Lessons Learned from NSF I-Corps Boot Camp

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Abstract
Audience Response System, (ARS), has proven its values as a tool to enhance students' engagement and participation in the classroom. Since 2011, the author was working on to creating a web based application, Click2Text, to incorporate cell phones and smart phones in traditional and online classes to replace ARS. Several web-based solutions were tested and launched, however, it was hard to convince fellow faculty members for its adoption. It is also a known fact that most academic researchers in universities and college have little or no previous knowledge of entrepreneurial process nor do they possess the entrepreneurial mindset and related skills. So, when in the winter of 2016, the author was presented with an opportunity to participated in the NSF I-Corps introduction to customer discovery course, boot camp at Wayne State University, it was seen as a great opportunity to learn entrepreneurial process and skill. This paper documents how I-Corps boot camp helped in refining author's research on Click2Text by identifying right customer segments and their needs and using them to create feature list that will eventually contribute to popularizing Click2Text within the university. The study also document lessons learned that would help new and young academic researchers making the intelligent decision of choosing to participate in I-Corps activities and how to get the most benefit of the boot camp.
Keywords: NSF, I-Corps, customer requirements, product design, commercialization

1. Introduction

There are many new product development process models, (Browing, 2009), however, most consist of some general steps; concepts/seed, product development, alpha/beta test and finally launch, Figure 1. This model is useful for existing companies that usually know their customer base, or has well define product features and already has known market and competitions. Ulrich and Eppinger, (2011), describe a generic product development process, Figure 2, that can be used for product that opens an entirely new market or the one that adopts or replaces an existing product or the one that significantly broadens the market for an existing product or an old product that is been introduced in a new market or old product packaged in a different way or sold in a different way.
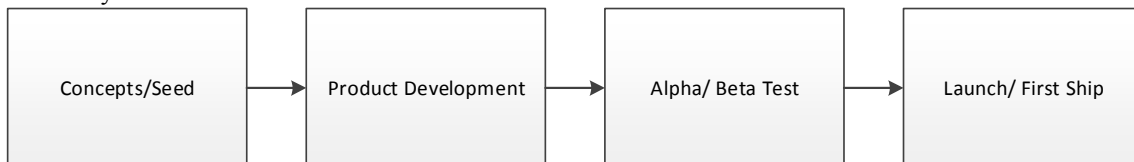

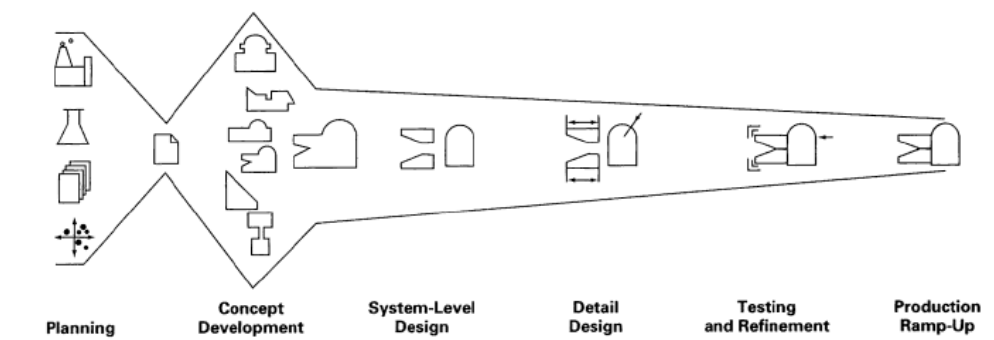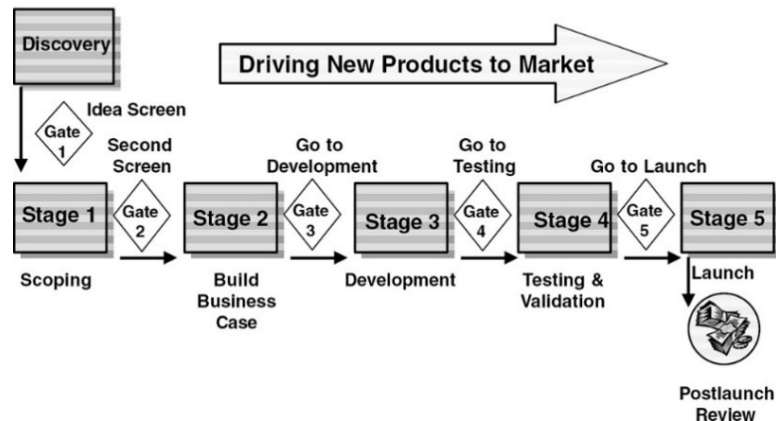Figure 1. Generic Product Development Process

Figure 2. Ulrich and Eppinger's generic product development process

The product development problem arises with "startups", or when new product is an innovative product, or a new product lines that can launch the firm to an existing market, or an addition to an existing product line or an improvements and/or revisions of existing product that can reposition it to target a new market. In such cases, most of the companies do not even know their customers. Company's founders or high executives usually capture the vision for their business or their product in a very crudely manner and converts them into business ideas. A typical New Product Development, process, NPD, is shown in Figure 3, which breaks the innovation process into stages and gates (Cooper, 2001).

