The

Lean Canvas for Invention

Building Attitude for Innovation

Arabella Bhutto

"If technology is not solving the societal issues, then why is it worth spending so much time, effort, and funding over it!"

Contents

FOREWARD

Never has global society been faced by such enormous challenges as it faces today. Its long-term survival is threatened by climate change, pollution of our atmosphere, contamination of our oceans, and resource depletion. Economic inequalities destabilize society. World poverty abounds and mass migrations of desperate people are becoming unsustainable.

The solution to these problems lies in the technological exploitation of our scientific developments, and never have these opportunities been greater. The exponential development of all branches of science over the past 50 years has been unprecedented. The abilities of engineers to harness these developments and translate them into useful products unimagined half a century ago has been extraordinary. The opportunity for innovative products in power, electronics, telecommunications, information technologies, healthcare, food production, etc. is endless. National economic development and corporate growth are increasingly dependent upon the successful exploitation of science and technology in the development of these new products.

That said, identifying opportunities and bringing ideas to market is not easy. Many successful research achievements fail to realize their potential for product development and many product developments fail to achieve commercial success. Why does so much potential fail and why is so much money, time and effort wasted in bringing products to market? This is largely because the exploitation process has become so complicated. The available science and technology affecting every stage of design is increasing dramatically. Searching the literature and patents for relevant information is a major undertaking. Recognizing what science and which technologies are relevant and putting together and coordinating teams with the range of skills necessary for bringing complex products to market is formidable.

This book provides a unique and systematic approach to addressing these challenges. Through a rigorous questioning approach, it provides a methodology which takes the researcher and developer from the identification of real-world problems and opportunities to the development of appropriate solutions. The approach is practical and has been validated in a high-tech innovative environment. Each of the 11 components of the approach is accompanied by checklists and templates. The approach is targeted at bridging and exploiting the knowledge and expertise of researchers, academic inventors, entrepreneurs, and technology managers. It is the most comprehensive approach in the current literature and aims to improve the likelihood of successful research exploitation, provide better returns on research investment, and underpin the next generation of product development to meet societies' needs.

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INTRODUCTION

This book presents a newly developed academic tool named the Lean Canvas for Invention (LCI) and its associated training guide with twenty-five hands-on activities. It is based on learning gathered during my postdoc journey of nine months which I spend at the University of Utah, USA. This book teaches about the LCI and offers a training guide for researchers, academic inventors, entrepreneurs and product developers to pursue their research for inventions having great potential for innovation and commercialization. The outcome of the LCI training guide is a well-developed research proposal that an academic inventor and entrepreneur individually or along with the research team submits for seeking the national and international grants and resultantly come-up with technological inventions that will soon be converted to innovations for commercialization. In addition, this training guide is equally effective for an industrialist and product developer who looks for real-world problem and solve it with technological inventions.

After my PhD from Nottingham University Business School, I planned to pursue my postdoc to apply my knowledge of technological co-evolution which I gained during my PhD. Though it took me ten years to move ahead in my academic progression, but I believe whatever happens, happens for a reason. I felt that my ten years which I spend at Mehran University of Engineering and Technology (UET) as a professor enriched my practical experience and prepared me for pursuing my postdoc more effectively. I was lucky to have a supervisor for my postdoc who envision herself as a change agent for this world. I remember very well; she told me in 2018 that *“she is left with only seven years to change this world*”. She was so eager to contribute which made me realize that every individual, exists in this world, must play a role to contribute to a world such a way that one’s presence must be associated with concrete goals and their associated massive actions. I feel I was lucky to have my nine months with someone who was so eager to play her role in this world.

I established contact with my supervisor because of the USAID project which was in progress at Mehran UET those days. My Vice Chancellor took me along with his academic team to the University of Utah for formally signing the MoU and initiate the USAID project. During that visit, I was asked to establish contacts and seek admission for my postdoc there. I started my search and through the USAID Project Director I successfully managed to acquire my admission at Utah, US. I submitted a research proposal having theme of establishing mechanism to facilitate the entrepreneurial ecosystem in universities. Those days I recently won a grant of PKR. 200 million for the establishment of Innovation and Entrepreneurship Centre (IEC) at Mehran UET. Through this grant, I earned funding for my postdoc under the human resource development component of the scheme. As funding was for the establishment of IEC, I planned to learn how the entrepreneurial universities in the developed world facilitate their scientists, researchers, and academic inventors in product development and commercializing their research, supporting them in earning royalties and facilitating the process for entrepreneurship. I wished to learn certain systems during my postdoc and implement those systems in the Innovation and Entrepreneurship Centre at Mehran UET. I wished to see IEC as an agent for converting Mehran UET to the entrepreneurial university. Etzkowitz (2003) discusses that innovation, commercialization, economic and social development are now the *third mission of Entrepreneurial Universities*. I wished that through IEC, Mehran UET contributes towards the economic development of region and country. I asked my supervisor to facilitate me in establishing my contact with the technology transfer office (TTO) at University of Utah and enable me to conduct my postdoc research and guide me towards establishment of mechanisms at universities supporting the entrepreneurial ecosystem.

On the first day of my admission, I was offered a lunch from my supervisor accompanied with a Director and a Manager from technology transfer office of the University of Utah. I remember well, I almost said everything that I wanted to achieve from my postdoc, and I was informed by those three dignitaries that it is not going to be an easy journey. As a result of our discussion during lunch, it was decided to allocate me a sitting place in the technology transfer office where I can observe and learn from routine practices of different directors, managers and analysts and decide about how I can progress my postdoc. Since then, every passing day was a great source of learning and lead me towards development of an academic tool, the **Lean Canvas for Invention (LCI)**.

I initiate my learning process with observing and interviewing different directors and managers in search of an answer that ***how do they facilitate the process of invention disclosure, assisting in granting and licensing patents and then looking for exact market for inventions and convert these inventions to innovative companies?*** Not only that but during interviews I learned that the technology transfer office also facilitates in search of investors who can share equity and guide the academic inventors in the process of commercialization. There were different teams operating in the technology transfer office and each team was responsible for accomplishing their goals related to the technology management, facilitating processes of granting and licensing patents, marketing, and entrepreneurship respectively. Though this process was fascinating for me to learn but at the same time I realized that these teams at the technology transfer office, who are trying to facilitate the process of technology transfer, are also struggling with some problems due to knowledge asymmetries between the technology developers and the technology managers. Auerswald and Branscomb (2003) discusses that one of the reasons that deter technological development is asymmetry in information. These asymmetries are also observed for intellectual property and royalty regimes by Lockett, Wright and Franklin (2005).

During my interviews, I asked directors and managers about their problems they face when they interact with researchers and academic inventors and try to understand in depth about inventions to facilitate the process of invention to innovation and commercialization. I remember, after every interview I had to update a list of problem they encounter. Gradually I converted all problem statements to questions whose answers technology managers and directors require in order to facilitate the process of technology transfer. By the end of my several interviews I managed to develop a list of 101 questions. From a list of these questions, realization occurred that most of the questions are related to the technology management e.g. motivating academic inventors for entrepreneurial activities (Kenney and Goe, 2004), Understanding early stage of technology (Thursby and Thursby, 2003), Cooperating for moving IP to market (Siegel and Wright, 2015) etc. and it is very difficult to seek answers to such questions from the academic inventors and technology developers at the time of invention disclosure. Because a language that is used by technology managers is very different from the language of technology developers and academic inventors and that is the reason why knowledge asymmetries exist between them.

This much big list of questions clearly proposed that how difficult it is for directors and managers of technology transfer office to gain insights of new inventions and move forward towards commercialization. This list also identified that technology developers, researchers and academic inventors do not consider most of the important parameters before developing technologies and resultantly cause wastage of their time, effort, and even huge national and international grants on inventions having no potential of commercialization. The technology developers and academic inventors may come up with inventions which seem so fascinating for science but have no viability for the market. These inventions may be sufficient for publishing good research papers but might not be acceptable for granting patents. The question raised in my mind that, ***"is it always necessary to commercialize every new technology?"*** and an answer strike that, ***"if technology is not solving the societal issues, then why is it worth spending so much time, effort, and funding over it".***

While discussing this entire situation with my supervisor we reached an idea to develop a mechanism that can facilitate these directors and managers having most of the answers available at the time of invention disclosure and create new knowledge supporting the process of commercialization and contribute towards literature of the entrepreneurial ecosystem. Since then, the search for such mechanism begun which could be presented to directors and managers, as a business process, along with detailed Standard Operating Procedure for its smooth operation. Only coming up with a list of 101 questions and presenting these in a simple table to be shared with researchers and academic inventors at the time of invention disclosure was insufficient. It was important to help academic inventors and product developers to think about multiple parameters at the time of initial idea of technology development. This seems impossible without consistent capacity building of technology developers and academic inventors and making them realize the importance of their time, effort, and grants. It was important to develop a training guide that enables researchers and academic inventors to look for answers to the most important questions at the time of conceiving ideas for new products and inventions. Therefore this book presents a training guide that builds the capacity of technology developers to interact with stakeholders of new technologies, seek guidance from existing solutions, research patents details, understand about technological viability and technology readiness levels and develop research proposals, individually or along a research team, for inventions with high potential of commercialization.

It was identified that the training guide must enable technology developers and academic inventors to answer most of the questions the technology managers and directors need to learn for initiating the process of commercialization at the technology transfer office. The training guide discussed in this book is based on lessons gathered in the process of developing an academic tool, the Lean Canvas for Invention (LCI). The development process of this tool, the LCI, is discussed by Bhutto and Furse (2020), however details related to the training guide supported by 11 components, 11 checklists, and 25 templates designed for hands-on activities for every component of the LCI, are offered in this book to enable technology developers, academic inventors, product developers and entrepreneurs to consider important questions and search for their answers at a time of conceiving ideas of inventions. Each chapter of this book explicitly discuss every component distinctively. In chapter 1, the concept of LCI and its structure is discussed. From chapter 2 to chapter 12, every component is discussed in detail, discussing about how this component can help in reaching the expected stage of the research proposal with the supportive example.

The LCI and its training guide is designed keeping in mind that technologies to be developed must solve the real-world problems, must have feedback received from stakeholders, must be patentable, must be viable for market, must offer the technology readiness level and must be seen as a finished products, processes or services. Having all these parameters considered by academic inventors and entrepreneurs can save a lot of time, effort, and grants to be wasted on inventions which may not be ready to pass through the process of invention to innovation for commercialization at the technology transfer office.

The duration of nine months at University of Utah enabled me to test the LCI and its training guide with the postgraduate students and faculty members who were at the point of starting their research process. I got chance to teach Master students of the USAID project for water and sanitation related technologies, Master and PhD students of Electrical and Civil Engineering department at University of Utah, and a team of faculty members who were submitting their research proposals to seek grant from National Science Foundation (NSF) and other funding institutes in USA. Every participant appreciated and commented that how effectively this academic tool drives their thought process towards societal problems and build their attitude for inventing solutions to solve these issues. Not only with these groups but then later the LCI and its training guide was tested, with the more than 100 PhD students at Mehran UET with 17 engineering disciplines, as a complete credit hour course for entire semester. Resultantly, those PhD students developed their research proposals for pursuing their PhDs on technologies with market viabilities. This book also shares multiple examples of their PhDs proposals with respect to their relevancy under different components of the LCI.

After teaching these multiple groups and having received the positive feedback from them, it encouraged me to write a book on LCI which may not only be considered as a training guide for researchers and academic inventors but may also be taught as a separate course to the Master and PhD students of STEM (Science, Technology, Engineering and Mathematics) or as a part of their curricula while teaching research methodologies. This book is an effort contributing towards capacity building of scientists, researchers, technology developers, academic inventors, product developers and entrepreneurs to make them realize the importance of the technological inventions and their relevancy with solving the societal issues with scarce grants available at the national and international level. Resultantly, these researchers and the academic inventors can contribute, as change agents, towards the knowledge economy, through their time and effort dedicated towards inventing technologies, products and services having potential of commercialization. It is as true as mentioned by UNESCO[1] that *Science and Engineering education* and *research capacity* need to be built to allow countries to *develop their own solutions to their specific problems* and to play their part in the international scientific and technological arena.

Science, Technology, and Innovation (STI) ecosystem of any country is proved as an engine for socioeconomic development, and it is mandatory to equip the nation with knowledge to play their role for the STI and entrepreneurial ecosystem. Therefore, at the one hand, this book is a humble effort towards capacity building of scientists, researchers, academic inventors and entrepreneurs for technology development and at the other hand, facilitating directors and managers of the technology transfer office with the supportive mechanism for their endeavors of technology management. Ultimately, this book adds a new knowledge in the existing literature guiding the process of the entrepreneurial ecosystem through an academic tool the Lean Canvas for Invention and its detailed training guide.

[1] https://en.unesco.org/themes/building-capacity-science-and-engineering#:~:text=Science%20policies%20are%20not%20enough,international%20scientific%20and%20technological%20arena.

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Chapter 1

What is the Lean Canvas for Invention (LCI)?

The Lean Canvas for Invention (LCI) is an academic tool that provoke the thought process of researchers and academic inventors to build an attitude of investing their time and effort on inventions having potential of commercialization. It can be useful for academic inventors belonging multiple science and engineering disciplines e.g., civil, electrical, mechanical, textile, software, water, environment and sanitation etc., intending for entrepreneurship. The LCI is developed on understanding that bridging knowledge asymmetries between technology developers and technology managers at the technology transfer offices is extremely desired. It is a systematic thinking process that allows researchers, academic inventors, product developers and entrepreneurs to ponder upon multiple parameters which must be considered as prerequisites for technological inventions and for invention disclosures. The expected outcome of the LCI and its training guide is to pave a way towards great number of future inventions for solving the real-world problems. The objective is to create alignment of inventions with needs of end users to enhance their chances of commercialization. The LCI incorporates 11 components supported by 11 checklists and 25 templates for hands-on activities to allow researchers, academic inventors, product developers and entrepreneurs to explore on different dimensions which are important to be considered for the process of invention to innovation. These components and checklists will be discussed later in depth in every chapter explicitly. Every chapter is dedicated to an individual component.

It is observed through multiple research funding and grant institutions that most of the technologies while going through stages of technology development struggle at the valley of death which technology transfer professionals try to bridge through multiple ways (Takata et al., 2022). It is the stage where technologies die due to lack of support, resultantly wasting all the grants utilized at the earlier stages of technology development (Helman, 2022). Similarly, my observation reached the same conclusion while interviewing different researchers, technology developers, academic inventors, and technology managers during the postdoc journey. During an interview with an academic inventor, it was revealed that he spent 20 years of his life and huge grant on a process of developing a technology having capacity of collecting enormous data during through the MRI scan. He mentioned that after much research he developed a prototype product. In order to check the usability of his prototype, he left it with radiologists so they can offer their feedback on the utility of technology. After a few days he returned to them to learn about the potential usage of his technology. Unfortunately, he was informed that technology is good but due to its inappropriate design it is causing wastage of 15 minutes between every other patient on which this technology is tested. Resultantly, radiologists refused to use his technology. I felt so much discomfort that I could not stop myself asking him that why he did not change a prototype design according to the demands of radiologists for another trial. The response that I received from him was even more heartbreaking. He clearly mentioned "*by that time I was out of grant and could not continue with my research for redesigning the prototype*". This story is a practical example of valley of death and emphasis on a dire need of establishing contacts between technology developers and their stakeholders at the earlier level of research. It emphasizes on developing an academic tool that enable researchers, academic inventors, product developers and entrepreneurs to learn a process of establishing contacts with stakeholders for future technologies at the earlier stages of technology development and avoid the issue of death of valley.

When I see from my personal experience, I found scientists and researchers working extensively on their inventions but in a closed environment of their research labs. They read research articles comprehensively, they present their research work in conferences, they publish good number of research articles, but they hardly meet their stakeholders to learn about the prospective utility of their technologies. The current academic system contributes towards these actions as it only drives scientists and researchers for publications and winning grants and does not demand much for entrepreneurship and technology commercialization (Siegel and Wright, 2015). On the other side, when entrepreneurs invest on research, they make calculated decision e.g. how much should be invested and when return on investment is expected. They use different indicators such as RQ (research quotient), for measuring how much investment in the research productivity results in increase in market value (Goldense, 2018). Though 100% prediction may not be possible but at least their indicators go beyond merely counting the amount of spending on R&D and number of patents published.

In era of knowledge economy, where knowledge of scientists, researchers and entrepreneurs drives the productivity, is it feasible for research funding and grant awarding institutions to invest millions of dollars on technologies having no clear roadmap towards commercialization? ***Well, if not!*** Then how these institutions can guard that at least 50 - 70% of their investments are for those inventions that have clear potential of commercialization and solving the real-world problems (Jacob and Lefgren, 2005). Not all types of research (e.g. basic research focused upon extending understanding of the science governing the nature of universe) are immediately exploitable but technologies based on applied research are required to be developed in such a way that their chance of getting commercialized must be enhanced. Of course, it can be done by designing programs and projects that can propose that grant decisions will be judged through advanced indicators measuring return on R&D and number of licenses from patents granted etc. But would it be justified to demand this much from researchers and academic inventors without planning for their capacity building?

Before answering this question, let us learn those major parameters which researchers and academic inventors usually miss out at the time of conceiving ideas for their future inventions. They are usually:

1. *Interacting* with scientists and researchers at the academic institutions only, and *do not consider opinion*s of all other stakeholders of the technology.
2. *Extensively reading* research articles only, and *do not make patents* a part of their literature review.
3. *Contributing* with a mindset of developing technology for academic purpose only, and *do not observe its utility and viability for market* where similar existing products may already be solving the societal problems.
4. *Thinking* of invention as a technology only, and *do not conceive it as a product or service,* to be defined at technology readiness level.

The researchers, academic inventors, product developers and entrepreneurs who fortunately do not miss out on these parameters, successfully build their startups, and gradually initiate the journey of contributing towards the knowledge economy. The list of Fortune 500 (Li, McLeod Jr, & Rogers, 2001) presents multiple names of such companies which flourished as startups. Their success is mainly because of developing technologies for meeting the societal needs and adding value to the lives of individuals. They invent to commercialize and along with their research and marketing teams they take massive actions to see their technologies as market viable products and services.

In fact, the multiple considerations and actions taken by established companies already engaged in commercializing their inventions cannot be fully expected to be accomplished from researchers and academic inventors in isolation. However, it is justified to expect that a few of these major parameters must be considered at the time of conceiving ideas for inventions, as it can multiply the chance of commercialization and return on investment done in a form of research grants from national and international institutions. What is needed in fact is to make our researchers and academic inventors think about these major parameters at the time of conceiving ideas of future technologies and inventions. It needs an organized effort to create a systematic thinking process for researchers and academic inventors and build their attitude for market viable inventions.

The researchers and academic inventors need to get trained and learn about those parameters which have never been a part of their usual graduate learning. The capacity building either through short training programs or through semester long courses can bridge the knowledge asymmetries between technology developers and technology managers and resultantly can increase the chance of commercialization of inventions. The LCI (Bhutto and Furse, 2020) is exactly designed to add towards the capacity building of researchers, academic inventors, product developers and entrepreneurs with the help of 11 components, 11 checklists and 25 templates for hands-on activities. Each chapter of this book will discuss in depth each component evidently. For this chapter let us see how does the **Lean Canvas for Invention** look? And what are the 11 components of the LCI? The LCI is elicited in figure 1.1.

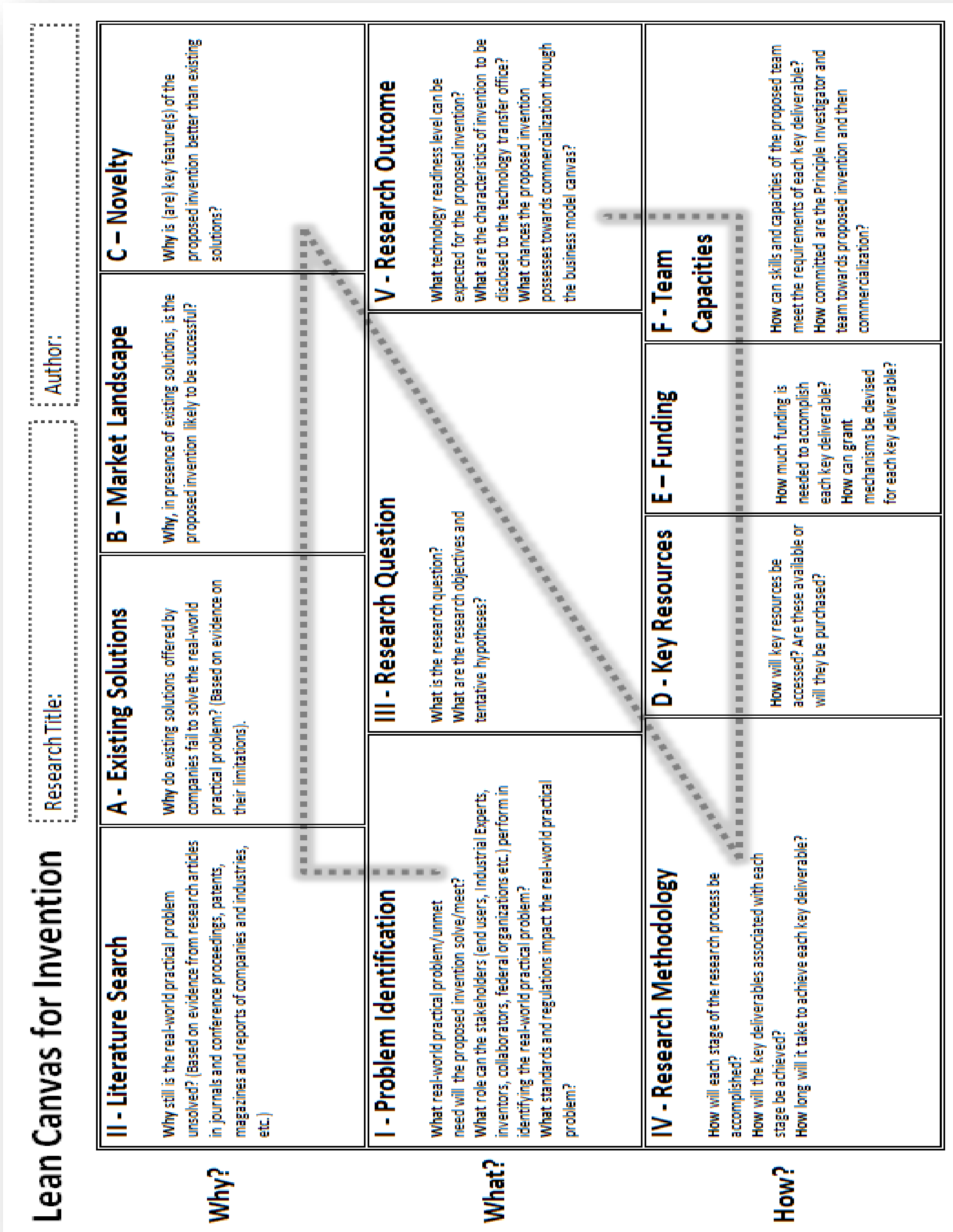

Figure 1.1. The Lean Canvas for Invention (LCI)

The LCI, as name indicates, is a sketch on single sheet eliciting a research process supporting inventions having potential of commercialization. It is a visual aid to guide researchers and academic inventors for aligning their research and inventions with the real-world problems, inventing solutions for solving the real-world problems and increasing chance of acceptance of their inventions in the society.

