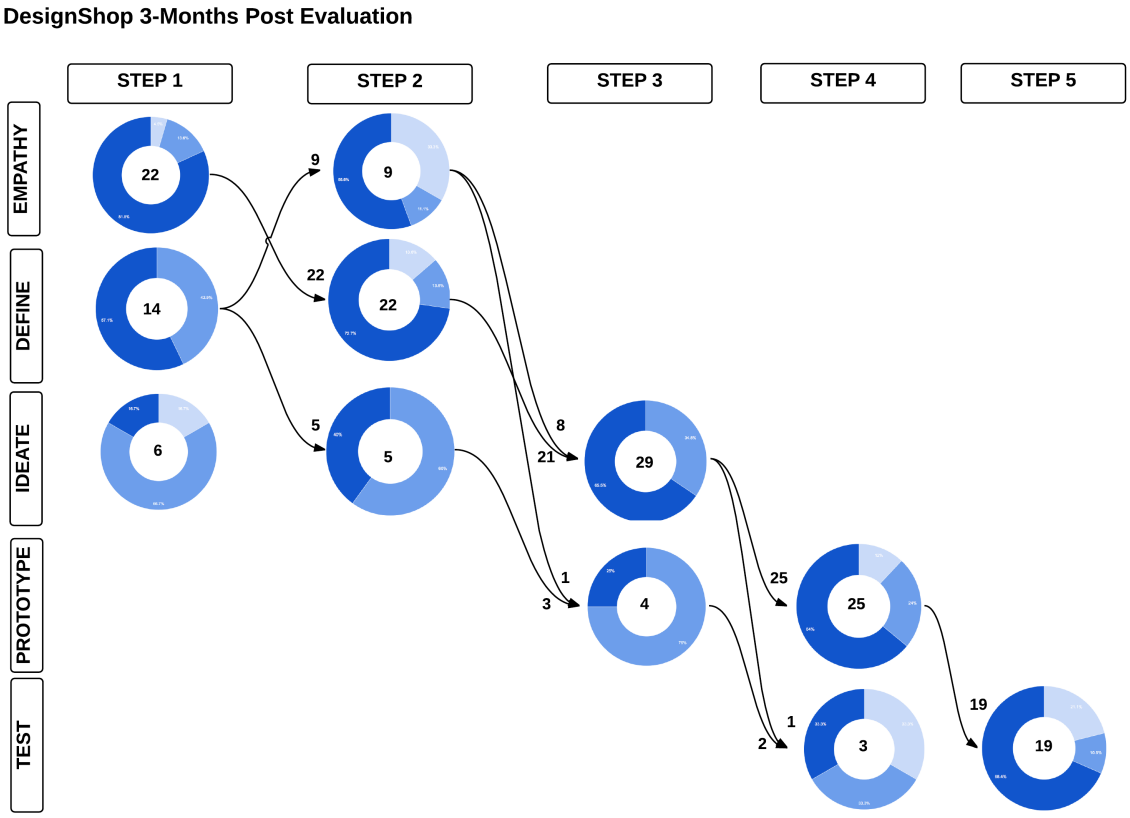

Figure 24: Chronological flow of design thinking process within participants' responses in the Post-Post-Event Survey; n=44 participants

Conclusions and Future Work

Time and time again we are reminded that the world needs more engineers. Although the world is certainly in need of mechanical, chemical and electrical engineers, there is also the more general fact that world needs more people who *think* like engineers. By teaching the frameworks in which engineers think to non-engineers, the world may perceive itself differently.

The data from the DesignShop show that non-designers—or those who have not been traditionally trained in design or design thinking—can begin to think and act upon their ideas like a Design Thinker would over the course of a weekend. By making this workshop model available to people young and old with a variety of background experiences and education levels, these projects show immense creativity and concern for finding solutions to solve systemic everyday problems. The eight components of the DesignShop are part of the main reason for this change. Topics to attract like-minded individuals, an open online space for research and information, effective team creation, hands-on learning workshops, mentors for help, free use of materials, prizes to motivate, and surprises throughout facilitate a collaborative learning space that is engaged, focused, and eager to create projects.