[1]Stage-Gate® is a registered trademark of Product Development Institute Inc. in the U.S.A.; see: www.prod-dev.com.

Figure 3. New Product Development Process

The product development process, especially the NPD, requires creativity, thus, the discipline demand a systematic approach to guide the operations. The NPD process is based on a series of development stages that are interpolated by some evaluative steps. The development stages of the NPD process, Figure 4, include the discovery of new product ideas, the development of an initial product concept, an assessment of its business attractiveness, the actual development of the product, testing it within the market, and the launch of the product in the marketplace, followed by post launch reviews (Tzokas, Hultink, & Hart, 2004)
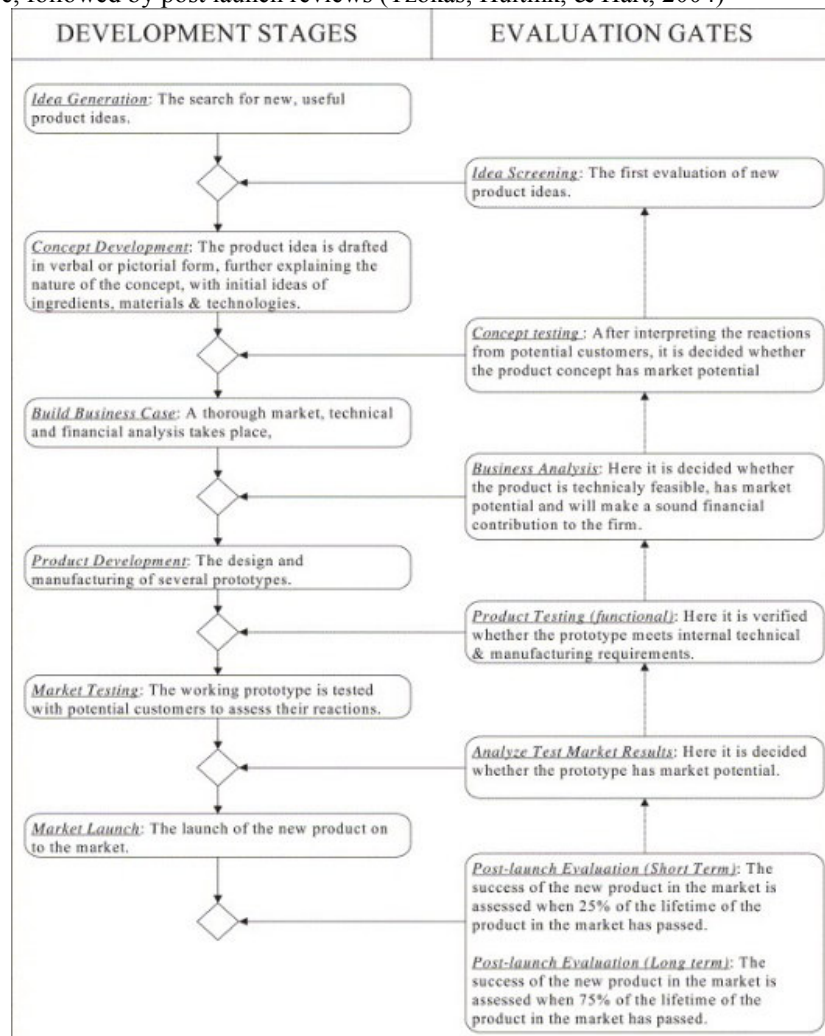

Figure 4. Development Stages of the New Product Development process

Researcher in entrepreneurship argues the fact that interesting entrepreneur research can be produced by passionate researchers who invest time on ideas that are important to them and the one they are emotionally attached with (Oliver Mallett, 2017). Academic researchers also work similarly. Fink and colleagues, (2016), concluded that the study with greater passion behind it produced a more interesting paper. This conclusion potentially doesn't appear to be a surprise output of their research rather than the nature of the result. In any way, there is a clear link between the passion of the authors and their outcomes. Nonetheless, Fink and colleagues, (2016), argue that passion is a vital component in the production of interesting research and this is certainly a worthwhile aspiration for all researchers (Oliver Mallett, 2017). It is also proven that qualitative research usually reveals meaning and understandings that are taken for granted. Which is further complicated by researchers' 'blind spots' in the research process that is also linked to investigators' enthusiasm about their research, (Holtan, Strandbu, & Eriksen, 2013). So researchers' emotions and excitement at one hand is needed to create effective research, and at the same time it can falsely convince scientists and entrepreneurs that the market and customer for their technology exist, and being the creator of the technology they have a complete understanding of features their customer need and how their product will ultimately reach them. The issue will get complicated when the researchers are academic researchers and entrepreneur simultaneously.