As elicited in the figure 1.1, the LCI sketch shows 11 components as they are organized to answer following three basic questions:

1. **What** is the real-world problem which needs solution?
2. **Why** it is important to solve this real-world problem?
3. **How** this real-world problem can be solved?

These three questions are associated with different components of the LCI. The process of LCI begins with its first component the **"Problem Identification"**, under first **WHAT question**. Followed by **WHY question** with components, **"Literature Search"**, **"Existing Solutions"**, **"Market Landscape"** and **"Novelty"**. The next **WHAT question** is then answered by a component **"Research Question"**. The **HOW question** is then answered by components, **"Research Methodology"**, **"Key Resources"**, **"Funding"** and **"Team Capacities"**. Finally, the **WHAT question** is then responded by a component, **"Research Outcome"**.

These 11 components then have more focused questions to answers. Each of these questions are then answered with the assistance from 11 checklists and dedicated 25 templates for hands-on activities. These are designed to help researchers, academic inventors, product developers and entrepreneurs to think and explore multiple dimensions in order to answer the focused questions of each component separately. The checklists are devised particularly to guide the researchers, academic inventors and entrepreneurs to consider and incorporate the important dimensions at the time of conceiving ideas for their inventions with intension and attitude to get these inventions commercialized in future with the assistance of technology managers and directors at the technology transfer offices. Detail of these focused questions, checklists and templates for hands-on activities associated to each component will be seen in upcoming chapters one by one.

Now, in order to answer a question of being justified in demanding from researchers and academic inventors to come up with technologies having potential of commercialization, the LCI is developed as a planned process for their capacity building. All its components and focused questions are derived from a list of 101 questions that technology managers are looking for, at the time of invention disclosures. The 25 templates for hands-on activities of the LCI are the part of training guide that must be practiced by researchers, academic inventors, product developers and entrepreneurs and technology managers for bridging the knowledge asymmetries that exists between them. One of such example can be seen in the picture 1.1.

Picture 1.1. Teaching LCI – Researchers and Academic Inventors

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Chapter 2

First Component of the LCI: Problem Identification

ABSTRACT

This chapter explicitly discusses the first component of the Lean Canvas for Invention. Each component of the LCI is guided by the corresponding checklists. This chapter with the help of examples will reflect how researchers and academic inventors can begin their search for a real-world problem and what insights can help them in this exploration process.

Problem Identification, LCI Checklist – I, Eight Items, LCI Template – I, Root Cause Analysis, LCI Template – II, Stakeholder Mapping, LCI Template – III, Problem Investigation Script.

PROBLEM IDENTIFICATION

The first component of the LCI is termed as the **Problem Identification**. This component is associated with the **WHAT question** of the LCI. Here the purpose is to guide the researchers and academic inventors to look for a real-world problem (Okuda, Runco, & Berger, 1991) that needs a solution through technological inventions. Most of the seasoned academic inventors usually gain the knowledge of real-world problems through the academically published research articles. These articles guide in the process of finding a research gap which then academic inventors try to fill with advancing their knowledge and technology-based inventions. However, an academic inventor may endure from disconnect between the real-world problems and the academically published articles at the time of exploration of research gap. Most of the work published in the academic journals is more than a year old and therefore enhance the chance of missing-out the existing situation in society (Gray, 2021). At that moment, if academic inventors initiate to look for the existing real-world problems, their inventions will have more chance of acceptance in the society for solving those problems. The first component of the LCI, therefore, guides the researchers and the academic inventors in a search process of the real-world problems and their depiction in a form of the research gaps.

The **Problem Identification** component instigate researchers and academic inventors to look for real-world problems by asking the following three questions:

1. **What** real-world practical problem or unmet need will be solved or met by the proposed invention?
2. **What** role stakeholders (end users, industrial experts, inventors, collaborators, policy makers, federal/provincial organizations etc.) may perform in identifying the real-world practical problem?
3. **What** standards and regulations exist within industry and what impact these involve on the real-world practical problem?

The answers of above three questions enable the researchers and academic inventors to explore the real-world problem by interacting with different stakeholders of the proposed inventions and to ultimately connect these to the society. In order to facilitate process of problem identification, discussed above, the LCI guide proposes the **LCI Checklist – I.** There is a higher chance that when researchers and academic inventors will explore answers for every item given in this checklist, a research proposal in support of real-world problem will begin to develop. That may later be submitted to the funding institutions for funding and grants. The academic inventors may conduct a research individually on the proposed inventions but may also establish a research team to work upon it collectively. The expected outcome of the entire process of the LCI is the invention that will be disclosed to the technology managers of the technology transfer office for commercialization. As that invention is already based on a real-world problem, the chances of commercialization become broader. Therefore, it is suggested to initiate the process of conceiving an idea of invention to be commercialized by answering:

- Three questions of problem identification component
- Exploring answers for eight items of **LCI Checklist – I**
- Seeking assistance from three LCI templates I, II and III, designed for hand-on activities.

The eight items of the **LCI Checklist – I** are given below. These eight items prompt the researchers and academic inventors to look for the real-world problem that exists in our society. Multiple issues may be considered depending upon the discipline the academic inventors belong to. For example, we are surrounded by issues related to water scarcity (Al-Ansari et al., 2021), energy crisis (Javed et al., 2016), global warming (Jacobson, 2009), COVID-19 (Denys et al., 2020), cyber security threats (Rathore et al., 2017) and road traffic safety (Makino et al., 2018) etc. This checklist directs the academic investors to establish facts related to these issues through incidents, events or conditions causing and characterizing these real-world problems. For example, an accident on a road led towards invention of a motorcycle safety vest support frame which even later got patent protection (WO2007038848A1). Today, road safety has new technological trends e.g. advance driver assistance systems which are though under development but having more than hundreds of patents already granted.

The **LCI Checklist – I** then gradually leads researchers and academic inventors towards exploring motivations and justifications behind their proposed inventions. Once, I remember myself playing a role of judge in the start-up competition and one of the academic inventors there, presented an idea of generating electricity with the human blood. This idea astonished me with the question striking my mind, ***"Is trade between human life and generating electricity justified?"*** That moment made me realize that every idea is not justified enough to be invented and commercialized. It is of utmost importance that the researchers and academic inventors justify the need behind their ideas and proposed inventions. This checklist supports the justification of an idea with different items after exploring the intensity of the real-world problem. The academic inventors can gather evidence from websites, news, conferences, reports, and other resources about the concentration of the real-world problem. For example, intensity of COVID-19 can be observed with thousands of research articles published covering its medical perspectives, social perspectives, and psychological perspectives etc.

Table 1.1. LCI Checklist – I: Problem Identification

Problem Identification	LCI Checklist – I		
	i.	Identification of the real-world practical problem.	
	ii.	Incident, event, or condition causing and characterizing the real-world practical problem.	
	iii.	Motivation and justification of the proposed invention for solving the real-world practical problem.	
	iv.	Existence and intensity of the problem with reference to websites, news, conference proceedings, research articles and reports etc.	
	v.	Stakeholders (end users, industrial experts, inventors, researchers, collaborators, federal/provincial organizations etc.) related to the problem.	
	vi.	Details of informal/formal meetings and academic/industrial conferences where the real-world problem is discussed.	
	vii.	Supportive Associations/ Foundations/ Standards/ Regulations e.g., Food and Drug Administration, Federal Communications Commission, Federal Energy Regulatory Commission, Federal Trade Commission, IEEE Standards Committees etc.	
	viii.	Code of relevant industry available at Standard Industry Classification, North American Industry Classification, and any other relevant websites.	

This checklist encourages academic inventors to go out of their research labs and interact with multiple stakeholders at the earlier level of their inventions to learn; ***what exactly end users are looking for***; ***what industrial experts are demanding for***; ***what other inventors and researchers are doing in their fields***; ***what collaborative opportunities may emerge*** and ***what federal organization are expecting*** etc.

In addition, these interactions also may open new dimensions in search of the real-world problem. I remember, during my master's degree program at University of Sussex, interaction with industry experts led towards development of an industrial collaborative model. It was necessary for each student that along with other academic tasks, they had to submit a project report based on real-world industrial problem. It was mandatory to meet industry experts multiple times and explore their issues and propose solutions. For each project a team was established and along with one professor students' teams visited the industry. I remember, during my meetings while discussing with one of the industrial experts sitting at a company in UK, a need has emerged and that need demands development of a collaborative model through which that company was intending to establish networks with their supplier, buyers, and competitors at the same time. If my professor had not arranged that meeting, there was less chance that such industrial need may ever been reached to researchers and academic inventors, and therefore the **LCI Checklist – I** encourages the researchers and academic inventors to have multiple meetings with stakeholders.

Alongside, it is also important to learn from different associations and relevant foundations for standards and regulations the proposed invention have to meet in future. For example, if an invention is related to communication industry either through wired or wireless protocol then knowing standards from Federal Communication Commission is highly important (Coase, 1959). Additionally, this checklist guides the researchers and academic inventors to follow certain codes of their relevant industries, developed for different economic sectors before inventing future technologies. These codes can be accessed either from published reports or may be available on concerned websites.

All three questions and eight items of the **LCI Checklist – I** need a systematic approach to be taken by the researchers and academic inventors to reach to their appropriate answers. Different methods exist in literature that can help in understanding the problem in depth and scrutinize the problem to reach the root causes. It is highly possible that if problem will be understood only at its superficial level, the proposed invention to solve the problem may not exactly solve it from depth. It is therefore of utmost importance that researchers and academic inventors seek assistance from the supportive tools and techniques to understand the problems clearly. One of the common technique available to understand the root cause of problems is **5Whys**. This technique is developed by a Japanese inventor, Sakichi Toyoda (1867 – 1930). The academic inventors may adopt the systematic way of using 5Whys to understand the real-world problems and reasons behind causing and characterizing those.

The 5Whys techniques may enable the researchers and academic inventors to ask five times, ***"What is causing the real-world problem to occur and what is must to be understood before inventing any new technology for solving it"***.

Sometimes simple changes in the existing processes can solve the complex problems effectively however sometimes novel inventions are required to do the same (Arthur, 2007). What solutions will be required for the real-world problems therefore necessitates a clear and in-depth understanding of the root causes of problems through the 5Whys technique. However, for researchers and academic inventors it is also mandatory that any information they use for the 5Whys technique must be gathered from authentic sources. Therefore, looking for variety of authentic sources of information such as recent news, current interviews, discussions with stakeholders etc. along with conference proceedings, published articles and reports embrace the equal importance. For facilitating in the process of utilizing the 5Whys technique, the LCI training guide offers the **LCI Template – I: Root Cause Analysis** that researchers and academic inventors can readily use to answer the first important question raised by the **Problem Identification** component of the LCI.

The **LCI Template – I: Root Cause Analysis** is shown in the figure 2.1 and is designed to list down the possible causes of problems, connected in a flow with each other and gathering evidence from the authentic sources of information with references. As mentioned, these references may signify some published work but at the same time observations gained from discussions with other researchers and academic inventors and with various stakeholders can also be represented.

All the information may be explored in a flow of eight items in the **LCI Checklist – I** and different templates may be used for hands-on activities. The **LCI Template – I: Root Cause Analysis** adopts the 5Whystechnique with supportive references. This template allows the academic inventors to explore in-detail and list down answers for every why to understand the real-world problem clearly with the help of different stakeholders. The references mentioned for every answer of why, add credibility to the entire search process.

In order to understand how to use the **LCI Template – I: Root Cause Analysis**, a practical example is discussed below. It is developed by one of the academic inventors who already attended the LCI training program at Mehran UET. The academic inventor was from the civil engineering discipline and discussed the real-world problem related to delays in completing most of the projects in the construction industry. According to his observation, almost every construction project suffers from delays and resultantly cause burden of more expenditure on the funding. He was asked to explore in detail the root causes of delays and try to propose a viable solution.

Figure 2.1. LCI Template – I: Root Cause Analysis

The 5Whys for understanding the root cause of the real-world problem related to delays in the projects of the constructions industry are:

1. **Why it delays in multiple projects in the construction industry?**
   Because it takes more time to make decisions, resultantly slowing down the routine operations (Reference: Research Article).

2. **Why it takes more time to make decisions?**
   Because there is poor communication between designer, consultant, client, and operations manager (Reference: Stakeholder Interview).

3. **Why communication between designer, consultant, client, and operations manager is poor?**
   Because there is no automated knowledge management system developed or in practice for construction industry (Reference: Conference Discussion).

4. **Why there is no automated standard knowledge management system developed or in practice for the construction industry?**
   Because the industry inhibitors influence and slow down the development and acceptance of the knowledge management system within industry (Reference: Stakeholder interviews).

5. **Why the industry inhibitors influence and slow down the development and acceptance of the knowledge management system within industry?**

   Because there is no standard or regulation set for knowledge sharing and for knowledge management between multiple stakeholders of the construction industry (Reference: Conference Discussion).

The above example of the real-world problem calls for research by an academic inventor for exploration of industry inhibitors and accordingly development of standards and regulations for the automated knowledge management system to solve the problem of delays in completion of projects in the construction industry. For each why question an authentic source of information is considered e.g., published articles, interviews with stakeholders and discussions with many academic inventors during conferences. The resultant is the identification of problem or if I call it more academically then it is the exploration of research gap (Korthagen, 2007). In addition, it can also be seen that research gap is not only explored after reading research articles but role of multiple source of information is evident enough in the example illustrated above.

Though reading research articles and discussing with other researchers during conferences is a norm for the academic inventors, however, looking for relevant stakeholders and then interviewing them, further needs a systematic guidance. Therefore, it is now proposed to use the **LCI Template – II: Stakeholders Mapping** to assist the researchers and academic inventors for listing and classifying different stakeholders of the research and asking them the relevant questions during interviews. Imperial College London (2007) presents a technique of stakeholder classification through the influence-interest grid. The use of this grid is to classify stakeholders with respect to their distinct roles in the decision-making process while progressing towards implementation of new technologies in future. Using this technique of influence-interest grid (Ackermann, & Eden, 2011) for the academic inventors can guide them to search and plan interviews with only those stakeholders who will have much interest in the upcoming invention and will also be influential in accepting the invention later in the society.

The interest can be observed through interviews with end-users or with the industry experts who can use the proposed invention to solve their real-world problem in future. In addition, other researchers and academic inventors can also be placed in the interested groups. However, the influential stakeholders can be the actors from different associations, foundation, government institutions and policy makers who are devising policies, standards and regulations related to the invention. In addition, the investors who may be willing to invest in new technologies can also be considered as the influential stakeholders. The researchers and academic inventors need to explore for these actors and list down their names according to their interest and influence. Later they can be allocated different positions while using this template for hands-on activity for the stakeholder mapping. Their names can be explored from websites of concerned institutions, daily news articles, TV media etc. Other convenient sources of reaching stakeholder relevant information may include multiple social networking forums including LinkedIn, Research Gate, Facebook and others. These professional social media platforms can offer benefits of consolidated information available in a form of existence of readily established discipline-oriented groups. For example, if a researcher is looking for experts in the construction industry, the groups for “Civil Engineering and Construction” are already established at the LinkedIn platform. Similarly, if stakeholders are related to IT industry then these can be explored through the “IT Consulting Services” and “IT Project Manager” groups.

The **LCI Template – II: Stakeholders Mapping**, as depicted in figure 2.2 below, can be readily used for the hands-on activity for selection of appropriate actors for future interviews. As far as identification of the real-world problem is concerned, actors with high influence and with high interest must be interviewed to gain insights. This group of people needs strong integration and frequent interaction. Along with this group, another group of actors with high influence and low interest must also remain under consideration for interviews. To understand how to use this template for stakeholders mapping, lessons can be drawn from a practical example developed by a researcher who attended one of the LCI training programs. This researcher was from the cybersecurity discipline and interested in inventing a service which can detect and stop the spread of misinformation and cyber propaganda. The focus of the researcher was towards an invention to be developed for government through adopting various cybersecurity strategies e.g., demystifying the false stories, imposing regulations, and penalizing the culprits. The stakeholders listed by researcher include customers, software vendors, companies and employees, Internet Service Providers, financial foundations and above all the government institutions. Though each of the stakeholders possess their interest and influence but the government as the direct user of the invention got its position in the top right box of the **LCI Template – II: Stakeholders Mapping**. So, a researcher started to establish contacts for interviewing different government officials to understand the real-world problem in-depth.

While using different platforms for establishing contacts with the potential stakeholders for interviews, it is essential that researchers and academic inventors have their two minutes story (for pitching their real-world problem) ready to be shared. The two minutes story, may be written in a document form or may be developed through PowerPoint slides. It will enable the researchers and academic inventors to build a foundation for discussion with multiple stakeholders. It is very important for academic inventors to understand that stakeholders are busy in their routine tasks and attracting them towards exploration of the real-world problem for future inventions can be a challenging task. Therefore, a systematic guide is required to drive discussions between academic inventors and multiple stakeholders. Therefore, it is now proposed to use the **LCI Template – III: Problem Investigation Script**, as depicted in figure 2.3 below, to make the discussion process more effective and fluent with realization that every stakeholder have precious time which must not be compromised due to unplanned discussions.

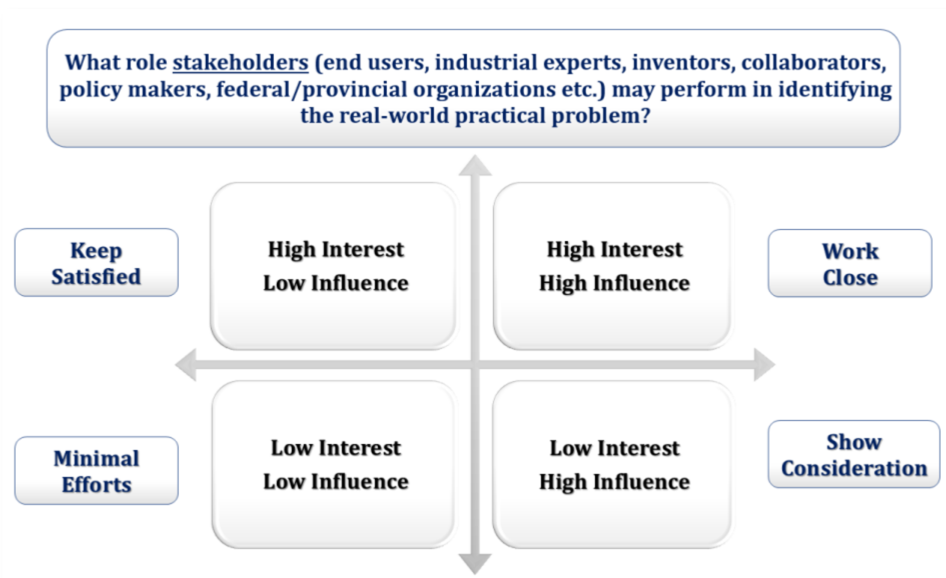

Figure 2.2. LCI Template – II: Stakeholders Mapping

Problem Investigation Script

Introduction by an Academic Inventor

Name : ________________________________ **Institutional Association:** ____

Research Expertise: ____

Objective of conducting research: ____

Two Minute Story:

____
____
____
____

What is required from this interview? ____

Why it is important to have this interview? ____

Problems Identified through 5Whys Technique

Problem 1: ____

Problem 2: ____

Problem 3: ____

Problem 4: ____

Problem 5: ____

1. What are three main problems stakeholders are facing? / What tasks are difficult to achieve? Where changes are possible?

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____
____
____

NOTE: Once 3 problems are given by stakeholder, try to find any match with already identified 5 problems.