These eight components helped push the DesignShop participants above and beyond to think about their project and its implementation in a way that it could have a real place in the world and affect real people. By applying these methods to future hackathons projects will likely show similar results where participants think about, work on, and continue beyond the hackathon projects that evoke real solutions to real problems. These methods do not only apply to the area of Education. By taking these components and adapting them to hackathon themes of other societal or systemic issues, the projects born from it are likely to have a much higher chance of making a real impact on the world.

The DesignShop is a model in which this type of teaching and thinking can happen. It is important to note the success that the DesignShop has had at bringing together and teaching concepts to both students as young as 9 and adults as old as 63. The fact that the DesignShop caters to such a wide range of participants, and is successful at doing so, gives insight in to how the structure of hackathons, designathons, or DesignShops should take shape in the future to support a myriad of non-traditional engineers and the value-added by opening these types of events to the any willing participant. Current pedagogy in education does not capture the ability to step back and ask a question about a problem before trying to solve it. Events like the DesignShop allow participants to learn how to solve a problem by asking questions first, like a traditionally trained engineer. The structure of the DesignShop could be used in the future to support the shift to project-based learning and having our citizens understanding how to create empathy.

References

[1] E.S. Raymond. Technopedia, 2003. URL http://www.catb.org/jargon/html/online-preface.html.

[2] C. Jansenn. Technopedia definition of hackathon, 2013. URL http://www.techopedia.com/definition/23193/hackathon.

[3] A. Llewellyn. The power of hackathons in government, 2012. URL http://open.nasa.gov/blog/2012/06/29/the-power-of-hackathons-in-government/.

[4] International music hackday, 2015. URL http://new.musichackday.org/.

[5] M. Mendoza. Hackathons on the rise, 2014. URL http://www.mercurynews.com/business/ci$_2$5162580/$hackathons - riseFvgfg$.

[6] RemixEd Hackathon, 2013. URL http://remixedk12.com/resources/.

[7] Clean web hackathon, 2013. URL http://boston.cleanwebhack.com/wp/.

[8] Mass EduData Challenge Hackathon Hackathon, 2013. URL http://www.eventbrite.com/e/the-mass-edudata-challenge-registration-11540647387?aff=eor

[9] Tufts Entrepreneurs Society Tufts Empower Harvard Developers for Development, MIT Global Poverty Initiative. International development hackathon, 2015. URL http://idhack.developersfordevelopment.org/.

[10] MIT Hacking Medicine, 2015. URL http://hackingmedicine.mit.edu/.

[11] Renee Libby Beck. Prototyping teaching at education hack day. November 2011. URL http://www.bmoremedia.com/features/educationhackday110811.aspx.

[12] Jessica A. Artiles. Borrowing from hackathons: Overnight designathons as a template for creative idea hubs in the space of hands-on leanring, digital learning, and systems re-thinking. In *World Engineering Education Forum*, 2013.

[13] David R. Wallace. 2.009 product engineering processes, 2014. URL web.mit.edu/2.009/www/.

[14]

[15] IDEO. A design and innovation consulting firm, 2015. URL http://www.IDEO.com.

[16] Tim Brown and Jocelyn Wyatt. Design thinking for social innovation. In *Stanford Social Innovation Review*, pages 30–35, 2010.

[17] Massachusetts Executive Office of Education. Innovation schools approval process, 2010. URL http://www.mass.gov/edu/government/special-initiatives/education-for-the-21st-century/c

[18] Jessica A. Artiles. Methods for innovation: Observations from the education designshop. In *FabLearn Conference*, 2014.

[19] Tim Brown. *Change by Design*.

[20] Harvard Graduate School of Education. Education hackathon, 2014. URL http://www.eventbrite.com/e/hgse-student-education-hackathon-registration-13223426625.

[21] Beverly Anderson. The stages of systemic change. *Educational Leadership*, 51(1):15–17, 1993.