During the winter of 2016, the author was working on a new technology solution, Click2Text, to enhance students' attention in the classroom through the use of smartphone and Short Messaging Service, (SMS). The objective of the research is to obtain a replacement of Audience Response System (ARS) a.k.a. "clicker," (Kendrick, 2010). So when in January of 2016 National Science Foundation (NSF), announced I-Corps Customer Discovery Workshop (short course) at Wayne State University, the author thought it to be an excellent opportunity to further develop research subject matter, by incorporating customer discovery for research, so as to collect data for research /publications and ultimately obtain additional funding through participation in the National NSF I-Corps program or launch a new product in the market.

It was this author's perception that I-Corps program will help to ensure that his research did not encounter issues related to "emotion and enthusiasm" effects. This paper document the changes made in the research on the use of smartphones in classrooms to gain student attention by following the methodology taught during the I-Corps Customer Discovery Workshop. The study also documented lessons learned from I-Corps workshop and how academic researchers can benefit from it. The remaining paper is organized as follows; NSF and I-Corps program description, details about I-Corps customer discovery methodology along with its application in the Click2Text research, and finally, in the last section, lessons learned, results and conclusions are presented.

2. NSF-Innovation Corps (I-Corps)

The National Science Foundation (NSF) is an independent U.S.A. federal agency and was created in 1950 "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense..." (NSF website https://www.nsf.gov/about/). However, lately the foundation has shown a keen interest in commercialization of research into customer based product and processes, (NSF 2011).

NSF Innovation Corps (NSF I-Corps [TM]) program was launched in 2011 when NSF adopted the Lean LaunchPad methodology, which involves entrepreneurial immersion, hypothesis-driven customer discovery, and business model validation, (Blank & Dorf 2012; Osterwalder & Pigneur 2012). NSF I-Corps is a signature project of Subra Suresh, director of NSF during 2011 and later the president of Carnegie Mellon University, (Pellicane, Blaho). I-Corps is a unique, public-private partnership that focuses on introducing scientists and engineers with business tools that can help them to translate their academic work, from lab to marketplace, (Robinson, 2012). There is, however, always a debate over whether science and entrepreneurship can coexist in research universities, (Roach, 2017). One side contends that faculty and graduate students should embrace entrepreneurship as a means of broadening the impact of university research on society and economic growth, while the other express concerns that encouraging entrepreneurship may undermine the core mission of research universities by shifting attention away from fundamental research, (Roach 2017).

I-Corps has two components; the I-Corps Teams and the I-Caps Nodes, together they form the National Innovation Network. I-Corps, utilizes seasoned commercialization experts, including serial entrepreneurs, investors, and directors of innovation to teach/ support academicians on how to make their research into a marketable product, in seven weeks long NSF I-Corps boot camp. Academicians and their graduate students/post-doc, team up with an industrial mentor to develop business model hypotheses about their technology's Value Proposition and Customer Segments, which together create a product/market fit. The main essence of this boot camp is to ensure that researchers test their hypothesis by actually interviewing at least 100 potential customers. According to Blank (2013), this process favors experimentation over elaborate planning, customer feedback over intuition, and iterative design over traditional "big design up front" development.

3. Introduction to Customer Discovery (ICD)

NSF I-Corps Introduction to Customer Discovery (ICD) course is based on the Innovation Corps (I-Corps)

curriculum that teaches a methodology to help researchers discover the commercial potential of their research/technology. The course targets university researchers who are working on a technology that, they think, has the potential to benefit society and would like to seek help in increasing the commercialization of that technology into products and processes.

The objective of the ICD course is to introduce NSF I-Corps to participant, teaches them the start-up company process by differentiating it from the traditional new-product development process and finally teaching researchers methods to engage with their customers by actually getting out of the lab/building, to modify the research thesis and by discovering the value of their technology. The ultimate course objective is to better equip the researcher to go on to the NSF I-Corps national program competition to seek new grant for successful commercialization. The entire course is about avoiding building something that no one cares about and finding something they do care.

All members of the I-Corps Team are required to participate in an intensive, formal curriculum based on Stanford University's Lean Launchpad course developed by Steve Blank. I-Corps Teams are the "on the ground" practitioners of innovation and usually consists of three members, the principal investigator (PI), entrepreneurial lead (EL), and the mentor. The principal investigator (PI) is the original NSF grant venture who act as the technical lead and project manager. The entrepreneurial edge, (EI), is usually a postdoctoral or graduate researcher responsible for assessing commercialization considerations and eventually transitioning the technology to the marketplace, should a "go decision" be made. The mentor serves as the guide and the interpreter of the business world for the team's scientists and engineers, (Robinson, 2012). A significant portion of the course deals with the learning of how to build a business model, talk to customers, make decisions about the research based on their inputs and gain insight from experienced industry Entrepreneurial leaders regarding its commercialization.