2. Share the already identified 5 problems with the stakeholders and discuss these one by one?

Intensity of Problems (To be asked by Stakeholders)					
No.	Problems	Detail of Problems	Intensity of Problem		
			High	Moderate	Low
1.	**PSKH 1				
2.	**PSKH 2				
3.	**PSKH 3				
4.	*PAC 1				
5.	*PAC 2				
6.	*PAC 3				
7.	*PAC 4				
8.	*PAC 5				
*PAC = Problem Identified by Academic Inventor; **PSKH = Problem Identified by Stakeholder					

Rank Problems on Emergency Scale (1 – Not very crucial; 10 – Must solve now)			
No.	Problems	Detail of Problems	Rank on Emergency Scale
1.	**PSKH 1		
2.	**PSKH 2		
3.	**PSKH 3		
4.	*PAC 1		
5.	*PAC 2		
6.	*PAC 3		
7.	*PAC 4		
8.	*PAC 5		
*PAC = Problem Identified by Academic Inventor; **PSKH = Problem Identified by Stakeholder			

3. What Standards and Regulations exist within industry and what impact these involve on the real-world practical problem?

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Figure 2.3. LCI Template – III: Problem Investigation Script

The **LCI Template – III: Problem Investigation Script** enables researchers and academic inventors to organize the entire discussion process with stakeholders and delve into the knowledge gathered about the real-world problem. This script is developed based on learning derived from Lean Startup and innovation pipeline processes (Bailey & Horvitz, 2010). The ultimate goal of the LCI is to facilitate the researchers and academic inventors in a journey from invention to innovation and it becomes possible only when inventions take shape of innovation with characteristics and capacity of solving the real-world problems. This chapter therefore emphasis on problem identification and involvement of multiple stakeholders in this phase of journey from invention to innovation. All three templates of the LCI, therefore, support in achieving the target of invention to innovation.

The **LCI Template – III: Problem Investigation Script** begins by allowing researchers and academic inventors to introduce themselves to the stakeholders at the time of establishing contacts. In a very short introduction, the academic inventors are recommended to mention their names, institutional association, research expertise in their discipline and objective of conducting the research. All this information adds credibility and creates a reciprocate environment. The academic inventors then share a short two-minute story (already documented) and inform the stakeholders about what is desired to be explored through the interview session.

Once an introduction phase accomplished the academic inventors, who already has a list of five problems (identified in LCI Template – I: Root Cause Analysis), may initiate an exploration process related finding more problems by asking questions from stakeholders. The questions like, “**What are three main problems, stakeholders are facing? What tasks are difficult to achieve? Where changes are possible?”** will help enriching the list of identified problems further. Once the three main problems are revealed by the stakeholders, an academic inventor is then advised to initiate discussion over already identified five problems based on the LCI Template – I: Root Cause Analysis. This discussion can lead towards finalizing the eight real-world problems conceived after accomplishing the systematic discussion between the academic inventor and the stakeholder.

Once eight problems are listed, the next step is to evaluate these problems through two scales. The first scale drives the discussion towards measuring the intensity of problems at **High, Moderate** and **Low** levels. For each of the eight problems the academic inventor can ask stakeholder to classify these on three levels. This step will help in filtering down those problems which are not so important to do research upon. The second scale then drives the discussion towards evaluating the rank with respect to emergency for solving these eight problems. Each of the problems can be evaluated on a scale from **1 to 10**; where 1 represents “not very crucial to solve now” and 10 represents “must be solved now”. Both of these scales will enable the researchers and academic inventors to make an evidence-based decision for choosing the most relevant and appropriate real-world problem to conduct research upon and devise the solution. Multiple interviews can be conducted depending upon the willingness and availability of the stakeholders for participating in the discussion process (Makady et al., 2017).

It is observed that establishing the first contact is always difficult, however, once it is established the stakeholders can themselves help in establishing the future contacts. A technique of snowball sampling, developed by Coleman (1958) and Goodman (1961), may offer referrals, and facilitate in moving further towards different stakeholders. It is advised that at the end of every interview, academic inventors must ask for referrals to one or two relevant people and establish contacts with them through emails or calls. These referrals play strong role in adding more credibility towards the research work of the academic inventors and increase chances of receiving responses from different stakeholders.

In addition, other sources of information including LinkedIn, Research Gate, and Facebook etc. may also facilitate in approaching the relevant stakeholders. The discipline-oriented groups are already created at these platforms and their group moderators can help in opening up a debate on the real-world problem identified through three templates and solicit feedback from multiple group members. These groups usually have members from different institutions including those who are responsible for industrial standards and regulations. These relevant stakeholders can be identified online, and discussions may be generated through question answer sessions, writing blogs, and following the tweets and posts. It is proposed that academic inventors must not avoid establishing contacts and asking help through groups and forums.

The entire process supporting the first components of the LCI is with a purpose of reaching the problem worth conducting research upon and inventing solutions having potential of commercialization. Three templates proposed for hands-on activities including **Root Cause Analysis**, **Stakeholders Mapping** and **Problem Investigation Script** for stakeholder interviews can collectively advance the knowledge of researchers and academic inventors about the real-world problem, identify the societal needs and begin a journey towards inventing solutions for future commercialization. These all activities follow a process and lead towards identified real-world problem. The process supporting the LCI Component – I is depicted in figure 2.4 below.

Figure 2.4. Process of the LCI Component – I: Problem Identification

CONCLUSION

This chapter discussed an entire process of exploration of real-work problem to be followed by researchers and academic inventors. The process is depicted to present the entire **LCI Component – I: Problem Identification**, which begins with three main questions and is supported by the eight items of the **LCI Checklist – I.** In addition, the flow of three templates named **LCI Template – I: Root Cause Analysis, LCI Template – II: Stakeholders Mapping,** and **LCI Template – III: Problem Investigation Script** to answer three questions discussed at the beginning of this chapter in search of the real-world problem is also deliberated upon. In the next chapter the LCI process will be elaborated further through learning related to the LCI Component – II designed for the extensive work related to the literature search. A picture 2.1 shows how LCI is being taught at University of Utah where research teams can be observed busy with hands-on activities.

Picture 2.1. Teaching LCI – Research Teams busy with Hands-on Activities

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Chapter 3

Second Component of the LCI: Literature Search

ABSTRACT

This chapter discusses the second component of the Lean Canvas for Invention in terms of its questions and a detailed checklist. This chapter with the help of examples will reflect on a process of how researchers, academic inventors and product developers can seek guidance from existing knowledge including literature published in research papers and patents for building foundation in support of a real-world problem.

Literature Search, LCI Checklist – II, Five Items, LCI Template – IV, Keyword Search, LCI Template – V, Article Matrix, LCI Template – VI, Patent Matrix.

LITERATURE SEARCH

The second component of the LCI is the **Literature Search**. This component is associated with the WHY question of the LCI. Here the purpose is to guide the researchers, academic inventors and product developers to collect academically published literature supporting the real-world problem identified through the LCI Component – I: Problem Identification. It is observed that researchers and academic inventors are very good in reading the research articles published in various impact factor journals. They frequently visit conferences to present their research findings and also publish in conference proceedings. However, reviewing patents is observed as extremely rare practice by researchers and academic inventors (Basberg, 1987).

The literature related to patents, already granted or licensed, is easily accessible through different open databases and for which there is no fees required (Singh, Chakraborty, & Vincent, 2016). Usually, this available pool of knowledge resource is not considered by the academic inventors and researchers during their literature review process and then may lead to certain inventions which are already there and therefore cannot be patented in the future. This is one of the multiple issues that technology managers face at the time of invention disclosures. The academic inventors complete their research, develop a technology and then ask the technology managers to guide in the process of filing patents. Usually, at that moment, process of prior art search for patents and citations begins by the IP and technology managers (Chisum, 1976). They explore for features like novelty, obviousness and freedom to operate. Because these features are not being considered by the academic inventors and researchers during the process of technology development, the findings by the technology managers may conclude that similar solutions already exist and therefore it prevents inventions to be patented (Judd, 1985).

The **Literature Search component of the LCI** instigates the researchers, academic inventors and entrepreneurs to expand their pool of knowledge resources and along with the research articles include the review of patents for gathering evidence related to the real-world problems. The following question is proposed by the LCI to be answered by the researchers and academic inventors:

1. **Why** still is the real-world practical problem unsolved? (Based on evidence from research articles in journals, conference proceedings, and patents).

The answer of above question enables the researchers and academic inventors to explore the variety of open and proprietary databases (Chandrasekharan et al., 2009) available and look for reasons of not having solutions for the identified real-world problems.

Multiple evidence gathered from published research articles, conference proceedings and patents guide the researchers and academic inventors in the search process of inventions, having similar problems and already invented relevant solutions. The findings may present some inventions having capacities of solving the real-world problem with small changes in their existing features. To facilitate in this literature search process, this book now proposes the **LCI Checklist – II**. It is suggested that when researchers, academic inventors and entrepreneurs will seek guidance from this checklist, the literature review section of a research proposal will be developed gradually. That will lead towards research gap and building attitude for inventing solutions with a possibility of granting patent in future.

Once patents granted, the TTO professionals (directors and managers) also facilitate in the process of licensing patents and the commercialization of inventions (Dalmarco et al., 2011). Therefore, it is suggested that once the real-world problem is identified with the guidance from the first component of the LCI, the relevant evidence must be gathered with the assistance of the **Second component of the LCI: Literature Search** and by answering its **one question**, exploring **five items of the LCI Checklist – II** and seeking assistance from **LCI Templates IV, V, and VI** designed for hands-on activities. The five items in the **LCI Checklist – II** are discussed in table 3.1.

Table 3.1. LCI Checklist – II: Literature Search

Literature Search		LCI Checklist – II	
	i.	Keywords representing Problem, Proposed Solution and Context for research application.	
	ii.	Research gap conceived through observations and discussions with stakeholders.	
	iii.	Research gap conceived through research articles and patents via keywords and semantic search techniques.	
	iv.	Comparisons of findings, similarities, and differences in features of existing research.	
	v.	Reference list of research articles and patents etc.	
Databases for Research articles: Google Scholar, IEEE, Inspec, SciFinder, Scopus, Science Direct and Web of Science etc. *Databases for Patents:* Google Patents, USPTO, Espacenet, and Innography *Symbols for classification of patents can be accessed through:* Cooperative Patent Classification (CPC) and International Patent Classification (IPC)			

One question of the second component of the LCI and **five items of the LCI Checklist – II** need a systematic approach to be taken by the researchers and academic inventors to reach to the appropriately search the literature. Different databases exist to enable the academic inventors and entrepreneurs to access the relevant published knowledge (Zhang, Zhang, & Wu, 2004). Depending on different disciplines of studies, the academic inventors can select the open or proprietary databases e.g., IEEE, Inspec, SciFinder, Scopus, Science Direct and Web of Science etc. However, the simplest way to start the literature search is from the Google Scholar (Falagas et al., 2008). It is open database and offers multiple features to filter down the search process of the published articles. The academic inventors and entrepreneurs can filter the research articles with respect to years of publications, field relevance, and publishing dates etc. In addition, the search engine allows to either include or exclude citations of the research articles in other papers (Noruzi, 2005). Alongside, the setting options of the Google Scholar enable the academic inventors to save articles for future reading and importing the citations in the Bib TeX or EndNote format. There are added features too that collectively enable the academic inventors and researchers to organize the search process and offer convenience in keeping the relevant articles organized and in the specific format.

Similarly for any other search engine the academic inventors need to organize the search process with the help of keywords (Younger, 2010). The keywords are usually chosen to consistently manage the relevance to the field of study and to the issue on which research is taking place. The book now proposes **LCI Template – IV: Keyword Search** for the selection of keywords related to the real-world problem. According to Genrich Altshuller (1926 - 1998), developer of TRIZ (Russian acronym for Theory of Inventive Problem Solving) concept, 95% of problems in the world are solved with solutions that already exist, inside or outside the relevant industry (Ilevbare, Probert, & Phaal, 2013). He suggests that it is required to see these existing solutions through the prism of TRIZ (Gadd, 2011). The TRIZ prism can offer solutions to the real-world problems by proposing some amendments and improvements in the existing inventions. Therefore, the LCI demands looking for similar problems and similar solutions that already exist in literature to guide the search process towards novel inventions. The **LCI Template – IV: Keyword Search**, proposes that academic inventors and entrepreneurs must look for three keywords related to the real-world problem. The first word is a **problem** itself, then the proposed **solution** and then the **context** in which the solution will be applied. In order to further polish this search, three synonyms can be explored for each of the proposed keyword to reach the similar and appropriate academic words. The synonyms enable the academic inventors and entrepreneurs to expand the scope but keeping the relevancy intact (Pickering et al., 2016).

Sometimes it is observed that a keyword is itself a combination of two or three words. Let us understand this concept with the example of LCI. "**The Lean Canvas for Invention (LCI) is a solution designed to solve the problem of knowledge asymmetries between the technology developers and technology managers at the time of invention disclosures in the Technology Transfer Offices"**. If we read the above sentences in terms of three keywords then problem is **Knowledge Asymmetries**, proposed solution is **Lean Canvas for Invention** and context for application is the **Technology Transfer Office** at universities but can also be applied at the R&D departments of industries working on new product development. Though we can read three keywords explicitly, but each keyword is itself a combination of two, four and three words respectively. In situation where a single keyword is the combination of multiple words then it is proposed to opt quotation marks in order to apply a filter during literature search and keep it as relevant as possible. For example, "knowledge asymmetries", "Lean Canvas for Invention" and "technology transfer office", all are grouped together within the quotation marks. The very purpose of quotation mark (Ileanu et al., 2019) is to tell the search engine to look for only those research articles where two words of "knowledge asymmetries" are always together rather searching for all other research articles where a word "knowledge" and a word "asymmetry", both are presented separately. This technique of using quotation mark serves through the Boolean operators and is applicable to almost all the databases mentioned in the **LCI Checklist – II**.

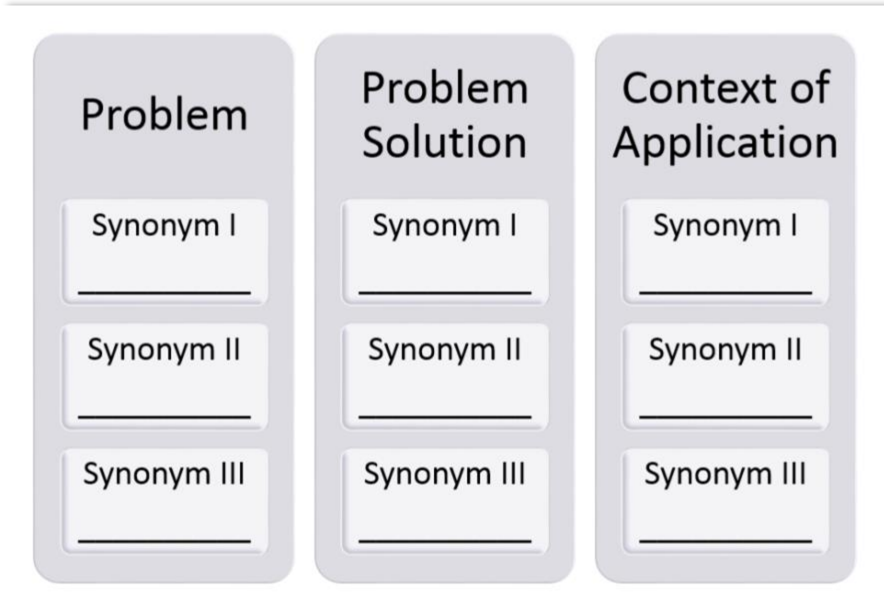


Figure 3.1. LCI template – IV: Keyword Search

After choosing keywords the researchers and academic inventors may start looking for appropriate synonyms. For example when I was in a process of selecting an appropriate academic word for defining my problem of "Knowledge Asymmetry", I explored multiple words before reaching it. At once, I was looking for literature about skewness in cognition level, inequality in awareness and dissimilarity in expertise etc. Exploration of multiple synonyms then guided me to the most appropriate word of knowledge asymmetry. This example is also depicted in figure 3.2 for clear understanding.

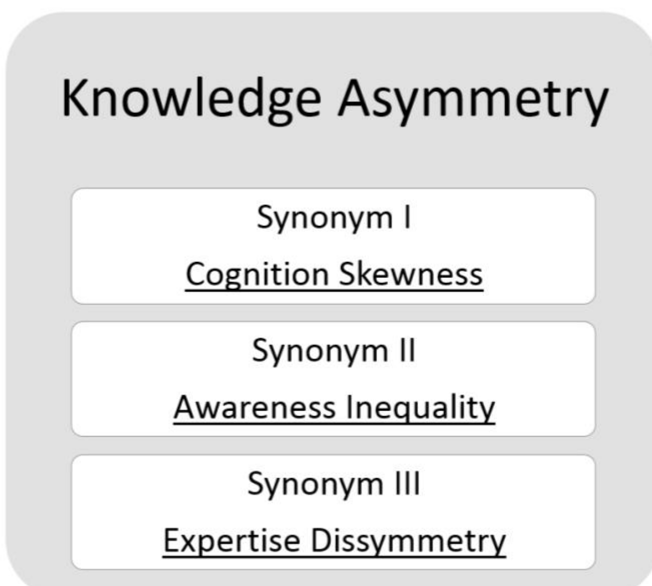


Figure 3.2. LCI Template – IV for word "Knowledge Asymmetry"

Once all three keywords (problem, solutions and context) are chosen then the academic inventors and entrepreneurs begin the process of extensive literature search, establish foundation knowledge, and accumulate most of the research work carried out for the real-world problem. It is very much possible that along this journey of literature search, keywords explored earlier become more polished and focused. The literature search process allows the academic inventors to organize the existing research in a way that lead towards research gap which is already guided by the discussions done with the multiple stakeholders during the first component of the LCI: Problem Identification. The very purpose here, in the second component of the LCI, is to see the real-world problem as a research gap academically with the evidence gathered through research articles and patents explored through the variety of open and proprietary search engines.

In order to facilitate this search process, it is proposed to use the **LCI Template – V: Article Matrix** and **LCI Template – VI: Patent Matrix.** These templates are given in figure 3.3 and 3.4 respectively and are designed to systematically guide the academic inventors and entrepreneurs in the search process of research articles and patents respectively. The **LCI Template – V** and the **LCI Template – VI** direct a way of gathering and organizing the required information in a specific format. These matrices also guide by informing what is required to be searched from the research articles and patents respectively.

The Article Matrix is designed to enable academic inventors and entrepreneurs to organize the information in a depicted format. The format has few elements that include title of the research paper, name of research journal or conference proceedings in which article is published, name of author(s), findings of published research and then what research gap was explored. For every article the academic inventor is suggested to note down all these details clearly. As all details will be available in a standard format, it will help in synthesizing most of the research work published and reach to the systematically derived research gap (Robinson, Saldanha, Mckoy, 2011).

Each of the research article can then be listed down for preparing the bibliography and reference list. This step is important for every kind of the academic research and academic inventors accomplish this task frequently, however, what is ignored most of the time is a search for relevant patents (Michel & Bettels, 2001). The LCI therefore emphasis on including the patent literature to offer the technical landscape to the academic inventors and entrepreneurs for enriching their knowledge and increasing chances of patentability of the proposed inventions as one of the major outcomes of the LCI guidelines.

Article Matrix: Published Work in Research Journals and Conference Proceedings

Keywords: ____________________

No.	Title	Journal/ Proceeding	Author(s)	Findings	Research Gap

Figure 3.3. LCI Template – V: Article Matrix

Patent Matrix

Keywords: ____________________

No.	Title	IPC	Inventor(s)	Assignee	Claims

Figure 3.4. LCI Template – VI: Patent Matrix

Alike multiple databases for research articles, open and proprietary databases also exist for patent search. This information is already offered in the **LCI Checklist – II**. Along with variety of databases including US Patent and Trademark Office (USPTO), and Espacenet etc., the simple way to start the patent search is to follow the Google Patents Site (Kousha & Thelwall, 2017). The same keywords, the academic inventors and entrepreneurs select for the research article, must be used for the patent search. As google scholar supports the Boolean technique to filter the search process, the google patents site also follows the same technique to do so. The academic inventors and entrepreneurs can use the quotation marks to narrow down their search process. Once keywords are entered, the google patents site allows to download a complete patent, free of cost. It looks similar to research articles, however, nomenclature used for patents is different. For example, for research articles the academic inventors look for authors' names but in patent search they look for inventors' names (Atkinson, 2008). In research articles, the academic inventors look for findings, however, in patents they look for claims. This difference is visible in both matrices explicitly.

One of the important search engines that further filters down the patent search process is known as the Innography Patent Scout (Germeraad, 2017). Though this search engine is an expensive choice, but it allows an added feature of semantic search along with the keyword search. The semantic search (Guha, McCool, & Miller, 2003) enables the academic inventors and entrepreneurs to use a complete abstract, rather than only few keywords at the time of exploring relevant patents. This search engine is artificially intelligent and develops the logical connections between the words used in the abstract and return only those patents having extreme relevancy to the identified real-world problem. If Innography patent scout is not available to the academic inventor, the suggestion is to access it through the technology transfer offices established at the entrepreneurial universities for the prior art search. The IP managers at these offices may be consulted in the process of developing the patent matrix too.

An added feature to further filter the patent search process is to seek guidance from the patent classification. This classification can be found through the World Intellectual Property Organization (WIPO) and the Espacenet websites. These websites offer the International Patent Classification (IPC) (Fall et al., 2003) and the Cooperative Patent Classification (CPC) (Montecchi, Russo, & Liu, 2013) numbers respectively. This classification starts from **A to H**, where **A** represents patents for human necessities; **B** represents patents for performing operations and transporting; **C** represents patents for chemistry and metallurgy; **D** represents patents for textile and paper; **E** represents patents for fixed construction; **F** represents patents for mechanical engineering, lighting, heating; **G** represents patents for physics and **H** represents patents for electricity. In addition to this classification the Espacenet website also offers **Y** classification to represent patents for general tagging of new technological developments and for cross-sectional technologies spanning over several sections of the IPC.

The IPC goes down to the detailed number e.g. **A** is for patents related to the human necessities. It then goes for further classification to **A23** having patents for treatment of food. Then it further goes towards **A23L** classification having patents for preservation of food. Then it classifies further to **A23L 2/08** having patents for concentration or drying of juices etc. The IPC number therefore also guide the academic inventors and entrepreneurs to look for the most relevant patents for the proposed invention to solve the real-world problem. The information needed by the academic inventors and entrepreneurs to gather and organize information related to patents in a specific format is given in the figure 3.4 **LCI Template – VI: Patent Matrix.**

The Patent Matrix is designed to enable academic inventors and entrepreneurs to organize the information based on those elements which are different for the article matrix and are different for the patent matrix. The different elements of the patent matrix include title of the patent, IPC for patent classification, name of inventor, and a name of company to which the patent is either granted or licensed by and finally it allows to accumulate knowledge related to the claims made by different patents. In summary, the article matrix leads towards exploring the research gap and the patent matrix leads towards the existing solutions which are available in the patent database and are also licensed by companies selling their products and services to the real-world customers.

The information regarding to whom the patent is granted or is licensed by, will be filled in the "Assignee" column of the patent matrix. Having this information available with the academic inventors and entrepreneurs, at the earlier stage of their research process, preclude them in wasting their time and effort in developing a technology which is already available. In addition, if academic inventors and entrepreneurs have conducted the patent search earlier and they are already aware about the IPC/CPC related to their inventions then there is a greater chance that when their proposed inventions will be disclosed to the TTO professionals, the full assessment of the prior art will be much convenient, and patentability and market adoption will be guaranteed.

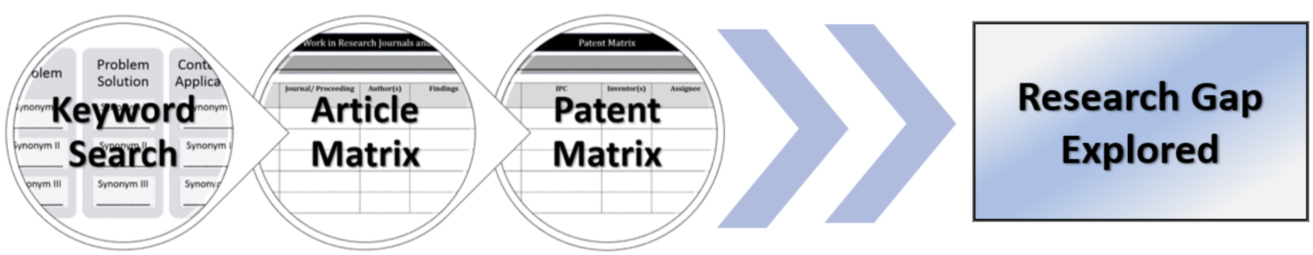
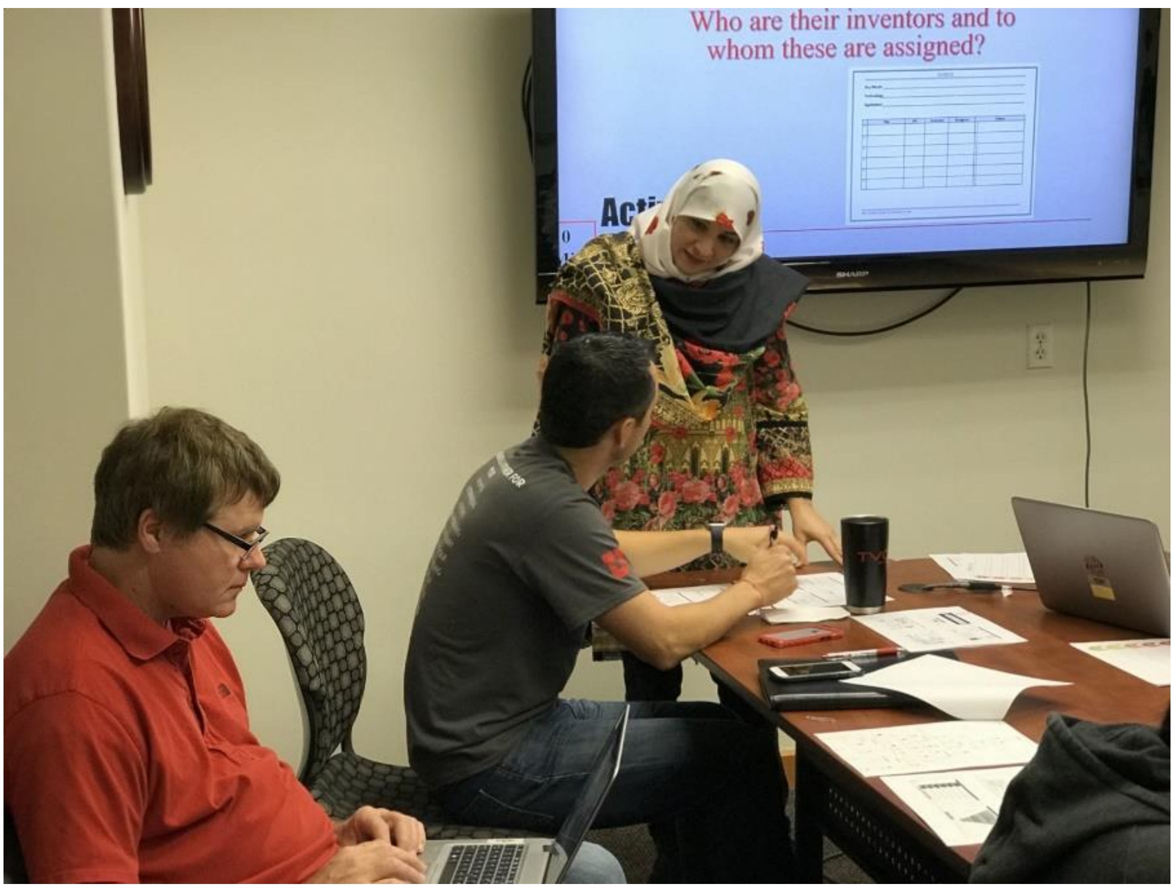


Figure 3.5. Process of the LCI Component – II: Literature Search

CONCLUSION

The overall purpose of three hands-on activities discussed in this chapter is to learn from the available literature including research articles and patents and offer underpinning related to the real-world problem. The objective is to reach the research gap and learn about the existing inventions available in a form of patents granted and/or licensed. As following the LCI format, three hands-on activities are proposed in this chapter to guide the academic investors and entrepreneurs to achieve the said task. The discussed literature search process is depicted in figure 3.5 for the LCI Component – II, which can be achieved through the five items of the **LCI Checklist – II, LCI Template – IV: Keyword Search, LCI Template – V: Article Matrix,** and **LCI Template – VI: Patent Matrix** to answer a question presented at the beginning of this chapter. In the next chapter details regarding already commercialized solutions will be explored further through a guided approach for the LCI Component – III, the existing solutions. An example of teaching LCI at the technology transfer office at University of Utah is evident in picture 3.1 below.



Picture 3.1. Teaching LCI – Principal Investigators' Training at TTO

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Chapter 4

Third Component of the LCI: Existing Solutions

ABSTRACT

This chapter discusses the third component of the Lean Canvas for Invention and deliberate upon its questions, detailed checklist and templates. This chapter guides the researchers, academic inventors and product developers to explore deeply what types of existing solutions are available in the market. The purpose is to learn from available products and services and go ahead of these solution for future inventions solving real-world problem.

Existing Solutions, LCI Checklist – III, Six Items, LCI Template – VII, Market Matrix, LCI Template – VIII, Affinity Diagram for Problem Synthesis.

EXISTING SOLUTIONS

The third component of the LCI is the **Existing Solutions**. This component is associated with the WHY question of the LCI. Here the purpose is to guide the academic inventors, product developers and entrepreneurs to look for already commercialized solutions in the market to solve the real-world problem, identified earlier through the LCI Component – I: Problem Identification. As it is discussed earlier that researchers and academic inventors rigorously read research articles, however, miss-out the patent literature. Similarly, at the time of conceiving an idea about future inventions, the researchers and academic inventors hardly explore the market to observe and learn about the existing solutions which may possess the capacity to solve the identified real-world problem. As research articles and patents literature can be accessed through the open and proprietary databases, similarly several databases e.g., IBISWorld (Tucker, 2006) and others can be used to explore the existing solutions available in the market. Reviewing literature of existing solutions in consideration offers two advantages:

- Firstly, it favors academic inventors and entrepreneurs in saving their time, effort, and grants for investing on inventions which have no future in market.

- Secondly, the knowledge about shortcomings in the existing solutions can pave a way forward towards inventions clearly depicting limitations (O'Neill, 2015) and justifications for future inventions.

In addition, the availability of such a knowledge with the academic inventors can lead towards smooth and concrete discussion between the academic inventors, product developers and the technology managers at the time of invention disclosure. Including this review of existing solutions, at the earlier stage of literature search, ultimately enhance the chance of future inventions with clear need in the market and therefore having great potential of commercialization. This LCI component of the existing solutions prompts the academic inventors and entrepreneurs to consider this added knowledge resource along with research articles and patents at the time of literature review for searching the real-world problems and their solutions. The following question is proposed by the LCI to be answered by the academic inventors, product developers and entrepreneurs for its third component:

1. **Why** existing solutions fail to solve the real-world practical problem? (Based on evidence collected after reviewing the existing solutions in the market in terms of their presence and shortcomings).

The answer to above question calls for two prior questions to be answered first:

a. **What** are the existing solutions available in the market?
b. **What** are the limitations of the existing solutions available in the market?

These three questions prompt researchers and academic inventors in exploring different open and proprietary databases available and identify reasons behind absence of or shortcomings in the existing solutions in solving the real-world problems. To facilitate in this process of exploration, this chapter is proposing the **LCI Checklist – III**. It is suggested that when researchers, academic inventors, and product developers will seek guidance from the LCI Checklist – III, the literature review section of a research proposal will be enriched further with more evidence and research justification. The expected outcome is the explored research gap and proposed invention with potential of commercialization in future. It is expected that third component of the LCI will add strength to the evidence already gathered during first and second components of the LCI by answering the earlier discussed questions, exploring **six items of the LCI Checklist – III** and seeking assistance from **LCI Templates VII, and VIII** designed for hands-on activities. The six items in the **LCI Checklist – III** are given in table 4.1 below.

Table 4.1. LCI Checklist – III: Existing Solutions

Existing Solutions	**LCI Checklist – III**		
	i.	Listing of solutions of the real-world problem already available in the market.	
	ii.	Exploration of similar problems and solutions beyond the single industry.	
	iii.	Limitations of the existing solutions and reasons behind failing to exactly solve the real-world problem.	
	iv.	Patents associated with the existing solutions and their market status.	
	v.	Listing of companies licensing patents for offering existing solutions.	
	vi.	Justification behind how the proposed invention can meet the highlighted limitations of the existing solutions.	
Information for industry research and company research for exploring existing solutions, market size, growth and competitors can be accessed through database: Google Image, PubMed, IBISWorld, BCC Research, CAS SciFinder, NVCA, MarketResearch.com, D&B Hoovers, Global Data PLC, PCAST Historical Reports, and Thomas Net, PitchBook, Factiva, Business Source premier and Mergent Intellect etc.			

The three discussed questions and six items of the LCI Checklist – III also need a systematic approach, alike other components of the LCI, to be taken by the academic inventors and entrepreneurs to reach to existing solutions in the market. A variety of databases are proposed in the **LCI Checklist – III** to guide the academic inventors in this search process. Though at the earlier level the information on existing solutions offered through the open database e.g., Google Images and company websites may be sufficient, however, research based detailed information may only be accessed through the proprietary databases e.g., BCC Research, MarketResearch.com, IBISWorld, and ThomasNet etc.

These databases frequently publish their research reports and white papers, presenting the existing situations of different industries and companies. These reports discuss matters related to new and existing products and services, market outlooks, forecasts, and even strengths, weakness, opportunities, and threats (SWOT) etc. In fact, these reports cost a lot, however, free of cost features of these databases, e.g., "availability of the executive summary" and "search inside the reports", sufficiently offer concrete information to move forward in the research process. For filtering this search, the academic inventors and entrepreneurs are advised to adopt strategy of adding a specific keyword, "Global Market" along with the keywords related to the real-world problem. The "Global Market" word within the quotation marks in the google search will return the executive summaries of the research reports published by consultancy companies. However, for accessing the detailed reports, the academic inventors and entrepreneurs may also get assistance from the technology transfer offices within universities, already having subscription to such proprietary databases (Clarysse, Wright, & Van de Velde, 2011).

By utilizing same keywords, already explored through the **LCI Template – IV: Keyword Search**, the academic inventors and product developers are now proposed to adopt the **LCI Template – VII: Market Matrix** to answer three questions of the third component of the LCI. The Market Matrix will have an assistance from the Article Matrix and the Patent Matrix discussed in the previous chapter. The Market Matrix further inspires the academic inventors and entrepreneurs to collect and organize the information in a format helpful to understand details of the existing solutions. The format has few elements, and these elements are depicted in the figure 4.1. **LCI Template – VII: Market Matrix**.

The elements include name of the existing solutions, name of company offering the existing solutions in the market, details of patents associated with the existing solutions (depending on whether product is based on patent or not, when the patent was granted and to whom it is licensed), details of features offered by the existing solutions and their limitations that are observed based on a fact that existing solutions are not solving the real-world problem. The information already gathered in the Patent Matrix must be synchronized with the information in the Market Matrix. The column for patents granted and licensed may validate the information from the patent matrix, wherever appropriate. In additions, details of companies whose solutions are not relying on any patent may also be added in this matrix. The information may be gathered from companies' websites and annual reports having details of solutions. The overall objective of this matrix is to reach the limitations and shortcomings in the existing solutions and to learn reasons behind the unsolved real-world problem.

Though gathering the entire information through three matrices empowers the academic inventors and entrepreneurs in exploring and reaching the research gap, however, it may be expected that information gathered from different knowledge resources, required to develop three matrices, may present some duplication. Therefore, appropriate synthesize of such a huge information is mandatory to explore the research gap systematically. Here, column for the gap reflected in the Article Matrix and column for the limitations reflected in the Market Matrix are required to be organized.

Market Matrix

Keywords: ______________________________

No.	Existing Solutions	Companies offering Existing Solutions	Patent Details (Granted/Licensed)	Features Offered	Limitations Observed

Figure 4.1. LCI Template – VII: Market Matrix

The Japanese anthropologist Jiro Kawakita in 1960's developed a technique known as the Affinity Diagram. This diagram guides in clustering huge information and finding relationships between multiple concepts (Takai, & Ishii, 2010). The affinity diagram may allow to organize and synthesize the identified gaps and the recognized limitations of the two matrices into taxonomies and guide the academic inventors and entrepreneurs to establish underpinning related to the real-world problem. The **LCI Template – VIII: Affinity Diagram for Problem Synthesis,** given in figure 4.2, is proposed to achieve the said target.

The **LCI Template – VIII** enables the academic inventors and entrepreneurs to follow step by step procedure towards exploration of the research gap. According to literature, an affinity diagram must be developed with following five steps. These steps are also depicted in the LCI Template – VIII.

- Step 1 is to generate ideas: The gaps and the limitations gathered through the Article and Market Matrix respectively will be considered by the academic inventors and entrepreneurs to begin with the affinity diagram.

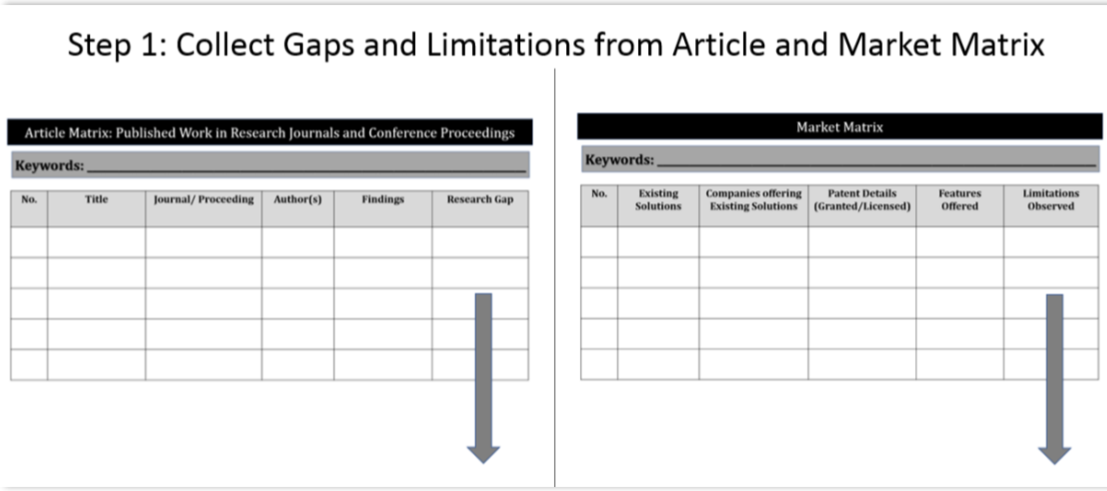
- Step 2 is to display ideas: Here the academic inventors and entrepreneurs are guided to use many sticky notes to write down gaps and limitations separately. These sticky notes can be displayed on a wall or on a table for proper visibility.

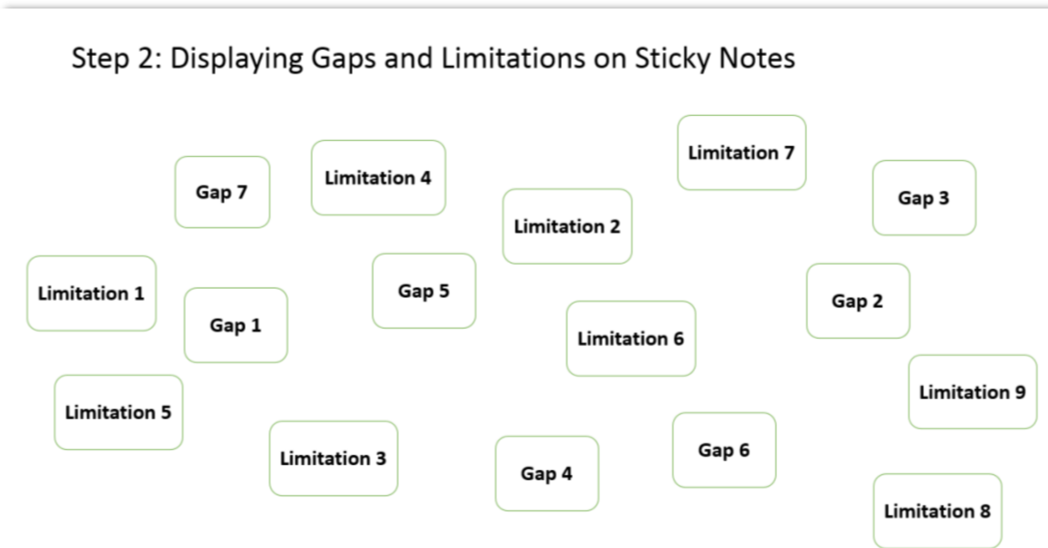
- Step 3 is to sort ideas: The academic inventors and entrepreneurs can initiate here a process of establishing relationship between different gaps and limitations based on similarities existing between them.

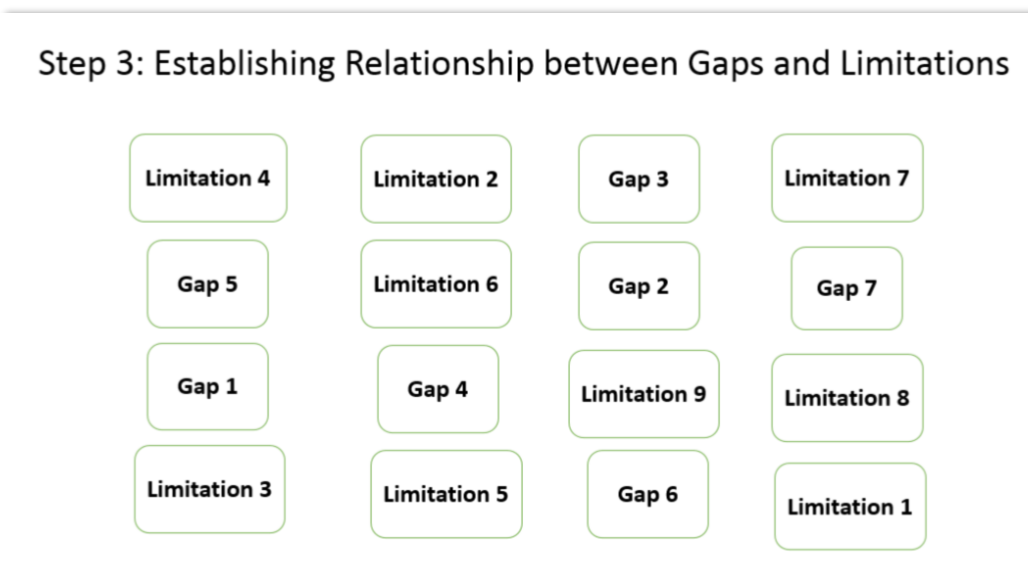
- Step 4 is to create headers: After establishing relationship, the academic inventors and entrepreneurs can propose theme titles to each cluster of related gaps and limitations.

- Step 5 is to draw finished diagrams: Once all logical connections are established the affinity diagram can present the synthesized themes on which academic inventors and entrepreneurs would like to move forward toward their inventions.