During the class sessions, the emphasis is given to the Business Model Canvas. The Business Model Canvas, (BMC), figure 5, is a strategic management and lean startup template for developing new or documenting existing business models. It is a visual chart with elements describing a firms' or product's key partners, activities, resources, value proposition, infrastructure, customers, and finances.

The customer discovery process in the NSF I-Corps program involved three different maps, called value chain, ecosystem and workflow, (Osterwalder, Pigneur 2010) described for users/buyers/payers customer segment.
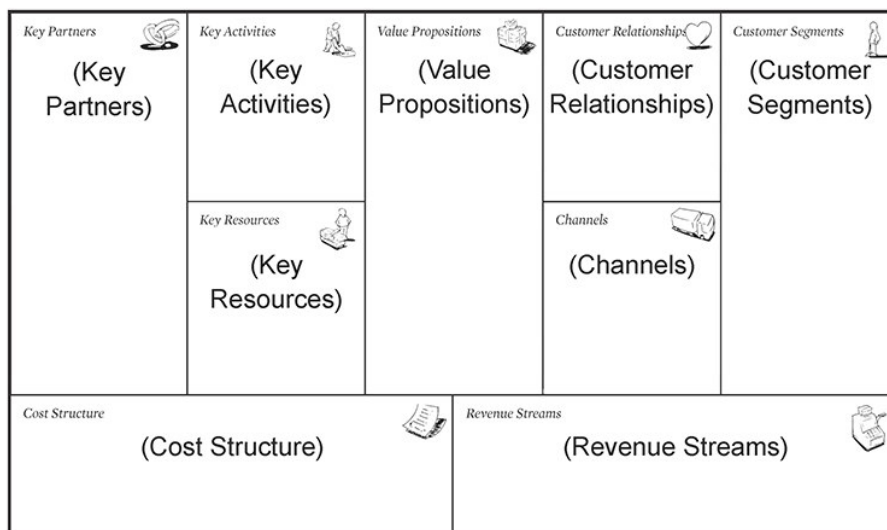

Figure 5. The Business Model Canvas

Teams present their weekly insights with feedback from the Teaching Team, followed by a discussion of a video and corresponding assigned text, which covers one block of the BMC, each week. During the ICD course, BMC blocks related to the customer, (i.e. value proposition, customer relationships, channels and customer segments) were dealt in detail. After sufficient data is gathered, the team can pivot because of a pattern of invalidations and must continue their customer discovery process to reach a Go or No Go conclusion by the end of the course. Simply put, the NSF I-Corps program enables academic researchers to quickly, determine the technology's readiness in the marketplace.

3. Customer Discovery – How it Improved the Research
3.1 The Research
In 2016, author and his graduate students were working on ways of incorporating cell phone/ smart phones in

classrooms. Many instructors across a variety of institutions are using technologies such as Audience Response Systems, (ARS), commonly called clickers, in an attempt to improve learning and engagement. Most reviews (Caldwell, 2007; Fies & Marshall, 2006; Kay & LeSage, 2009; Keough, 2012; Landrum, 2015) noted an over haulm majority of evidence in support of clickers helping in student engagement such as attendance, attention, and participation.

The author and his graduate students are trying to use Short Messaging Services, (SMS), within a learning infrastructure that will support instructor to communicate and teach using SMS. The research outcome seeks to find a replacement for "clicker," and a web based application called Click2Text. Click2Text would be a communication tool to develop various teaching and learning activities to enhance students' learning.

3.2 Customer Discovery Applied to Click2Text

The best part of NSF I-Corps goes beyond instilling a theoretical understanding of business models and practices in participating scientists and engineers, (Robinson, 2012). According to 100firsthits.com, 99.7% of all documented new ideas fail and the primary reason for failure, 38% of the total, is that no one wants them, figure 6.The most important point that I-Corps mentors and trainers passed on during the first part of the training is the importance of developing "things" that people want. They relate the "customer needs," and the problem that the clients are facing with "pain" one can suffer, thus creating a scale where the high customer demand or customer problem can be equal to pain because of "shark bite" and as little as a "mosquito" bite. In most cases, such mosquito bites are treated as a nuisance.

So, instead of using the traditional approaches for innovation that focus either on reducing technology risk or execution risk, I-Corps, on the other hand, emphasize on the following three aspects.