When the academic inventors and entrepreneurs seek information from all three matrices and develop some logical connections between them, it will become convenient to reach to a focused and convergent idea that will lead towards invention with higher chances of commercialization. At this stage, the idea is already endorsed by the research articles, patents, and the market reports and therefore an academic inventor can develop a strong justification for dedicating the time and effort and for seeking grants for eliminating the highlighted limitations of the existing solutions through the proposed invention.


Step 1: Collect Gaps and Limitations from Article and Market Matrix
Article Matrix: Published Work in Research Journals and Conference Proceedings
Keywords:
No.
Title
Journal/ Proceeding
Author(s)
Findings
Research Gap
Market Matrix
Keywords:
No.
Existing Solutions
Companies offering Existing Solutions
Patent Details (Granted/Licensed)
Features Offered
Limitations Observed


Step 2: Displaying Gaps and Limitations on Sticky Notes
Gap 7
Limitation 4
Limitation 7
Gap 3
Limitation 2
Limitation 1
Gap 1
Gap 5
Limitation 6
Gap 2
Limitation 9
Limitation 5
Limitation 3
Gap 4
Gap 6
Limitation 8


Step 3: Establishing Relationship between Gaps and Limitations
Limitation 4
Limitation 2
Gap 3
Limitation 7
Gap 5
Limitation 6
Gap 2
Gap 7
Gap 1
Gap 4
Limitation 9
Limitation 8
Limitation 3
Limitation 5
Gap 6
Limitation 1

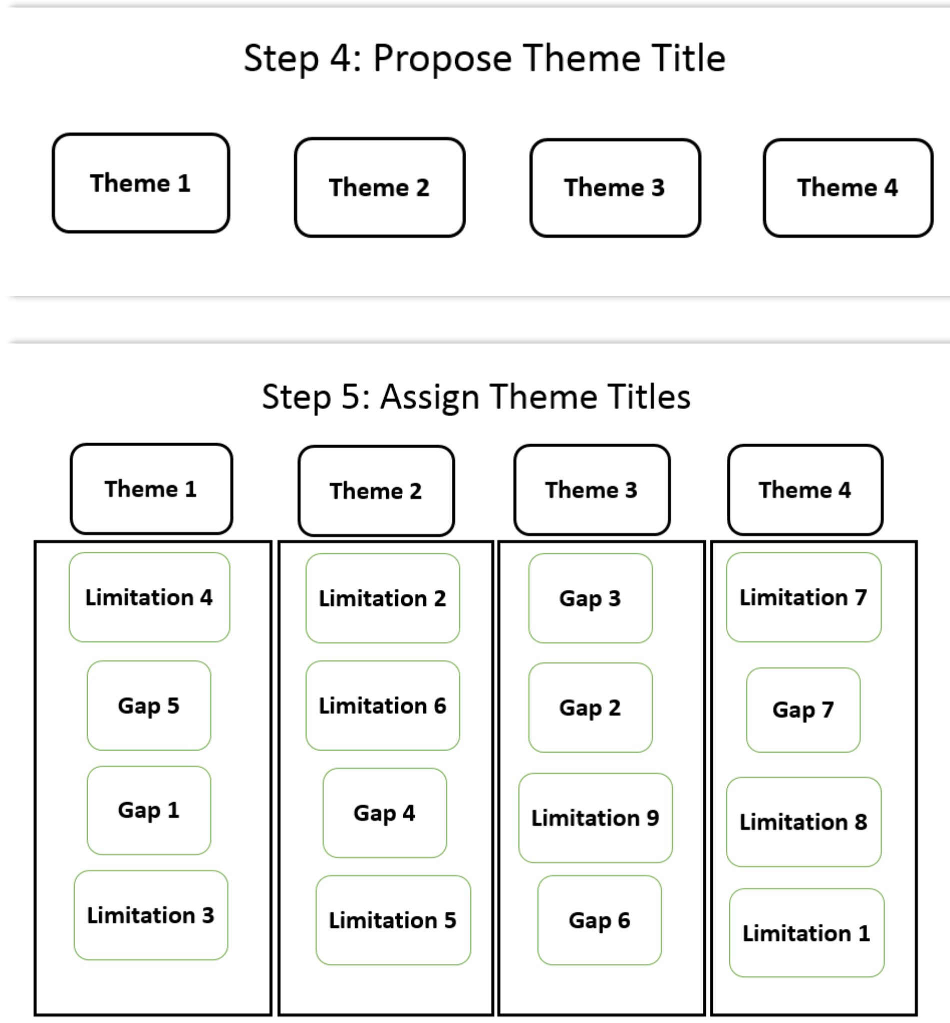


Figure 4.2. LCI Template – VIII: Affinity Diagram for Problem Synthesis

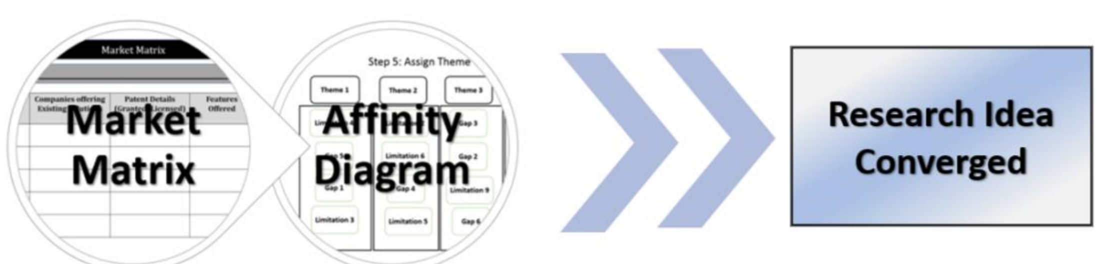


Figure 4.3. Process of the LCI Component – III: Existing Solutions

The overall purpose of two hands-on activities discussed in this chapter is to learn from the existing solutions already available in the market to solve the real-world problem. The purpose is to assure that in presence of existing solutions academic inventors and entrepreneurs do not waste their time, effort and grants on duplication. The knowledge gathered from the existing solutions is a great source of learning in terms of identifying shortcomings and then synthesizing the entire information with the research gaps explored in previous chapters. The affinity diagram is also proposed by the LCI to be adopted for synthesizing the entire knowledge and reach to the converged idea. The LCI therefore proposes two additional hands-on activities in this chapter to guide the academic investors and entrepreneurs for expanding their scope of knowledge and converging to the point of curiosity.

CONCLUSION

The process for existing solutions is depicted as the **LCI Component – III** and is guided to be achieved by combining six items of the **LCI Checklist – III, LCI Template – VII, and LCI Template – VIII** to answer questions presented at the beginning of the chapter. In the next chapter details regarding market landscape and industries for which inventions are intended to be developed will be explored through the LCI Component – IV: Market landscape. The picture 4.1 adds further to the teaching journey of LCI.

Picture 4.1. Teaching LCI – Faculty Members

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Chapter 5

Fourth Component of the LCI: Market Landscape

ABSTRACT

This chapter discusses the fourth component of the Lean Canvas for Invention and deliberate upon its two important questions, detailed checklist and templates. This chapter guides the academic inventors and product developers to learn from market trends and landscape. The purpose is to learn from existing companies and their competitive advantage for available products and services in the market.

Market Landscape, LCI Checklist – IV, Seven Items, LCI Template – IX, Market Mapping and Competitive Landscape Matrix, LCI Template – X, Solution Acceptance Script.

MARKET LANDSCAPE

The fourth component of the LCI is the **Market Landscape**. This component continues its association with the WHY question of the LCI. Here the purpose is to guide the academic inventors and entrepreneurs to learn about the current and future trends of the market and the industry for which solutions will be invented to solve the real-world problems. Previously, the **LCI Template VII: Market Matrix** enabled the academic inventors, product developers and entrepreneurs to explore the existing solutions in the market and learn from their in-depth features and also investigate their shortcomings and limitations. The purpose of this chapter is to explore for further opportunities through these shortcomings of the existing solutions and learn about how to capitalize these opportunities through commercialization.

At the time of invention disclosure, the technology transfer office begins with a process of market mapping to understand whether a particular industry is willing to accept the invention or not (Guindalini, Verreynne, & Kastelle, 2021). The TTO professionals look for market viability and future growth of inventions in terms of customers' acceptance and competitors' profile (Willardsen, McGivern, & Hill, 2014). This knowledge connects them to the potential end-users of the invention and measure their willingness in utilizing the invention for solving the real-world problem.

This LCI component for the market landscape allows the academic inventors and entrepreneurs to explore the above said information much before investing their time, effort, and grants for inventions varying at different levels of chance for their market acceptance. The successful inventions in a form of products or services get accepted by the larger number of end-users in the market and reside in the growing industry having good Compound Annual Growth Rate (CAGR). The academic inventor, product developer and entrepreneurs are therefore guided through this chapter to look for indicators and explore in-depth the chances of market acceptance of their proposed inventions. The following question is proposed by the LCI to be answered by the academic inventors and entrepreneurs for its fourth component:

- **Why** in presence of existing solutions the proposed invention has potential to grow?

The answer to above question calls for one prior question to be answered first:

- **Which** companies are currently addressing the problem and how?

These two questions encourage the academic inventors and entrepreneurs for a guided search through market reports and meetings with stakeholders and explore the chances of market acceptance of future invention in presence of the existing solutions for solving the real-world problems. To facilitate in this process of search, the **LCI Checklist – IV** is proposed in table 5.1. The answers of the seven items of the **LCI Checklist – IV** seek guidance from the previous component of LCI, the existing solutions. The expected outcome includes the evaluation of the end-users' opinions towards future acceptance of invention in the market.

Additionally, it is expected that fourth component of the LCI will add clarity in positioning the invention with respect to market needs. The **LCI Checklist – IV** obtains assistance from **LCI Templates IX, and X**, designed for hands-on activities to answer two questions raised by the fourth component of the LCI. The seven items of the **LCI Checklist – IV** are given below. The two questions described and the seven items of the **LCI Checklist – IV** need an organized approach to be taken by the academic inventors and entrepreneurs for moving ahead with the LCI process. The databases are already proposed in the **LCI Checklist – III** and the same will be utilized here to gather the relevant information.

The very important information to explore is looking for the Compound Annual Growth Rate (CAGR) of the industry within which the existing solutions are residing. This value can be calculated with a mathematical formula to evaluate the rate of return after specified duration of time. Here, the CAGR value is not used for calculating the rate of return of the proposed invention rather it is used to measure the rate of return of the existing solutions in the industry where the proposed invention will be commercialized in future. The CAGR formula is used to offer the yield to investors at the end of investment duration and therefore is a good tool to motivate the investments for future. The mathematical formula is:

$$\text{CAGR} = [(\text{Ending Investment Value}) / (\text{Beginning Investment Value})]^{(1/n)} - 1$$

Where n is the number of years of investment

Table 5.1. LCI Checklist – IV: Market Landscape

	LCI Checklist – IV		
Market Landscape	i.	List of company names, websites, and contacts details offering the existing solutions in market.	
	ii.	Number of end-users and annual revenue of companies offering existing solutions in the market.	
	iii.	Evidence from news, reports and articles showing chance of potential growth or decline of the industry hosting the existing solutions in the market (e.g., CAGR).	
	iv.	Identification of potential end-users who are ready to pay for the proposed invention.	
	v.	Identification of similar inventions in the R&D pipeline, found during conferences and meetings with stakeholders.	
	vi.	Justification of market acceptance of proposed invention and chances of its growth in presence of existing solutions.	
	vii.	Payment mode for proposed invention (paid by direct end-user or by indirect end-users via intermediate business or channel).	

This value reflects that whether the time, and effort of the academic inventors and entrepreneurs are dedicated towards the booming industry or not. The higher the CAGR value the higher the chance that the proposed invention will gain more funding with more chance of attracting investors in future. It is a general fact that CAGR value more than 5% represents a booming industry. However, being more specific, for companies having experience of five years with CAGR of 10 – 20% is considered progressive for sales and companies having experience of ten years with CAGR of 8 – 12% signifies the progressive industry. The question may raise here that do the academic inventors and entrepreneurs must calculate CAGR for every company? No! not at all. This information is already calculated and forecasted by consultancy firms and can be found in the market reports published by them through the databases discussed already. Even if accessing these databases is difficult than a simple GOOGLE search with added keyword of "Compound Annual Growth Rate" can resolve this query. For example, a press release of July 7, 2021, by Market Watch forecasts for autonomous vehicle market, propose a growth at a CAGR of 63.5% by 2027. This illustrates a wider chance of market acceptance of any invention to be developed for the autonomous vehicle industry.

Market Mapping and Competitive Landscape Matrix

Compound Annual Growth Rate (CAGR):_________________

No.	Company Name	Company Website, Brochures and Fliers, Blog, Video, Webinar	Market Size Annual Revenue	Customer Segment	SWOT and PEST

Figure 5.1. LCI Template – IX: Market Mapping and Competitive Landscape

Though the CAGR is a good start to learn about the market landscape, however, more information is mandatory to be learned by the academic inventors and entrepreneurs for successful commercialization. The added information guides through the detailed profiles of companies offering the existing solutions in market. The information may be collected through company website, brochures, fliers, video, blogs, webinars, and any other source of knowledge shared by these companies directly. The purpose is to learn what existing companies are offering and what they are not offering. In addition, it is also good to learn how they are offering the existing solutions and to whom they are offering. Therefore, having knowledge about market share, annual revenue and customer segments of these companies is a great source of information (Hellofs & Jacobson, 1999).

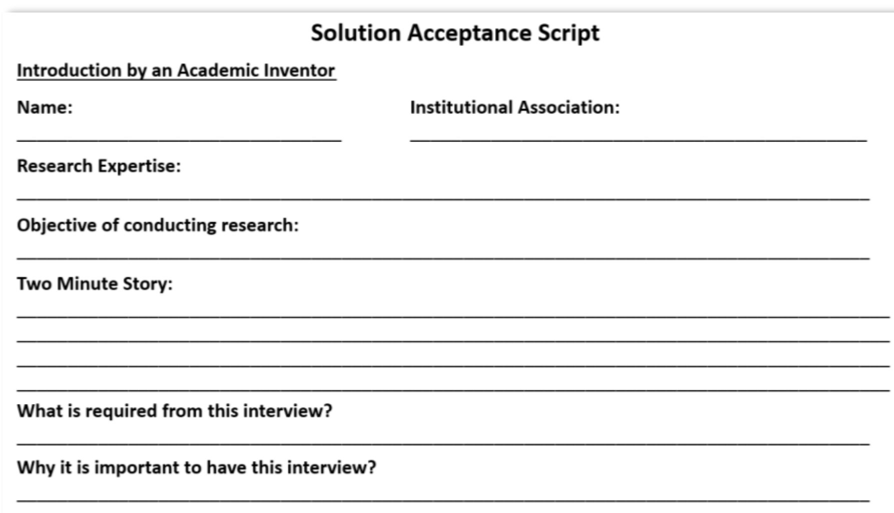
For organizing this information, the academic inventors and entrepreneurs are now offered the **LCI Template – IX: Market Mapping and Competitive Landscape Matrix** in figure 5.1. This template will seek information from other matrices discussed in the previous chapters and synthesize the information for further clarifying the market needs in terms of solving the real-world problem. The market mapping and competitive landscape matrix has important elements including the company name, details of different sources of information to learn about companies, customer segment, market size and annual growth. Added two important elements of learning in this matrix are SWOT (Strength, Weakness, Opportunities, Threats) and PEST (Political, Economic, Social, Technological) analysis (Sammut-Bonnici & Galea, 2014).

Any market is divided amongst many competitors for its share and size (Caves, 1974). The market share guides the academic inventors and entrepreneurs in a selection process for companies with big proportion (in percentage) of the existing market. Different firms publish the market reports and discuss their market share. For example, a report by Fortune Business Insights presents Europe as the second largest market share holder of the autonomous vehicles. In addition, case studies of companies published by research journals e.g., Harvard Business Review also offer discussions on the market shares. Additionally, companies also propose their market size to gain interest of investors in their future products and services. This knowledge helps in identifying the future customers. For example, the same market report on autonomous vehicles also presents the market size in Asia Pacific of 0.72 billion in 2020. For market share, companies also offer their targeted end-users and offer discussions for customers' preference towards their solutions.

In addition to above information, learning about customer segments and their preferences enable the academic inventors and entrepreneurs to align their proposed invention to meet the exact customers' choice. Let us explore an example from the autonomous vehicles industry to learn about the customer segments. According to a report published by Markets and Markets, this industry is segmented at different level of semi-automation e.g., level 1, 2, 3, 4 and 5, where 1 represents the lowest level of automation (Trimble, Bishop, Morgan & Blanco, 2014). One of the simplest ways to learn about the choice and preference of customers, is to follow the online reviews and comments for the existing products and services offered by companies. An interesting website of Amazon.com company named Alexa shares great source of information, collected from the websites traffic of companies offering existing solutions (Purington et al., 2017). From the Alexa website, competitive website analysis and target audience analysis of different companies can also be realized. In addition, the benchmarking graphs may be generated for comparing companies through indicators like Alexa Rank and end-user followers on social media like Facebook, LinkedIn, Twitter, and Instagram etc.

This systematic presentation of information leads academic inventors and entrepreneurs towards understanding of the unique features of different existing solutions (De Brentani, 2001) offered by companies and map these features against success of companies for their annual growth and market share. This learning is for enriching understanding about which companies are offering which features and how these particular features are adding more success in the company profiles. Finally, for SWOT and PEST analysis, market research reports and the published research articles can also be reviewed. For example, Delft University of technology and University of Kentucky published SWOT analysis of the autonomous vehicles and Fogmaker Company published the PEST assessment.

Once the market mapping and the competitive landscape template is done, the academic inventors and entrepreneurs need another set of meetings with the end-users. The end-users in fact use the final products and services offered by companies and pay for these services. The purpose behind this set of meeting is to discuss directly with the end-users to learn about the limitations of the existing solutions and chances of acceptance of future inventions by them. The **LCI Template – X: Solution Acceptance Script**, in figure 5.2 is now proposed to direct the discussion process with the end-users as more valuable and articulated.



Solution Acceptance Script

Introduction by an Academic Inventor

Name: ______________________ **Institutional Association:** ______________________

Research Expertise:
____

Objective of conducting research:
____

Two Minute Story:
____
____
____
____

What is required from this interview?
____

Why it is important to have this interview?
____

<u>Existing Solutions Available in Market</u>

Solution 1:

____

Solution 2:

____

Solution 3:

____

Solution 4:

____

Solutions 5:

____

1. What are three existing solutions end-users are already using? What limitations are observed in existing solutions? Where is improvement desired the most?

____
____
____
____
____
____

<u>NOTE: Once 3 Solutions are discussed by end-user, try to find any match with already identified 5 solutions.</u>

2. Share the already explored 5 solutions with the end-users and discuss their limitations one by one?

____
____
____
____
____
____
____
____
____
____
____

Existing Solution with Limitations (To be asked by End-Users)					
No.	Solutions	Detail of Existing Solutions	Intensity of Limitation		
			High	Moderate	Low
1.	**SEU 1				
2.	**SEU 2				
3.	**SEU 3				
4.	*SAC 1				
5.	*SAC 2				
6.	*SAC 3				
7.	*SAC 4				
8.	*SAC 5				
*SAC = Solution Explored by Academic Inventor; **SEU = Solution Discussed by End-User					

Rank Solutions on Emergency Scale in Eliminating Limitations (1 – Not Necessary to Eliminate Limitation; 10 – Must Eliminate Limitation Now)			
No.	**Solutions**	**Detail of Existing Solutions**	**Rank on Emergency Scale**
1.	**SEU 1		
2.	**SEU 2		
3.	**SEU 3		
4.	*SAC 1		
5.	*SAC 2		
6.	*SAC 3		
7.	*SAC 4		
8.	*SAC 5		
*SAC = Solution Explored Academic Inventor; **SEU = Solution Discussed by End-User			

3. What is the Probability of Paying by the End-User for the New Solution to be Introduced in the Market meeting the Identified Limitations of the Existing Solutions?

____
____
____
____
____
____
____
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____

4. Whether the End-User will Directly Pay for the New Solution, or it will be paid indirectly through other mode?

____
____
____
____
____
____
____
____

Figure 5.2. LCI Template X: Solution Acceptance Script

The **LCI Template – X: Solution Acceptance Script** shown in figure 5.2 enables academic inventors and entrepreneurs to coordinate the entire discussion process with end-users and examine this information collected for solving the real-world problem. This script follows the same technique as it was adopted by the academic inventors and entrepreneurs at the time of problem identification. The ultimate goal here is to interact with the end-users and gain three advantages:

- First, it is an added source of information, through which limitations of the existing solutions can be easily gathered.
- Second, it allows to quantify the level of acceptance, as it makes possible to consider limitations observed by the end-users as highly demanded but presently missing.
- Third, it allows to enquire the possibilities of acceptance of the proposed invention by the potential end-users in future.

The overall purpose is to reach a societal need which is still missing its solution and therefore requires advance invention to cater it.

The **LCI Template – X: Solution Acceptance Script** begins with the introduction of the academic inventors and entrepreneurs. A very short introduction is recommended to kick off the meeting in an organized way. The point of introduction include name, institutional association, research expertise and very clear objective behind conducting the meeting. It is then followed by a short story of two-minute where actions so far taken towards proposed invention can be demonstrated. Soon after an introduction session the academic inventors, begins with the exploration of limitations in the existing solutions utilized by the end-users.

The questions like, "**What are three existing solutions end-users are already using? What limitations are observed in the existing solutions? Where is improvement desired the most?"** will help enriching the list of existing solutions with limitations which is generated after practicing all the previous LCI templates. Once the three solutions with limitations are uncovered by the end-users, the academic inventors and entrepreneurs are then advised to initiate discussion over already identified five solutions with limitations extracted from **LCI Templates – VII: Market Matrix** and **LCI Template – IX: Market Mapping and Competitive Landscape**. The list of eight solutions can then be finalized at the end of above stated questions.

Once eight solutions with limitations are itemized, the evaluation phases of these solutions can be taken place on two scales. The first scale drives the discussion towards measuring the intensity of limitations in the existing solutions at **High, Moderate** and **Low** levels. For each of the eight solutions the academic inventors and entrepreneurs can ask end-users for classification on three levels. This step will help in highlighting those solutions where high limitations are being observed and therefore can be considered as important to conduct research upon. The second scale then drives the discussion towards evaluating the rank with respect to the emergency level for eliminating the explored limitations. Each of the solutions can be evaluated on a scale from **1 to 10**; where 1 represents "not necessary to eliminate limitation" and 10 represents "must eliminate limitation now". Both scales will enable the academic inventors and entrepreneurs to make an evidence-based decision for choosing the highly desirable limitation to be eliminated from the existing solutions to solve the real-world problem.

Depending upon the depth of knowledge required and the availability of the end-users, a number of meetings can be conducted. The **LCI Template – II: Stakeholder Mapping** developed earlier can be re-used here for the identification of direct and indirect end-users. The direct end-users are defined as those who make direct purchase of products and services from the companies who are offering inventions. For example, companies directly offer products and services to end-users through physical stores or through online delivery and generate value in return. The indirect end-users are defined as those who make purchase of products and services from other entities between end-users and companies inventing products and services. For example, end-users make a purchase through retail or wholesaler or any other intermediate entity like internet service providers who are earning from the customized targeted advertisement of multiple companies. The information regarding probability of payment by end-users for proposed invention and about the direct or indirect mode of payment is also required by the TTO professionals at the time of invention disclosure (Xu, Parry, & Song, 2010). So, it is good to discuss these parameters with the end-users during the meetings with the help of **LCI Template – X: Solution Acceptance Script.**

Picture 5.1. Discussion with Entrepreneurs at 1 Million Cups

Process of the LCI Component – IV: Market Landscape

CONCLUSION

The collective information, after conducting all the activities so far, is expected to refine the concepts of academic inventors and entrepreneurs about the real-world problem and its proposed invention with intention of commercialization in future. The two hands-on activities proposed in this chapter offer overall market landscape and cater most of the questions desired to be explored at the time of invention disclosure. The information about existing solutions with limitations and with inventions having prospects of innovation is represented through the **LCI Component – IV,** combined with the **LCI Checklist – IV, LCI Template – IX: Market Mapping and Competitive Landscape Matrix** and **LCI Template – X: Solution Acceptance Script** to answer two questions discussed at the beginning of this chapter. In the next chapter the LCI process will be elaborated further through the LCI Component – V designed to learn the novelty features of the proposed inventions. Picture 5.1 presents a discussion held during gathering of entrepreneurs in 1 million cups in Utah.

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Chapter 6

Fifth Component of the LCI: Novelty

ABSTRACT

This chapter discusses the fifth component of the Lean Canvas for Invention and deliberate upon a very important questions, the checklist of three items and a template. This chapter guides the researchers, academic inventors and product developers to explore the novelty feature of technology based on value an end-user may perceive from it.

Novelty, LCI Checklist – V, Three Items, LCI Template – XI, 30 elements of value pyramid.

NOVELTY

The fifth component of the LCI is **Novelty**. This is last component of the LCI that continues its association with the WHY question. Here the purpose is to guide the academic inventors and the entrepreneurs to explore the unique features to be offered to the end-users in future in a shape of the proposed invention. The solutions to be offered for the identified real-world problem must possess a value that stakeholders can perceive from invention and feel confident in paying for it (Mugge & Schoormans, 2012). A basic definition of any invention develops with a word of novelty that proves its significance and utility for the society. In today's world of advance technologies, novelty is one of the many important reasons that contributes towards rapid pace of developments and meeting the social problems. However, in order to make that novelty to be realized by the end-users, it is important that they view it from a value perspective (Aspara & Tikkanen, 2013). Therefore, it seems important for the academic inventors and entrepreneurs to connect the novelty of the proposed invention with a value to be perceived by customers.

During last few chapters, academic investors and entrepreneurs spent their time and effort in search of research gaps and of shortcomings due to missing features in the existing solutions, causing the unmet needs in society. In this chapter a connection will be established between missing features of existing solutions and the features to be offered by the proposed inventions in future. However, in order to make new features understandable to the end-users, it is desired to communicate those features in simple words. Literature proves that customers will only pay for products and services when they will be convinced that there exists a strong relationship between the utility of solutions and meeting their needs (Osterwalder at al., 2015). It is of utmost importance that as invention is intending to solve the real-world problem, their end-users must recognize the same.

One of my interesting observations regarding knowledge asymmetries between the academic investors and the technology managers is about lack of simple words. The academic inventors feel comfortable in using technical jargons and the technology managers try perceiving value in these words for future commercialization of proposed inventions. For example, an academic inventor demonstrating a prototype with introduction as “Di-Nanogistic bi-modulating energy conversion medical oscopy combinator”, will resultantly cause an eyebrow raised by the technology manager with statements like “Fantastic! What is it? Who cares for it?”. However, on the other hand, if an introduction of prototype is in simple words as the “Sliced Bread”, the responding statements can be like “Fantastic! That’s also a great name for a company” by the technology mangers. The connection between an invention and the company name can help in perceiving the value by the technology managers (Rao & Monroe, 1989).

An academic inventor, product developers and entrepreneurs are therefore guided through this chapter to look for proposed features with respect to value to be created for the end-users and also depicting this value in simple words for understanding of multiple stakeholders. The following question is therefore proposed by the fifth component of the LCI to be answered by the academic inventors and entrepreneurs:

- **Why key features** of the proposed invention are better than **features of the existing solutions?**

The above question inspires the academic inventors and entrepreneurs to assimilate knowledge about features of existing solutions and their limitations, derived from previous chapters, and associate the proposed features with value to be perceived by the end-users. In addition, presenting this value in simple words for understanding is of utmost importance. To accelerate this process, this chapter proposes the **LCI Checklist – V**. The expected outcome of this process includes the significance and value of the research for the acceptance of invention by end-users in the market. The **LCI Checklist – V** attains support from **LCI Templates – XI: 30 Elements of Value Pyramid**, designed for hands-on activity to answer the question mentioned by the fifth component of the LCI. The table 6.1 shows three items in the **LCI Checklist – V** below.

Table 6.1. LCI Checklist – V: Novelty

Novelty	LCI Checklist – V		
	i.	Key feature(s) of proposed invention linking to its value proposition with 30 elements of value (e.g., functional, emotional, life changing or social impact).	
	ii.	Mapping between identified problem and novelty feature(s) of proposed invention.	
	iii.	Discussions on whether proposed invention claims for similarities with other inventors' work or offers a critique that led to the novelty feature(s).	

The question illustrated above and three items of the **LCI Checklist – V** need systematized approach to be adopted by the academic inventors and entrepreneurs for associating novelty features to the perceived value (Ulaga & Chacour, 2001). Literature proves a connection between the Maslow's hierarchy of needs (McLeod, 2007) and a value that end-users perceive through inventions. An article published by Harvard Business Review (2016) proposes 30 universal elements of value. According to Bain & Company, these 30 elements (Almquist, Senior & Bloch 2016) represent the building blocks of value which guides companies in delivering to customers what they want in new products and services. These 30 elements are classified in four clusters to address the consumers' **Functional, Emotional, Life Changing** and **Social Impact** needs. These needs are guided by the theory of human motivation, the Maslow hierarchy of needs, offered by Russian American Abraham Maslow (1943) and can create opportunities for academic inventors and entrepreneurs to conceive for inventions which carry high value for the end-users. According to the Bain & Company, these 30 elements, if considered, can guide towards new product development and improvement of the existing ones.

For understanding and using these 30 elements of value for the proposed inventions, this chapter offers the **LCI Template – XI: 30 Elements of Value Pyramid** that academic inventors can freely bring in practice to answer a question illustrated by the **Novelty** component of the LCI. The **LCI template – XI: 30 Elements of Value Pyramid** is designed to read a list of 30 elements and try to connect one or many from these elements to the proposed inventions. This template can guide the academic inventors and entrepreneurs to simplify the technical jargon related to the inventions and present it in words to be easily embraced by the technology managers and the end-users while understanding the proposed inventions. These elements demystify connection between values observed by managers in technology with a gain of an edge for commercialization (Almquist, Cleghorn, & Sherer, 2018).

Let us understand a few of the 30 elements depicted in this template with the help of examples. The examples are developed by different researchers, already attended the LCI training programs. The researchers were from multiple disciplines including civil, electrical, communication, software, textile, industrial, architecture, city and regional planning etc. Each one of them were discussing the real-world problems they were intending to solve through their proposed inventions.

This template is divided in four clusters with the first one termed as the Functional cluster proposing 14 value elements associated to it. The first element is known as “Save Time”. As an example, discussed by one of the researchers in training session proposed development of an online inventory management system to continuously observe what is available in stock and use of artificial intelligence for making quick decisions for next order to save time of the end-users. The second element of this cluster is known as “Simplifies”. As an example, another researcher discussed the issue of security and development of technology for safe recovery of lost physical items, resultantly simplifying the search process for end-users. The third element of this cluster mentions about “Makes Money”. One of the researchers discussed about developing technical services and offering services through digital marketing for making money. The fourth element of this cluster is known as “Reduces Risk”. Here another researcher presents an idea of developing technology with focus on use of robotic arms in reaching difficult places in construction industry and keep human lives safe from risks. All the examples discussed by different researchers were very technical when seen through a lens of invention but each one of these ideas got simplified when association was established with the relevant value element.

Similarly, this template presents the second cluster termed as “Emotional”. Some of the researchers tried to establish association of their proposed inventions with the 10 elements proposed in this cluster. Suppose one of the elements is known as “Reduce Anxiety” and a researcher connects it to the development of technology to firmly organize a daily transportation routine of an industry and resultantly reduce the anxiety and hassle of the end-user. Then this template presents the “Life Changing” as a third cluster along with its 5 elements. One of the elements in this cluster is known as “Provide Hopes” and an example associated to it, discussed by a textile researcher, reflects upon the utility of smart textile and e-textile for monitoring and maintenance of the vital signs of humans. Finally, the “Social Impact” cluster presents 1 element of self-transcendence. An associated example discussed by a researcher reflects upon the integration of artificial and emotional intelligence and its balanced interaction with humans supporting well-being and self-transcendence.

30 Elements of Value		What value your proposed invention offers
Functional	Save time	
	Simplifies	
	Makes money	
	Reduces risk	
	Organizes	
	Integrates	
	Connect	
	Reduces efforts	
	Avoid hassles	
	Reduce cost	
	Quality	
	Variety	
	Sensory appeal	
	Inform	
Emotional	Wellness	
	Therapeutic value	
	Fun and entertainment	
	Attractiveness	
	Provide access	
	Reduce anxiety	
	Reward me	
	Nostalgia	
	Design / aesthetics	
	Badge value	
Life Changing	Motivation	
	Heirloom	
	Affiliation and belonging	
	Provide hopes	
	Self-actualization	
Social Impact	Self-transcendence	

Figure 6.1. LCI template – XI: 30 Elements of Value Pyramid

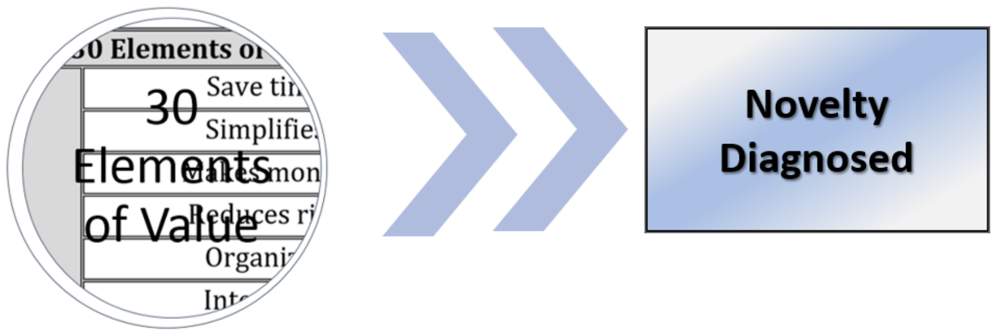

Figure 6.2. Process of the LCI Component – V: Novelty

CONCLUSION

Once the value is established with the proposed invention, it highlights the novelty feature of that invention. The novelty is aligned with all the previous hands-on activities carried out by the academic inventors and entrepreneurs in search of real-world problem for which inventing the solution is very important. All the components of the LCI which are answering the WHY question of the LCI, are in fact justifying that why it is important to invent the solution of the real-world practical problem identified earlier. The hands-on activity proposed in this chapter identifies the novelty features of the proposed inventions which will be used at the time of applying for intellectual property like patent once solutions will be developed. The information about value the end-users may perceive is represented through the **LCI Component – V**, combined with the **LCI Checklist – V**, and the **LCI Template – XI: 30 Elements of Value Pyramid** to answer one question discussed at the beginning of this chapter. In the next chapter the LCI process will be elaborated further through the LCI Component – VI: Research Question designed to learn about the Most Valuable Research question (MVRq) desired for the proposed inventions.

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Chapter 7

Sixth Component of the LCI: Research Question

ABSTRACT

This chapter discusses the sixth component of the Lean Canvas for Invention and explore in detail the two questions, the checklist and templates. This chapter guides the researchers, academic inventors and entrepreneurs to develop an exact statement which reflects the real-world problem technically for understanding of research team.

Research Question, LCI Checklist – VI, six Items, LCI Template – XII, Synthesis Matrix, LCI Template – XIII, MVRq Elements.

RESEARCH QUESTION

The sixth component of the LCI is the **Research Question**. Previously, four components, their checklists and hands-on activities were related to the **WHY question** of the LCI. This particular component is reverting back to the **WHAT question** before a journey of HOW questions begin. Here, purpose is to direct the academic inventors and entrepreneurs towards utilizing the entire information gathered through previous components of the LCI and develop a Most Valuable Research Question (MVRq).

The MVRq can only be developed after synthesizing information from academically published research literature, patent literature, market environment, and from interviews with multiple stakeholders. It is a single statement that clarifies about the most interesting questions that will lead to a viable solution of the identified real-world problem. It is highly recommended to be assured about the visibility and acceptance of inventions to their stakeholders. It can become possible if invention is defined through a uniquely designed statement (Doody & Bailey, 2016). This component helps academic inventors to design such statements related to the real-world problem in an academically written format and also helps entrepreneurs to approach such statements with the practical insight and implications. Therefore, it seems important for the academic inventors and entrepreneurs to develop the MVRq with the academic touch and practical approach at the same time.

The journey of finding the real-world problem and strengthening it with the underpinning of academic and market related evidence is already accomplished by the academic inventors and entrepreneurs in the previous chapters. In this chapter a concrete single statement will be developed to present the entire background story of the proposed invention to the stakeholders. However, in order to make it sure that a single statement is accepted by stakeholders particularly those who are responsible for publishing research articles and granting patents, it is desired to have certain elements embedded in the single statement. The elements to be included are originality, relevance, and rigour (Biggs & Büchler, 2007). The following two questions are proposed by the LCI to be answered by the academic inventors and entrepreneurs for its sixth component:

1. **What** is a single sentence statement presenting a research question?
2. **What** are the research objectives and tentative hypotheses?

Table 7.1. LCI Checklist – VI: Research Question

Research Question	**LCI Checklist – VI**		
	i.	Single statement most valuable research question (MVRq) describing the real-world problem to be solved.	
	ii.	Alignment of research question with research gap, found through literature search and observed through stakeholders' interactions.	
	iii.	Convergence from limitations identified in existing solutions.	
	iv.	Demonstration of originality and relevancy with different theories/ models.	
	v.	Supportive objectives and tentative hypotheses.	
	vi.	Consistency between research problem, research question, research objectives, hypotheses and research approach.	

These two questions encourage the academic inventors for synthesizing the explored information from previous five components of the LCI and convert it into a single sentence statement with supportive objectives and hypotheses (Farrugia et al., 2010) to portray a clear picture of the MVRq to stakeholders. To facilitate this process, this chapter proposes the **LCI Checklist – VI**.

Similarly, as each checklist assists each component of the LCI, the **LCI Checklist – VI** will enable researchers and academic inventors in devising the MVRq. The expected outcome is the conversion of already explored research gap to a properly stated research question and research objectives. It is expected that sixth component of the LCI will present an original and most valuable research question by answering above two mentioned questions, exploring items of the **LCI Checklist – VI** and seeking assistance from **LCI Templates XII, and LCI Template XIII** designed for hands-on activities. The **six items** in the **LCI Checklist – VI** are shown in table 7.1.

The two questions and six items of the LCI Checklist – VI need a systematic approach to be taken by the academic inventors to reach to the appropriate MVRq. As far as, the accumulation of knowledge is concerned, the previous components of the LCI have already taken care of it. Here, importance is of an information which may be synthesized to derive an original problem statement to lead towards the Most Valuable Research question. The academic inventors are now proposed to adopt the **LCI Template – XII: Synthesis Matrix** in figure 7.1 to reach to MVRq. This template initiates with similar keywords chosen at the beginning of the literature search. The keywords reflect about the “Problem”, “Problem Solution” and “Context of application”.

The **LCI Template – XII: Synthesis Matrix** then guides the academic inventors to summarize all the research gaps identified through article matrix and converge it to a single research gap statement, an academic inventor is interested to address. Similarly, the academic inventors are advised to originate the new claim which they found missing in the patent matrix, and the limitations mentioned in the market matrix. The proposed new claim is expected to be based on the novelty features which academic inventors have already explored in the **LCI Template – XI: 30 Elements of Value Pyramid**.

The synthesis matrix also facilitates the academic investors and entrepreneurs to add explicitly the value, the proposed invention is intending to offer to the end-users, as a novel contribution. Finally, the academic inventors are advised to derive a problem statement, blending the synthesized statements of this matrix. The idea here is to have a problem statement, reflecting upon every synthesized statements above and the themes derived earlier through the affinity diagram of the LCI Template – VIII. This entire process can be seen in the LCI Template – XII clearly. It is imperative to mention here that every proposed invention may not need to have synthesis from all previous matrices, discussed so far. If an academic inventor and entrepreneur feel avoiding any of the template, with an understanding that it may not be required for deriving the problem statement, it can be eluded.

Once a problem statement is derived, it may be rephrased multiple times with an intention of bringing as much clarity as possible. The problem statement reflects the problem for which it is required to invent a solution. However, in order to present it as MVRq, rephrasing is highly desired. Let us understand it with an example related to the problem statement mentioning about the contamination of the drinking water due to the industrial waste. The MVRq for this problem statement can be rephrased as: “How to treat the contamination of the drinking water caused by the industrial waste?" The synthesis matrix developed for this problem statement, may propose a variety of solutions (already existing) in a form of technologies or processes to treat a water from contaminations. The existing solutions can be compared and synthesized based on quality parameter (one of the value elements) these technologies offer for the treatment of contaminated water. The multiple claims from different patents can be compared to know about the level of quality and for proposing a solution which are presently missing in the synthesis matrix.

In order to solve any problem, the academic inventors and entrepreneurs may consider one of the two approaches: Proactive or Reactive. The above question adopts the reactive approach by proposing inventions through which contaminated water can be treated with highest quality than the existing solutions. However, if the academic inventors try to approach this problem with a proactive perspective, the MVRq can be rewritten as: "Why is contamination of the drinking water becoming more prevalent and how it can be assured that source of contamination may be eradicated?" This MVRq will be approached differently in comparison to the previous one. However, both approaches will lead towards inventing the solution of the real-world problem.

Once the problem statement and MVRq are derived, it is highly recommended that MVRq must be judged for the presence of some elements. Hulley (2007) proposes some characteristics of a good research question and termed it as the FINER criteria. The FINER criteria propose different elements including the feasibility and relevancy of a research question. The feasibility is judged in terms of competencies and capacities the academic inventors and entrepreneurs must have for solving the real-world problem. In addition, it also judges some measures like availability of time, money and other resources required to invent the solution. The second element of the FINER criteria judges the interest of academic inventors and of other stakeholders in the research question and in the expected solution.

Additionally, two more elements measure the novelty and ethical consideration in the research question. The novelty feature is given a due importance already in the fifth component of the LCI. Here, purpose is to evaluate it on a certain scale. The ethical consideration is always required to make it sure that inventions, the academic inventors are intending for, will not cause any harm to integrity and humanity, rather will bring quality and ease to the society. Finally, the most important element of the FINER criteria judges the relevancy of the identified problem and its proposed solution with the scientific knowledge and with the future research directions.

Synthesis Matrix

Keywords: ____________________

No.	Outcome	Synthesized Statements
1.	Article Matrix – Research Gap	
2.	Patent Matrix – Claim	
3.	Market Matrix – Limitations	
4.	Novelty Feature	

Problem Statement Derived
____
____
____

Figure 7.1. LCI Template – XII: Synthesis Matrix

Elements		Score 1 = Strongly Disagree, 2 = Disagree, 3 = Do not Know, 4 = Agree, 5 = Strongly Agree				
Feasible	Does Academic Inventor possesses enough capability to investigate the MVRq?	1	2	3	4	5
Interesting	Does Academic inventor and other stakeholders possess significant interest in MVRq?	1	2	3	4	5
Novel	Does MVRq lead towards new insights?	1	2	3	4	5
Ethical	Is MVRq suitable for ethical committees and review boards?	1	2	3	4	5
Relevant	Is MVRq relevant to the scientific community and of public interest?	1	2	3	4	5

Figure 7.2. LCI Template – XIII: MVRq Elements

This chapter now proposes the **LCI Template – XIII: MVRq Elements** in figure 7.2 to guide the researchers and academic inventors to judge all these five elements on a Likert scale from 1 to 5, where 1 measures the extreme level of disagreement and 5 measures the extreme level of agreement for the MVRq in meeting the FINER criteria. This judgement will enlighten the academic inventors in making some improvements, if required in the proposed research question.