1. The value this new technology/innovation will deliver. It specifically seeks actors that this value would be provided to, thus seeking the real market segment and the product-market fit.
2. What business model would be used to deliver this value? And finally
3. What will be the return on investment for this invention?

For I-Corps it is important that all three of the aspects are covered before assessing the viability of the research. The importance of these points was made apparent to the author and his team when they were asked to explain their research and its relevance to the mentors and instructors during the first day of ICD course.
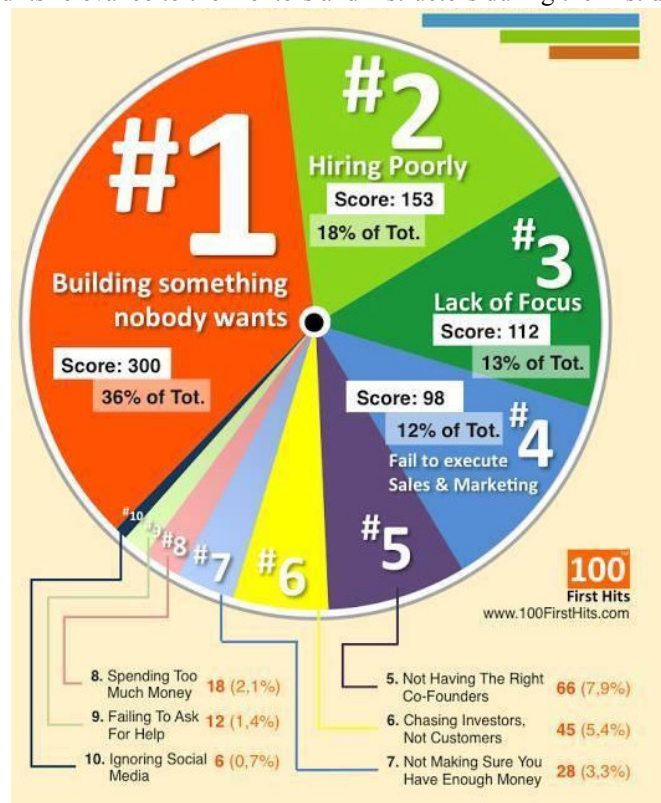

Figure 6. Reasons for failure of new ideas

These mentors asked particular questions to understand the product/technology while trying to discover potential customers, e.g. who they are and why do they care about the technology/product. Some of the mentors' comments were blunt, and few researchers found them demeaning. According to these researchers, mentors don't have the basic knowledge to understand their technology/product, while the mentors were of the opinion

that the researchers were unable to explain their research in the layman terms. As with so many other participants, initially the author and his team also found the process and course progress as daunting, and mentors'/experts' comments as degrading. However, later this become the most valuable aspect of their experience.

I-Corps customer discovery, (CD) process starts by identifying the value proposition (VP), and the customer segment, (CS), of the proposed research. CD helps to answer, who is the customer and why do they buy? CS is external to the research system and helps in identifying the customers and benefits they get when using the researched technology/product. The VP, is internal to the researched technology/project and help to identify its features. VP is built around the list of all product and services. It describes how the product or service alleviate customer pains and creates gains. The VP and CS should fit each other; that is features are addressing customer pains and gains. Figure 7 represents the initial work done for VP and CS. Figure 8, illustrates the original eco diagram. An ecosystem diagram illustrates how the system will work and what are the essential subsystem, and how the customer will interact with it. Table 1, accounts for the features outlined on the first day by the author's team for Click2Text.
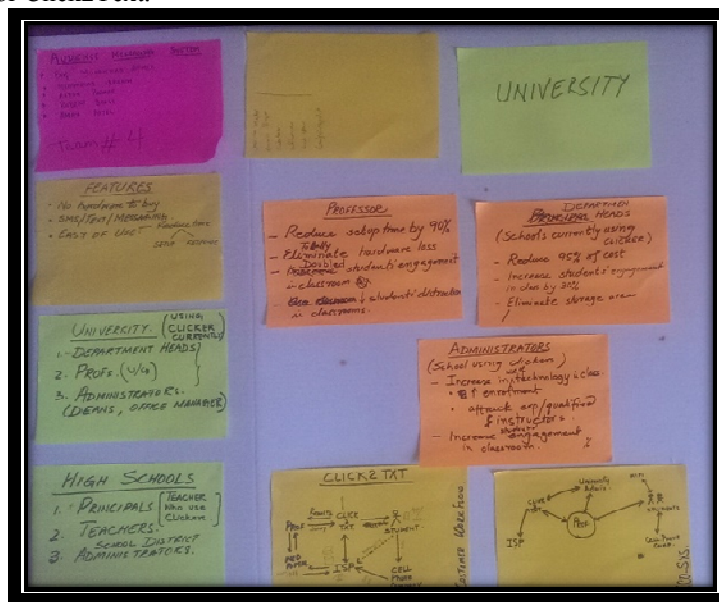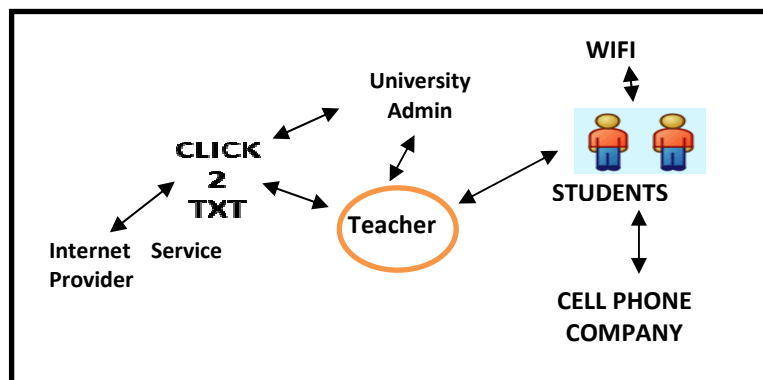