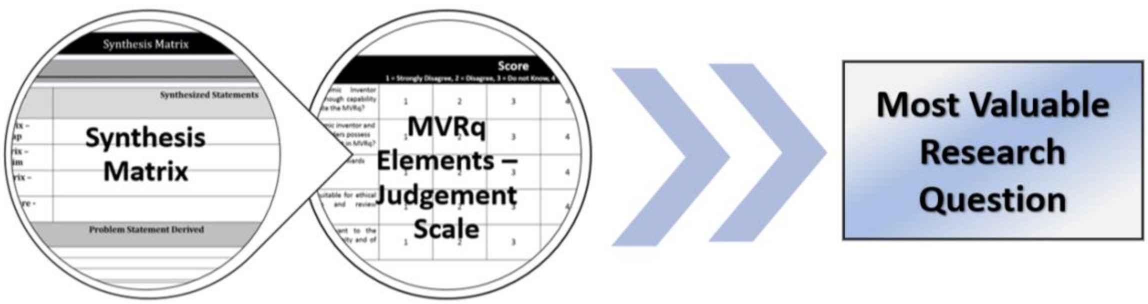
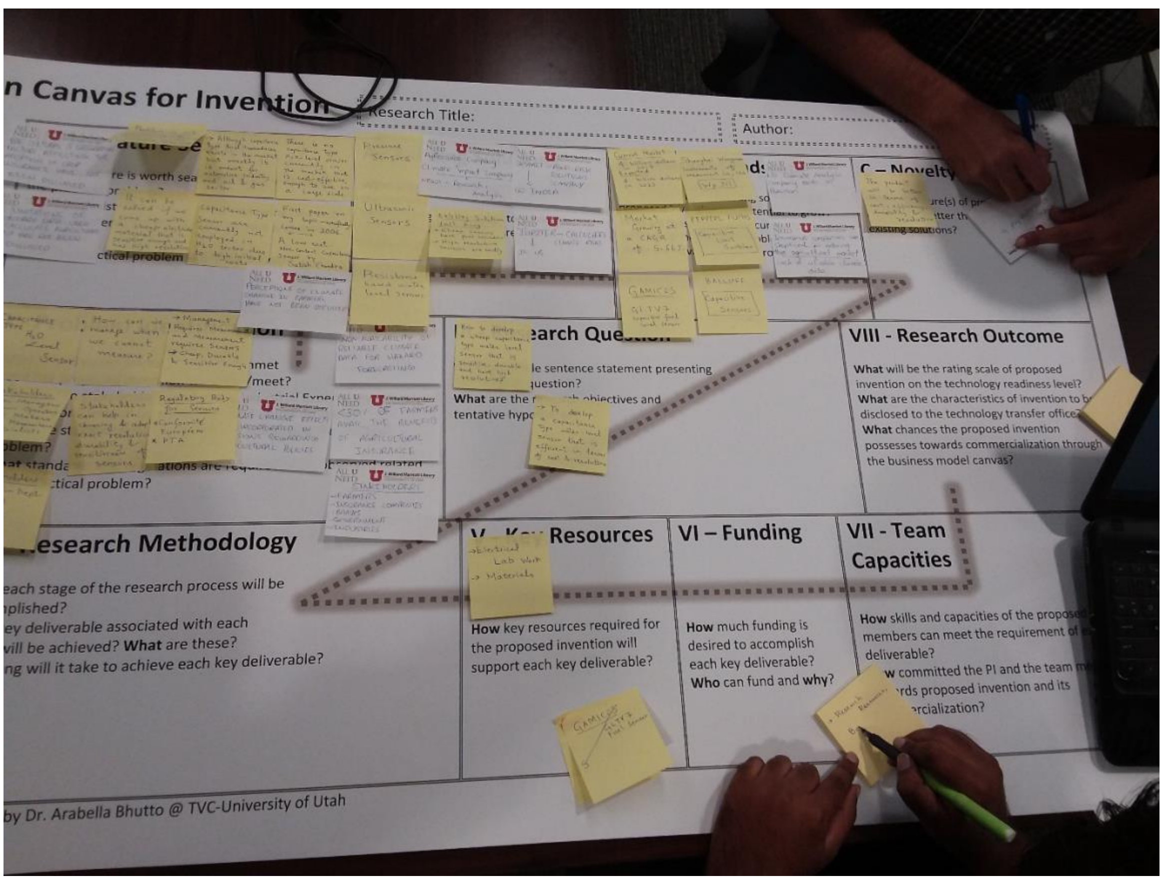


Figure 7.3. Process of the LCI Component – VI: Research Question



Picture 7.1. Developing LCI for Proposed Invention

Once the problem statement and MVRq are developed after synthesizing all the knowledge accumulated in the previous components of the LCI, it further clarifies the WHAT picture of the proposed invention. The MVRq relies on information gathered through all previous hands-on activities carried out by the academic inventors and entrepreneurs. After the first WHAT question of the LCI, which was in search of real-world problem, this second **WHAT question** of the LCI clearly derived a most valuable research question related to the real-world problem. The two hands-on activities proposed in this chapter synthesized the entire information and judged the MVRq through the FINER criteria.

CONCLUSION

Overall, this chapter presents the **LCI Component – VI**, supported by the **LCI Checklist – VI,** and the **LCI Template – XII: Synthesis Matrix** and **LCI Template – XIII: MVRq Elements** to derive the Most Valuable Research question (MVRq). The process for adopting these templates is clearly given in figure 7.3. In addition, the Picture 7.1 shows glimpse of activities carried out with LCI during the researchers' training.

In the next chapter the LCI process will be elaborated further through the LCI Component – VII to learn different Research Methodology techniques in order to develop solutions of the problems identified and synthesized so far.

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Chapter 8

Seventh Component of the LCI: Research Methodology

ABSTRACT

This chapter discusses the seventh component of the Lean Canvas for Invention and explore in detail the three questions, the checklist and templates. This chapter guides the researchers, academic inventors to devise a research methodology through which a plan for invention to innovation can be executed.

Research Methodology, LCI Checklist – VII, six Items, LCI Template – XIV, Research Process Flow, LCI Template – XV, Invention Plan.

RESEARCH METHODOLOGY

The seventh component of the LCI is the **Research Methodology**. In the previous components, the questions, checklists and the hand-on activities guided to answer the WHAT and WHY questions of the LCI. However, in this component, the focus is shifted towards the HOW question of the LCI process. After identifying the problem, building evidence around it, exploring novelty feature and developing the most valuable research question, the focus is now towards understanding how the solution will be conceived. It is very important to understand, what methods the academic inventors and entrepreneurs may plan to opt for their future inventions.

It is observed that different types of inventions need different types of methods and therefore different researchers, and academic inventors adopt different methods and techniques. In literature, a research method is known as an investigation technique the academic inventors apply to commence the research (Kothari, 2004). At the same time, it is also evident that multiple investigation techniques are combined to develop a system of methods for solving the real-world problem. Therefore, academic inventors and entrepreneurs systematically associate multiple methods and develop an approach as the research methodology for inventing their solutions (Pandey & Pandey, 2021).

Though methodologies for solving real-world problems vary with respect to the nature of invention, however, a general process may be sketched to guide the academic inventors and entrepreneurs to facilitate the process of invention. Therefore, this component intends to help in designing flowcharts, along with justified timelines (Kunte & Rungruang, 2018) to achieve the key deliverables, to keep the academic inventors and entrepreneurs on track throughout their invention process. To move forward in the journey of inventing solutions for the real-world problem the following three questions are proposed by seventh component of the LCI to be answered by the academic inventors and entrepreneurs:

1. **How** each stage of the research process will be accomplished?
2. **How** the key deliverables associated with each stage of the research process will be achieved? (Listing of all deliverables).
3. **How** long will it take to achieve each key deliverable?

These three questions reassure the academic inventors to view the entire research process through a lens having distinct deliverables. The learning derived in the LCI component six, highlighted about different objectives and hypotheses supporting the MVRq. In fact each of the research objectives is associated with its distinct key deliverable. For example, if a research objective is characterization of Nano material then its key deliverable would be a report presenting an analysis of the Nano particles. If a research objective is the image processing then its key deliverable would be enhanced image after adopting types of signal processing etc.

For different types of inventions, different types of research objectives are framed, similarly for different types of research objectives different types of key deliverables are planned. But for achieving any key deliverable, it is mandatory to define a method and decide upon time and effort to be dedicated to each one of them. To facilitate in this process of defining and deciding about the research methodology, this chapter proposes the **LCI Checklist – VII**. Similarly, as each checklist assists each component of the LCI, the **LCI Checklist – VII** will enable academic inventors in planning for the research methodology. The expected outcome is a detailed flowchart reflecting upon each key deliverable of the entire research process of invention. The said task is expected to be achieved after answering above three questions, exploring items of the **LCI Checklist – VII** and seeking assistance from **LCI Templates XIV** and **LCI Template XV** designed for hands-on activities. The six items in the **LCI Checklist – VII** are given below:

Table 8.1. LCI Checklist – VII: Research Methodology

		LCI Checklist – VII	
Research Methodology	i.	Flowchart showing all stages of the research process e.g. literature review, survey, data collection, comparisons, production, modelling, simulations, experimentation, analysis, testing, designing, drawings, reporting, presenting work in conference, writing paper or patent or disclosing invention to the Technology Transfer Office (TTO) etc.	
	ii.	Separate research methods for accomplishing each stage of the research process.	
	iii.	Expected key deliverable for each stage e.g. experimental results, presentation, research paper, functional prototype, proof of concept, beta software etc.	
	iv.	Barriers or pitfalls (if any) in order to accomplish each stage and ways of handling these barriers.	
	v.	Timeline for each stage to be accomplished and collective time of completing the proposed invention.	
	vi.	Tentative details of travel outside lab (if desired).	

Above three questions and six items given in the **LCI Checklist – VII** in table 8.1 have to follow a logical approach to be taken by the academic inventors to devise an appropriate methodology (Langley et al., 2013). The MVRq is already proposed in the previous component and here the focus is shifted to align each objective with the applicable procedure to achieve the desired results. The said task can be accomplished with the assistance to be achieved from the LCI Template – XIV: Research Process Flow given in figure 8.1. The research process initiates with scripting a research problem identified already and summarizing what, why and how related to that problem. It then allows to summarize the findings of literature search and extracting the research gap out of it. Then it summarizes all the methods associated with each objective, making it sure that research ethics is under consideration and cost parameters are also considered in an account. Then the process flow mentions about the data collection techniques and synthesizing some preliminary information to understand the importance and authentication of available evidence. Then it will allow to reflect upon what an invention will accomplish and still what limitations will remain behind. Finally, the expected contributions from the invention and their importance will be depicted. Through this template the entire research process will be presented in the form of a flow chart to clearly illustrate the entire invention journey on a single sheet keeping in mind all the steps required to be taken during this process.

Once the flow chart is depicted then it is proposed to dig down the in-depth research methodology focusing on each objective explicitly (Parker, 2012). This chapter proposes the **LCI Template – XV: Invention Plan** in figure 8.2 to illustrate upon each objective and its key deliverable. This template is designed for a single year however, for every consecutive year this template can be reproduced.

This template guides the academic inventors and entrepreneur to list down every stage of the research process and also propose to whom a particular task may be assigned. It is evident that academic inventors are usually the principal investigators (PI) in the research team (Boardman & Ponomariov, 2014). They decide the execution for each step of the research journey and assign tasks to different team members including the Co-Investigators (Co-I), students, collaborators and industry experts etc. Though details related to these team members will be discussed later in chapter 11, however, their general classification is discussed here.

Usually, inventions in this dynamic era are complex in nature and are observed to be invented after combining several elements together. For example, for an academic inventor who is inventing the robotic arm, it is mandatory to take a few elements from the mechanical system and a few from control systems. Similarly, may be a few elements are related to the artificial intelligence and few are from the signal processing etc.

An academic inventor may not be able to accomplish individually all the tasks related to such complex invention and may therefore need to work with several stakeholders in the research team. Each of the team members will be working on an invention and can therefore be listed in this template besides the key deliverables as PI, Co-I or students etc. For example, the mechanical engineer may be involved in designing and developing the mechanical sensor of the robotic arm and an expert of the artificial intelligence may be working on improving the control of the robotic arms. For both of such elements the key deliverables could be the workable prototype or a simulation to be combined as a complete invention.

It is pertinent to mention that the academic inventors and entrepreneurs must have a clear plan in terms of duration an invention will take for accomplishment. May be achieving exact time duration is difficult but tentative timeline can clarify the accomplishment of the invention process. Inventions need protection and exploration of what kind of intellectual property the academic inventor may have, must also be the part of the invention process. The website of the USPTO mentions about patents, trademarks and copyrights and offers the online services to the academic inventors and entrepreneurs to work closely with their examiners. It is suggested that timeline and the associated key deliverables must be listed in the **LCI Template – XV: Invention Plan** for creating and meeting these deadlines too.

Introduction: Research problem	**What?Why?How?___** **MVRq?___** **Summary:**
Literature Review: Gaps	**Why?How?___** **Literature on topic/method:** **Gap:**
Methodology: Formulate objectives and hypotheses	**How?___** **Research Design and Procedure:** **Ethics Statement/Cost and Funding:**
Preliminary Data: source of data	**What?___** **Evidence of importance:** **Preliminary Findings:**
Statement of Limitation	**Alternatives/Weakness___** **What this invention will do?**
Conclusion	**What?Why?How?___** **Contributions and Importance:**

Flow Diagram

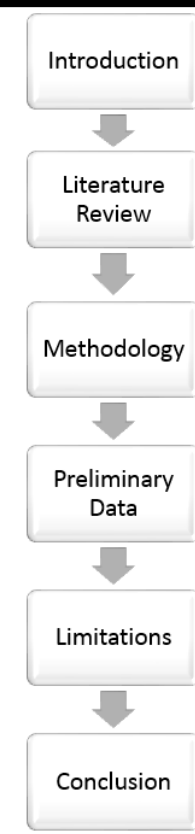

Figure 8.1. LCI Template – XIV: Research Process Flow

Stages of Research Process	Assigned to	Key Deliverables	Year ____											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Note: Different stages of research process may be assigned to different stakeholders including PI, Co-I, students, collaborators, industry experts etc.														

Figure 8.2. LCI Template – XV: Invention Plan

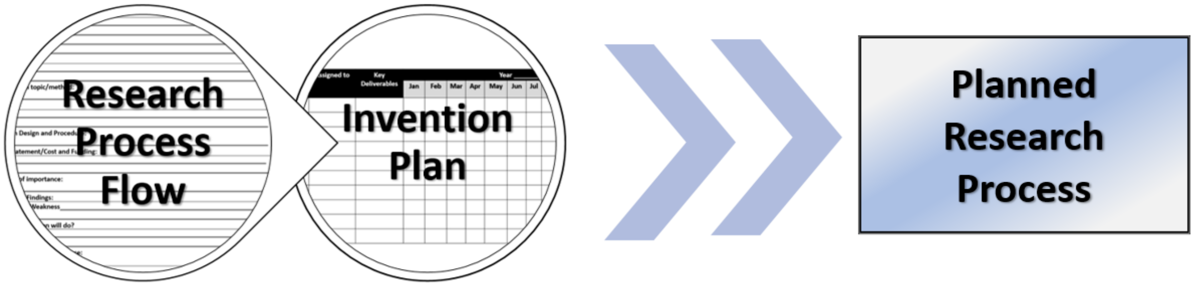

Figure 8.3. Process of the LCI Component – VII: Research Methodology

CONCLUSION

The overall purpose of activities discussed in this chapter is to plan the research process in terms of what stages are required to follow, what key deliverables are required to be achieved and how long the entire process of invention will take place to reach to the solution of the real-world problem. The expected outcome is the detailed and planned research process to be followed by the academic inventors and entrepreneurs. Following the LCI format, two hands-on activities are proposed in this chapter to guide the academic investors and entrepreneurs in the process of inventions.

From this component of the LCI, the focus is shifted towards the HOW question and its respective activities to answer three listed questions at the beginning of this chapter. In summary, this chapter presents the **LCI Component – VII**, supported by the **LCI Checklist – VII**, and the **LCI Template – XIV: Research Process Flow** and **LCI Template – XV: Invention Plan** to derive and progress in the entire process of invention. Figure 8.3 shows the process of this LCI component. In the next chapter, the LCI process will be elaborated further through the LCI Component – VIII to learn about the Key Resources required by the academic inventors and entrepreneurs to accomplish the process of invention.

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Chapter 9

Eighth Component of the LCI: Key Resources

ABSTRACT

This chapter discusses the eighth component of the Lean Canvas for Invention and explores in detail the answer of a question, the checklist and templates. This chapter guides the researchers, academic inventors and entrepreneurs that what key resources are required to meet the requirements of a plan for invention to innovation.

Key Resources, LCI Checklist – VIII, five Items, LCI Template – XVI, Resource Classification, LCI Template – XVII, Resource Positioning, LCI Template – XVIII, Resource Networks and Alliances.

RESEARCH METHODOLOGY

The eighth component of the LCI is termed as the **Key Resources**. From the previous component, the questions, checklists and the hands-on activities have shifted focus towards the HOW question of the LCI process. Once the entire research process related to the invention is depicted in a flow chart, with key deliverables and timelines stated, the LCI process now focus on listing down the key resources required to achieve these key deliverables. It is imperative to list down, what resources the academic inventors and entrepreneurs may require for their future inventions (Bhutto, & Furse, 2020). Varying with respect to types of inventions, various resources may be required by the academic inventors and entrepreneurs. Some of the required resources can be tangible in nature and some of them can be intangible (Kamasak, 2017).

The literature defines tangible as those resources which can be touched physically. For example, an academic inventor may need to build a robot, who can assist in the process of orthopedic surgery, requires tangible resources like robot arm and surgical instruments etc. On the other hand, the intangible resources are those which cannot be physically touched or seen. For example, for the same robot an academic inventor may need to acquire a copyright software of intelligence system with control algorithms and visual images processing to support functionality and accuracy of the robot. In addition, the academic inventor and entrepreneurs may acquire a human capital with intellectual capacities to develop an algorithm and it is also an intangible resource for accomplishing the definite key deliverable. Therefore, an academic inventor and entrepreneurs may need both the tangible and intangible resources at the time of inventing the solution of the real-world problem.

Though kinds of key resources for inventing the solution may vary radically, however, they can be classified as those which may be readily available to the academic inventors and entrepreneurs or may not be readily available to them (Fox, Park, & Lang, 2007). Those resources which are readily available to them, further needs exploration of locations where these can be accessed by the academic inventors and entrepreneurs. Those resources which are not readily available to them, further needs exploration of positions from where these can be accessed or purchased by the academic inventors and entrepreneurs. Therefore, this LCI component intends to help in classifying the information required for all essential key resources along with their possible placements of availability.

Following the LCI format towards inventing solutions, a following question is required to be answered by the academic inventors and entrepreneurs:

1. **How** does each key resource (from the listing of resources), required for the proposed invention, will support in attaining each key deliverable?

The stated question reassures that the academic inventors and entrepreneurs will look for required resources and organize the information with respect to exact key deliverables. This chapter facilitates this process with the help of **LCI Checklist – VIII.** Equally, as each previous checklist assists each component of the LCI, the **LCI Checklist – VIII** will enable academic inventors and entrepreneurs in exploring and accessing the requisite resources for the invention.

The information gathered will then be assisting in the execution of the invention plan continuously. It is expected that eighth component of the LCI will pave a way forward for converting an idea into reality with the support of answering above question, following items of the **LCI Checklist – VIII** and seeking assistance from the **LCI templates XVI, XVII and XVIII** designed for hands-on activities. The five items are stated in the table 9.1 the **LCI Checklist – VIII,** shown below. The above stated question and five items of the **LCI Checklist – VIII** facilitate the academic inventor and entrepreneurs in following a coherent approach in reaching the information of requisite key resources.

Table 9.1. LCI Checklist – VIII: Key Resources

Key Resources	LCI Checklist – VIII		
	i.	List of resources required to meet the key deliverables: - Tangible - Intangible	
	ii.	List of equipment e.g. 3D printers, 3D Scanners, mechanical and electrical labs, laser cutting, water jet cutter, engraving, simulators and software, CAD/CAM, Solidworks, Sprutcam, GWizard, Meshmixer, materials (PVC, Vinyle, Styrene) and material testing devices, chemicals and other supplies for liquid prototyping etc.	
	iii.	Two separate lists of equipment: - Available in academic and innovation labs and accessible - Not available and required to be purchased	
	iv.	Justifications behind advancing research within university premises and/or access to resources outside world.	
	v.	Identification of potential collaborators and researchers at other institutes and industries.	

The key deliverables are developed already, following the techniques from the previous component of the LCI, however, in order to realize these key deliverables, the academic inventors and entrepreneurs need access to certain key resources. These may be classified as tangible, intangible, available and not available. The classification can be illustrated following the guidance of the **LCI Template – XVI: Resource Classification,** shown in figure 9.1. This template can arrange the proposed information in a format which is handy and approachable and will be used as reference for the next templates of the LCI. The academic inventors and entrepreneurs can classify the information in four boxes separately to keep track of what will be required to reach to the solution of the real-world problem.