Figure 7. VP and CP for Click2Text

Figure 8. Initial Eco-diagram

Table 1.

Features			
Use Students' Cellphone	No hardware to buy Reduce cost by 95%	No hardware to break Reduce operating cost	No Maintenance
Cloud based application	Easy to use	Less setup time (90% reduced)	Increase response; time and number off

VP, CP and the outcome of the survey/interviews helped in identifying customers' pains and gains from the research itself. So for the Click2Text customer were defined along with their pain and gains, Table 2.

Table 2. Customer Segment with their Gains and Pains for Click2Text

Customer	Pain	Gain
University		
Administration	High cost of clickers Low students engagement in classroom	Low-cost solutions Increase technology usage Increase enrollments Attract qualifies instructors
Professor	Selective students' participation Phone distraction High In-class setup time Technology savvy students Loosing clickers Gauge classroom participation	Increase students engagement Phone become enabler Reduce setup time Increase student motivation
High School		
Administration	High cost of clickers Student attentiveness High student/teacher ration	Low-cost solutions Increase technology usage
Teachers	Student attentiveness Low students' participation Phone distraction High In-class setup time Breaking clickers	Increase students engagement Reduce setup time Phone become enabler

4. Results

In five weeks, the Click2Text team conducted 30 with the university, community colleges and high schools' administrators and instructors/professors. Table 3, presents the outcomes from these interviews that either accepted or rejected Click2Text's team fundamental theory, while Table 4 outline all results that were changed or modified the initial hypothesis and thesis.

Table 3. Results Accepting or Rejecting Original theory/hypothesis

1. Use of clicker, for students engagement, is common in undergrad classes
2. Setting up clicker system is time-consuming
3. Clicker enhance students participation
4. Clickers are costly and difficult to maintain (loss)
5. Clickers are great for quick survey type response
6. Cell phones are not allowed for personal use in certain institutes
7. Smart phones have potential for students engagement

Table 4. Results adding to original theory

1. In large size classes (100+ students) students' participation is almost zero, and only a few students always respond.
2. In large size classes (100+ students) it's hard to grade/evaluate students' participation during classes
3. Professors have used cell phones for surveys in classrooms
4. Grading students' classroom participations is very time-consuming.
5. Instructors value students' privacy, and FERPA is important to them
6. Not every student participate in class (some are shy).
7. Not all students participate equally in every class.
8. Everyone wants to use technology in class, but its use is minimum
9. Instructors prefer physical communication/ engagement in class through presentation/ discussions/ debate
10. Clicker cannot be used for detail participation
11. In certain classes (Ethics, etc.) students' participation has declined as they don't want to disclose their opinions openly.

Once customers were identified and their inputs, pains, and gains, are recognized, it helped the author to modified the features list so that smartphone is acceptable in classrooms as a tool for constructively engaging students in large classrooms, and ensuring an easy setup for the learning management system for Click2Text. Using these results the ecosystem and the BMC for Click2Text were modified as per figure 9 and 10, the administrators being the owner and decision makers for the purchases, create an account on Click2Text website

once they receive a technology purchase request from teachers/professors. The teachers then login to Click2Text to create a classroom with students' names and their phone numbers. Click2Text is linked through Internet Service Provider, ISP, to a cell phone interface. Once teachers pose questions to the students in the class, students use their cell phone and SMS their answers to a particular phone number. These students SMSs are collected by Click2Text and results are presented to the teacher.
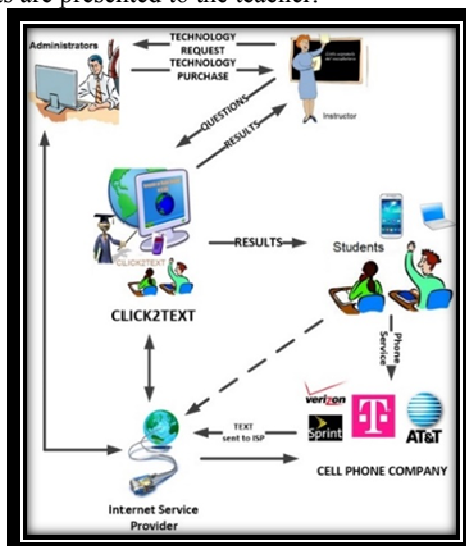

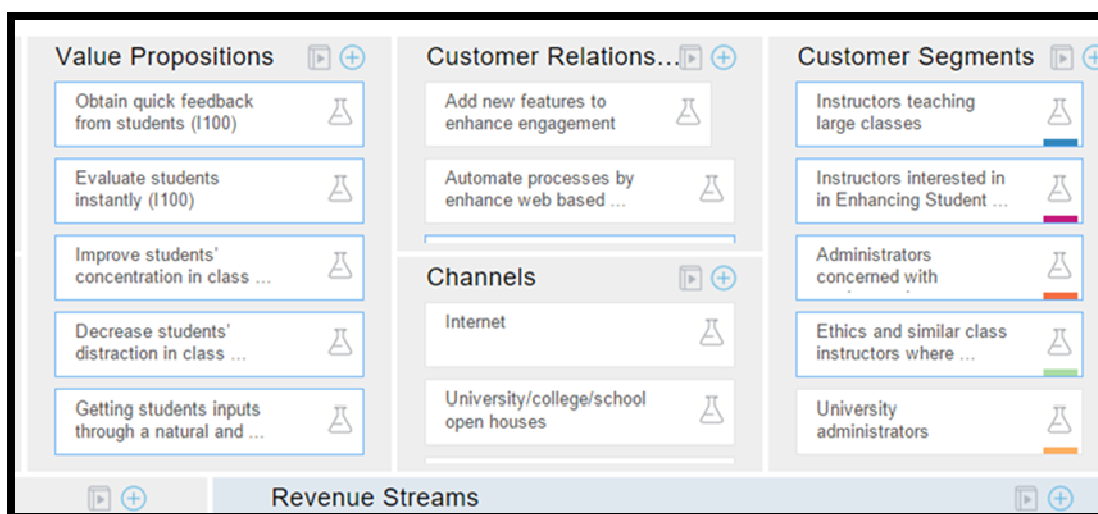
Figure 9. Modified Ecosystem Diagram for Click2Text

Figure 10. Final Business Model Canvas for Click2Text

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5. Lessons Learned

- I-Corps is not for every researcher; it is more suitable for researchers who lack experience with business plans, licensing technology, and other entrepreneurial skills
- Mentorship help teams to identify the skill set required to refine their basic research properties into something that is commercially meaningful.
- It teaches professors, postdoctoral scholars, and graduate students what it takes to be entrepreneurs
- Helps in identifying how their technology could be used and in identifying its customers.
- Teams need to start with a particular application or it 's hard to identify and communicate with potential customers.
- Always know your audience in advance before explaining them your research. When describing the research to venture capitalist or someone with little or no knowledge about the theoretical aspect of researched technology, it is better to use layman language.
- Mentors should use a different method to review researchers' pitches for commercialization. Currently, mentors are using the same review process as venture capitalist follows, which is a reflection of ABC

TV series "Shark Tank" and many participants find the process patronizing.

6. Next Steps

The main outcome of I-Corps is the understanding that the number one reason why an idea fails is because nobody wants it, thus it is equally important to capture customer's wants and be ready to change the idea accordingly. Next steps in this research will be to incorporate these customer findings/ requirements in Click2Text Applications by redefining the base architecture, and recoding it. The new Click2Text Application would then be tested in three courses and finally, a major research will be conducted to evaluate students learning using Click2Text in comparison with clicker.

7. Conclusion

Based on the knowledge gained by the author and his team, it is concluded that NSF's I-Corps ICD course proved out to be very useful in customer discovery and product feature identification for Click2Text. Working with other researchers during the course duration, the author concludes I-Corps ICD course is also a beneficial course for the most scholar, especially those who would like to investigate the commercial potential of their research. The paper also concludes that not every researcher would like to get into commercialization, however, attending the ICD course would help researchers in better understanding and acceptance of their customer and their needs.

It is further concluded that researchers, in general, need to be open to criticism about their research and should use simple language to explain the research when making presentations in front of I-Corp mentors or venture capitalist. Similarly, NSF I-Corps should develop a different method/ process to review researchers' pitches for commercialization. When the results of ICD course was applied to Click2Text, it helped in identifying new features for the researched product. Based on these new features, the Click2Text interface has been redeveloped with the hope that it will increase its chances of success. The new interface will be tested in three undergraduate courses in Fall 2017.

References

Ahmed, M. S; Lahidji, B (2011), Using SMS as a Teaching and Learning Tool; *ASEE Global Colloquium Proceedings* 2011, Lisbon Portugal.

Ahmed, M. S; Lahidji, B. (2009), Use of Learning Design Methodology and Knowledge Management in Online Graduate Courses; *Engineering Education in the 21st Century - Quality, Globalization and Local Relevance*. Editors A. Shanableh, K. Hamad, M. Omar and M. Bettayeb. pp 194-212.

Adelina Moura, Ana Am´elia Carvalho. (2010) Mobile Learning: Using SMS in Educational Contexts. Nicholas Reynolds; M´arta Turcs´anyi-Szab´o. Key Competencies in the Knowledge Society, 324, Springer, pp.281-291, 2010, *IFIP Advances in Information and Communication Technology*, 978-3-642-15377-8.

Blank, S., and B. Dorf. 2012. *The Startup Owner's Manual*. Pescadero, CA: K&S Ranch.

Browing, T. R. (2009). The many views of a process: Toward a process architecture framework for product development processes [Abstract]. *Systems Engineering, 12*(1), 69-90.

Cooper, R. G. *Winning at New Products: Accelerating the Process from Idea to Launch*, 2nd edition. Reading, MA.: Perseus Books, 2001.

Fink, M., Maresch, D., Hatak, I., & Lang, R. (2016). Entrepreneurship Research with Passion: A Note on the Aesthetics of Basic Research. In H. Landstroem, A. Parhankangas, A. Fayolle, & P. Riot (Eds.), *Challenging Entrepreneurship Research* (pp. 19-34). London: Routledge.

Goh, T, & Hooper, V. (2005) To txt or not to txt; that's the puzzle. *Journal of Information Technology Education*, 6, 441-453.

Holtan, A., Strandbu, A., & Eriksen, S. H. (2013). When emotions count in construction of interview data. *Nordic Social Work Research, 4*(2), 99-112. doi:10.1080/2156857x.2013.812043

Kendrick RA. Using an Audience Response System (ARS) a.k.a. "clicker" to do attention research. ProQuest *Dissertations* Publishing; 2010.

Lanhart, A. (2010). Cell Phones and American Adults. Pew research center. Retrieved March 23, 2015, from http://pewinternet.org/Reports/2010/Cell-Phones-and-American-Adults.aspx

Ledford, H. (2015). Biotech Boot Camp. *Nature, 519* (7544), 402-405. Retrieved from http://ezproxy.emich.edu/login?url=http://search.proquest.com/docview/1667161008?accountid=10650 Nordic Social Work Research, 4(2), 99-112. doi:10.1080/2156857x.2013.812043

National Science Foundation. 2011. "Empowering the Nation Through Discovery and Innovation: NSF Strategic Plan for Fiscal Years (FY) 2011-2016." http://www.nsf.gov/news/strategicplan/nsfstrategicplan_2011_2016.pdf.

Oliver Mallett, (2017) "Challenging Entrepreneurship Research", International Journal of Entrepreneurial Behavior & Research, Vol. 23 Issue: 1, pp.160-162, https://doi.org/10.1108/IJEBR-09-2016-0298

Osterwalder, Alexander & Pigneur, Yves (2010), Business Model Generation, John Wiley & Sons, Inc. attention research, *Doctoral dissertation*, 2010.

Pellicane, C., & Blaho, J. A. (2015). Lessons learned from adapting the NSF I-Corps curriculum to undergraduate engineering student entrepreneurship training. *VentureWell. Proceedings of Open, the Annual Conference,* 1.

Robinson, L. (2012). Member views of materials news: 2011 edition. *JOM: Journal of the Minerals, Metals & Materials Society, 64*(1), 8. doi:10.1007/s11837-012-0255-y

Roach, M. (2017). Encouraging entrepreneurship in university labs: Research activities, research outputs, and early doctorate careers. *PLoS One, 12*(2) doi:10.1371/journal.pone.0170444

Tzokas, N., Hultink, E. J., & Hart, S. (2004). Navigating the new product development process. *Industrial Marketing Management*, 33(7), 619-626. doi:10.1016/j.indmarman.2003.09.004

Simon W. W. So, Mobile Learning: A Topography and Research*, International Journal of Information and Education Technology*, Vol. 4, No. 4, August 2014

Ulrich, K. T., & Eppinger, S. D. (2011). *Product design and development* (5th ed.). Boston: Irwin/McGraw-Hill.

Why Are People Still Using SMS in 2015? (2015, February 16). Retrieved March 23, 2015, from http://thenextweb.com/future-of-communications/2015/02/16/people-still-using-sms-2015/

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