The requisite resources, as mentioned, may not be available to the academic inventors all the time. Therefore, it is important to organize this information in a format that allows a search for the source of availability of the required resources. In addition, some required resources may be expensive to purchase for testing data and information. However, a norm of resource sharing and pooling have been observed with universities and research labs globally. It is observed that universities share a list of available research equipment through their websites and on demand also offer time slots and space to the academic inventors and other stakeholders for laboratory testing (Ferrary, 2010). In literature, this process of resource sharing is recognized for the establishment of academic networks and alliances which may offer multiple benefits including effective utilization of funding, energy efficiency, avoidance of duplicate purchases, and quick access to the cutting edge of technology etc.

The resource sharing is not limited to the tangible resources only but intangible resources such as software and computing services are also offered on demand to the multiple consumers. Therefore, it is advised that academic inventors must explore and keep a record related to the positioning of the resources. The resources may be available in universities, industries, and innovation labs or may be even online (Baba, 1988). In case, when resources are not available at any of the locations, the academic inventors and the entrepreneurs need to make a strategic decision of either purchasing those or renting for a short duration. The **LCI Template – XVII: Resource Positioning** given in figure 9.2 guides the academic inventors and entrepreneurs to track this record and establish a relationship between each of the key deliverable with the respective key resources required. The key deliverables can be borrowed directly from the **LCI Template – XV: Invention Plan.** Against each row of these key deliverables the required resources, with respect to their tangible or intangible positioning, can be illustrated clearly.

Once the respected position of the requisite resources is illustrated, it may demand for establishment of new academic or industrial networks, alliances and collaborations. Different types of collaborations may occur, depending upon the need of inventions and tasks related to the ‘available’ and ‘not-available’ expertise. The **LCI Template – XVIII: Resource Networks and Alliances** shown in figure 9.3 now guides the academic inventors and entrepreneurs to accumulate this information for every required resource.

The information may include the name of focal person, institutional association, contact details and expected outcome for every required resource. The expected outcome can be a onetime contact for testing and data analysis or can become multiple time events of knowledge sharing. Though these networks will be established between individuals or institutions for the sake of invention, can be capitalized for more inventive research projects. The information gathered for one project may lead towards establishment of long-term alliances for future inventions. These networks can strengthen collaborations between researchers, inventors and innovators and reinforce their capacities through multiple opportunities and diversified knowledge collected through diversified sources.

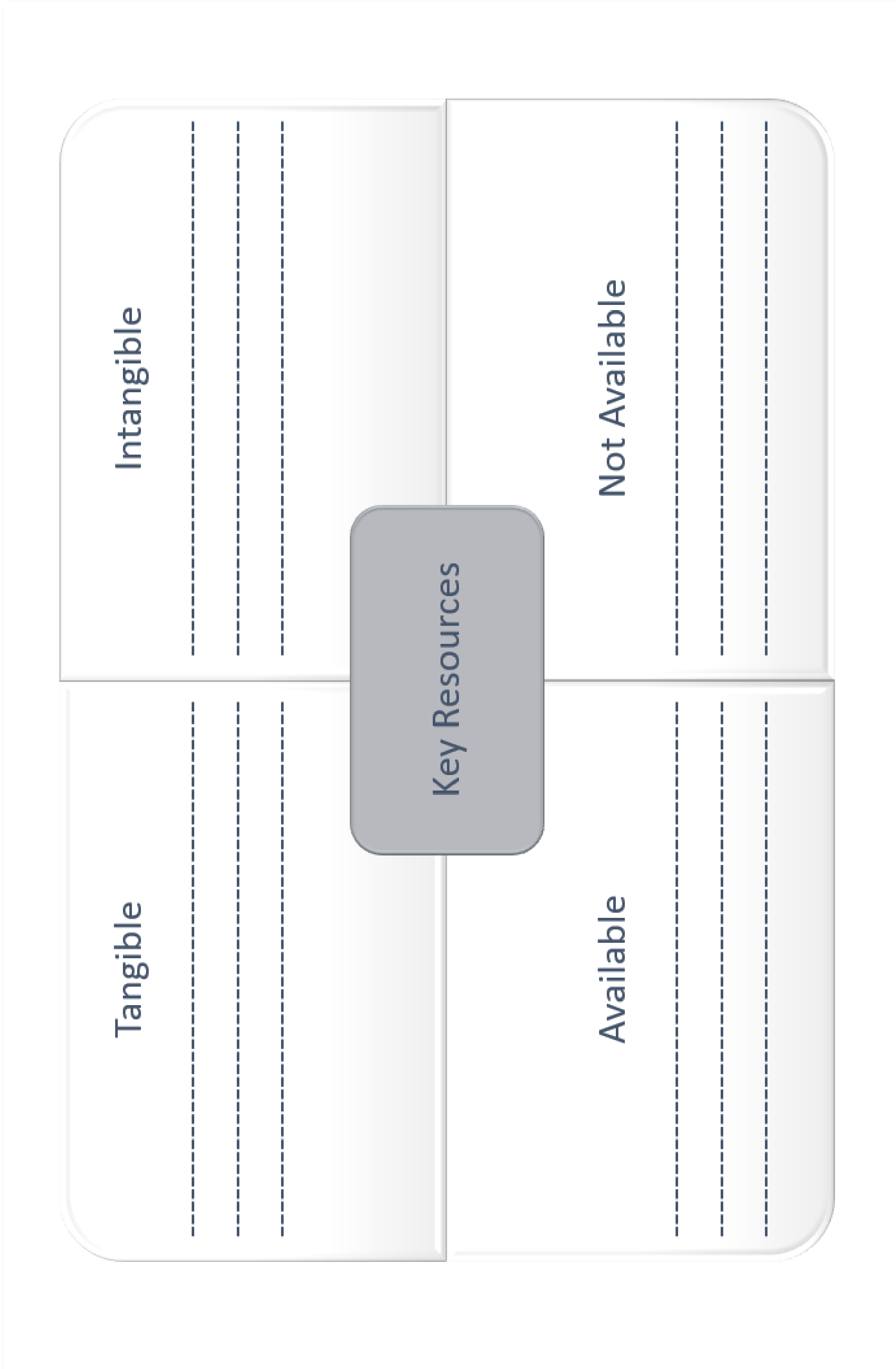

Figure 9.1. LCI template – XVI: Resource Classification

Key Deliverables	Key Resources Required					
	Available at				Not – Available	
	University	Industry	Innovation Lab	Online	Purchase from	Rent from

Figure 9.2. LCI Template – XVII: Resource Positioning

Resources Required	Networks and Alliances			
	Name	Institutional Association	Contact	Expected Outcome

Figure 9.3. LCI Template – XVIII: Resource Networks and Alliances

The objective of this component of the LCI is to equip the academic inventors and entrepreneurs with the information that can support the invention journey through the identification of key resources that will be acquired to accomplish each key deliverable respectively. The classification of resources and learning about their available positions and establishment of future collaborations for accomplishment of these resources for different key deliverables in order to solve the real-world problem, are all discussed in this chapter. Figure 9.4 shows the entire process of this LCI component.

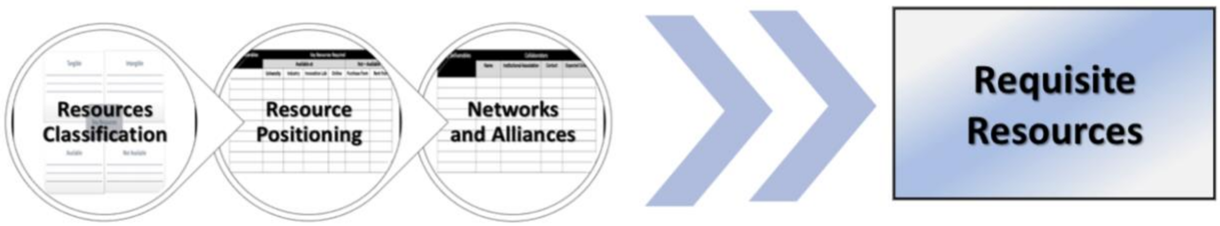

Figure 9.4. Process of the LCI Component – VIII: Key Resources

CONCLUSION

It is expected that once the academic inventors and entrepreneurs will have all this information handy, it will expedite their research process that now answers the HOW question of the LCI. Following the LCI format, three hands-on activities are proposed in this chapter that assist in answering the question of the eighth component of the LCI.

In summary, this chapter presents the **LCI Component – VIII**, supported by the **LCI Checklist – VIII**, and the **LCI Template – XVI: Resource Classification**, **LCI Template – XVII: Resource Positioning** and the **LCI Template – XVIII: Networks and Alliances** to identify and list all the requisite resources supporting the process of invention. In the next chapter the LCI process will be elaborated further through the LCI Component – IX to learn about the required funding and its available sources for the academic inventors and entrepreneurs to proceed further. Picture 9.1 shares some memories of teaching LCI at the University of Utah for the postgraduate students funded by the exchange programs of USAID.

Picture 9.1. Teaching LCI – Postgraduate Students

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Chapter 10

Ninth Component of the LCI: Funding

ABSTRACT

This chapter discusses the ninth component of the Lean Canvas for Invention and explores in detail the answers of a question, the checklist and templates. This chapter guides the researchers, academic inventors and product developer that how much funding is required to complete the entire journey of invention in order to really solve the real-world problem.

Funding, LCI Checklist – IX, five Items, LCI Template – XIX, Invention Budget, LCI Template – XX, Sources of Funding: Invention to Innovation.

FUNDING

The ninth component of the LCI is **Funding**. This component continues its association with the **HOW question** of the LCI. Here the purpose is to guide the academic inventors and entrepreneurs to develop a detailed budget desired to realize the proposed invention in future (Aagaard et al., 2021).

The purpose is to calculate the required funding with respect to distinct resources in order to accomplish each key deliverable discussed in previous chapters. It is learned that along with tangible and intangible resources, desired for accomplishing key deliverables, skills and capacities of the team members are also required to be obtained with respect to each key deliverable. These team members can be students in universities where academic inventors are conducting their research or they may be hired for inventions to be carried by entrepreneurs and product develops. In addition, visiting stakeholders, organizing meetings, conferences and workshops also require extensive planning and support of funding for the academic inventors and entrepreneurs.

The invention process passes through several stages and for each stage the expected outcome or a key deliverable varies. Usually, the process of investigation begins with R&D to first create knowledge and then this knowledge is converted to prototypes for testing the feasibility of the created knowledge. For example, 3M Company, which works on technologies for adhesives and abrasives, first develops any new material or membrane through extensive scientific knowledge. Then these materials and membranes are utilized to develop prototypes and check their feasibility for applications like protecting electronic displays, traffic signage and display graphics etc. Then engineering departments of these giant companies convert prototypes to finished products, packed and ready for the market (Ashley, 1995).

The academic inventors who are intending for inventions with more chances of commercialization need to look for distinct funding institutions, supporting distinct stages of the invention. For each of these stages, there exists separate funding possibilities that may begin with ideation, discovery, validation, customer creation and finally to company building (Tung & Chou, 2019).

This funding component of the LCI directs the academic inventors to plan for each resource required at different stages of invention and then associate the desired amount for each resource to realize a solution for the real-world problem. The following question is proposed by this component of the LCI to be answered by the academic inventors and entrepreneurs:

1. **How** much funding is desired to accomplish each key deliverable? (Check who can fund and why?).

The answer to the above question enables the academic inventors to explore multiple options available for funding and look for valid justification for demanding different institutions for the desired funding. For example, at the earlier stage of ideation usually government institutions offer funding to develop the required scientific knowledge. For future stages of discovery and validation, along with grants from government institutions, some interested industries may also offer finding.

The methods of crowd funding, engaging friends and family and seeking assistance from incubators and accelerators are also in practice for raising funds (Muscio, Quaglione, & Vallanti, 2013). Once academic inventors and their team members successfully cross these stages, then appears larger chance of engaging angel investors and venture capitalists in the process of creating customers and building companies respectively. As LCI asks academic inventors and entrepreneurs to invent a solution with more potential of commercialization, it is suggested that they must keep different stages of invention in their research process and for each stage of invention they must devise the key deliverables. For facilitation in organizing the discussed information this chapter is now proposing the **LCI Checklist – IX** given in table 10.1. It is suggested to follow five items of the **LCI Checklist – IX** and seek guidance from the **LCI Templates XIX and XX** to calculate the desired funding for the invention. The five items in the **LCI Checklist – IX** are given below.

Table 10.1. LCI Checklist – IX: Funding

	LCI Checklist – IX		
Funding	i.	Total grant desired for the research process supporting invention.	
	ii.	Budget desired for tangible resources and equipment required for different key deliverables.	
	iii.	Budget desired for intangible resources including skills and capacities of team members.	
	iv.	Budget desired for visits and organizing meetings with stakeholders for discovering end user needs and industrial interest.	
	v.	Funding desired w.r.t Technology Readiness Level (TRL) e.g., basic principles, technology concept, proof of concept, validation in laboratory, model demonstration, functional prototype, test qualified demonstration and/or evaluation of commercial potential.	
Types of Funding for Basic & Applied Research and Innovation is on websites of: Grant making Agency, Funding Institutions, and Foundation Directory online and Catalog of Federal Domestic Assistance (CFDA) programs e.g. National Institute of Standard and Technology (NIST), National Science Foundation (NSF), FedTrax: BizDev, Small Business Innovation Research / Small Business Technology Transfer (SBIR/STTR) etc.			

The previous chapter which guided in establishing association of resources with key deliverables, also discussed about availability and non-availability of the resources. It is obvious that if resources are not available then these may be purchased or hired. In both situations, academic inventors and entrepreneurs must explore this resource through websites. For example, for an invention where image analysis is required, the academic inventors must propose a cost of $2000 to $4000 for stereomicroscopes in total budget. For example, if academic inventors are intending to file a patent, then an amount of $1500 to $3000 may be proposed to cover the cost of attorney for services including drafting, filing, searching etc.

Along with above cost of tangible and non-tangible resources, if academic inventors and entrepreneurs need added skills and capacities, then they must decide whether undergraduate and graduate students are sufficient to contribute towards their inventions or expertise of postdoctoral associates are desired to be hired. In addition, some technical professionals may also be hired as team members, depending upon who can perform desired tasks to achieve the key deliverables.

The federal grant institutions e.g., National Science Foundation (NSF) and Small Business Administration (SBA) offer budget templates which may be considered for ready reference (Bozeman & Boardman, 2004). However, the **LCI Template – XIX: Invention Budget** allows the academic inventors and entrepreneurs to organize this information with respect to tangible resources, non-tangible resources, skills and capacities and visits and meetings in relations to each key deliverable. This template allows to gather the cost related information and reach to the total expected budget for accomplishing the proposed invention. The template id shown in figure 10.1 below.

This information can be repeated for each stage in the journey from invention to innovation initiating from ideation and ending with building company respectively (Björk, Boccardelli, & Magnusson, 2010). For each of these stages, though the sources of funding vary, however, the **LCI Template – XX: Sources of Funding from Invention to Innovation,** shown in table 10.2**,** can guide the academic inventors and entrepreneurs to look for these multiple sources of funding.

Multiple sources of funding are already proposed in the **LCI Checklist IX**; however, these are not only limited to these. The extensive web search with keywords like “Grants for research”, “Grants for research validation with customers”, “Grants for building company” etc. can lead towards more sources of available funding. The overall purpose is to gather funding in order to realize the invention to innovation process. As Kurt Levin said, “no research without action, no action without research” (Marrow, 1967) and therefore in order to convert the research to action the funding is an integral tool. Further, the entire process supporting this LCI component is given in figure 10.3. Picture 10.1 shows an online flip class conducted for the LCI teaching.

Key Deliverables	Funding ($) Desired for				Total ($)
	Tangible Resources	Intangible Resources	Skills and Capacities	Visits and Meetings	
Total Grants Desired ($)					

Figure 10.1. LCI Template – XIX: Invention Budget

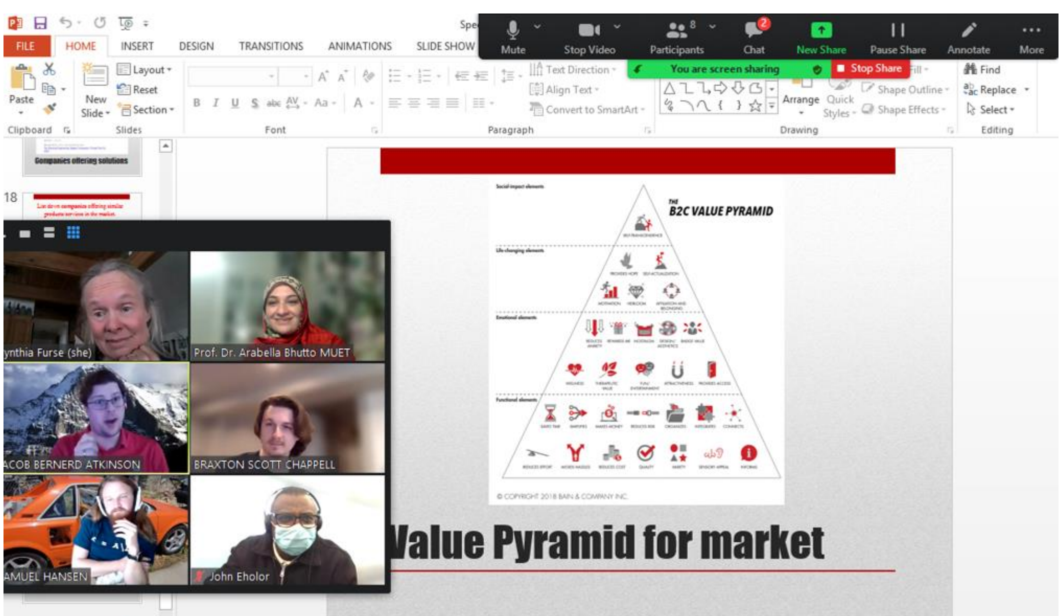
Invention to Innovation (Sources of Funding)				
Ideation Budget ($)	Discovery Budget ($)	Validation Budget ($)	Customer Creation Budget ($)	Company Building Budget ($)
Source Government and Federal Institutions	Source Crowdfunding and Founders	Source Government, Accelerators, Friends and Family	Source Angels and Seed Funds	Source Venture Capital Funds
Grand Total Desired ($)				

Figure 10.2. LCI Template – XX: Sources of Funding – Invention to Innovation

Figure 10.3. Process of the LCI Component – IX: Funding

CONCLUSION

Soon after gathering the above information and organizing in a format of templates the academic inventors and entrepreneurs are expected to process the funding requests and take actions to administer the invention to innovation journey. These steps support the HOW question of the LCI and are following the LCI format by answering **one question** of the ninth component of the LCI, with two hands-on activities. In summary, this chapter presents the **LCI Component – IX**, supported by the **LCI Checklist – IX**, and the **LCI Template – XIX: Invention Budget** and **LCI Template – XX: Sources of Funding – Invention to Innovation,** to quantify how much is required to begin a journey of invention which is intending towards innovation and commercialization. In the next chapter the LCI process will be elaborated further through the LCI Component – X to learn in depth more about the required team capacities and their relevancy with journey of invention to innovation to support the academic inventors and entrepreneurs further.



Picture 10.1. Teaching LCI Online

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Chapter 11

Tenth Component of the LCI: Team Capacities

ABSTRACT

This chapter discusses the tenth component of the Lean Canvas for Invention and explores in detail the answers to a question, the checklist and templates. This chapter guides the researchers, academic inventors and product developer that how an effective may be selected in order to execute the research process discussed in earlier chapter in order to really solve the real-world problem.

Team Capacities, LCI Checklist – X, six Items, LCI Template – XXI, Task Related Team Capacities, LCI Template – XXII, Collaborative Concept Mapping.

TEAM CAPACITIES

The tenth component of the LCI is the **Team Capacities**. As the previous three components are offering answers to the **HOW question** of the LCI, this component continues to answer the same. Once key deliverables are clearly depicted, required key resources have been explored, desired funding has been proposed, and therefore, focus is now towards identifying individuals' capacities within a research team and assigning research tasks accordingly. It is significant to understand that though teams are established to accomplish certain tasks and goals, it is merely impossible without creating trust, harmony and positive bonding between the team members (Holton, 2001). In addition, exploring the individuals' capacities within team and connecting these to specific tasks related to the key deliverables also needs a systematic approach. This chapter therefore emphasis on how the academic inventors and entrepreneurs may explore the capacities of research teams and can assign them distinct tasks to achieve the key deliverables effectively.

It is observed that different types of inventions need different types of capacities and therefore different team members are chosen for different key deliverables. Though team members may vary in their capacities according to the need of inventions for solving real-world problem, however, the methods for constituting research teams and assigning them certain responsibilities may remain similar.

The research team usually encompasses a Principal Investigator (PI), Co-Investigators (Co-Is), and multiple undergraduate and postgraduate students depending upon quantum of research work and invention. Alongside collaboration may also be made with other university and industry experts to enhance the team capacities (Dewar & Isaac, 1998). However, it is important to understand that each of the team members may possesses their own motivation towards invention.

The PI of the research team is mainly responsible for the execution of the entire research process including planning, developing, conducting, managing, monitoring and documenting reports etc. However, continuous support from one or multiple Co-Is and the team members in order to assist the PI in accomplishing the entire research process is also evident for research projects. Though Co-Is are not directly responsible for the invention and its commercialization but having their skills and capacities, in a form of in-depth investigations using multiple tools and techniques, certainly strengthen the accomplishment of the research process. For accomplishing the research objectives, selection of team members (undergraduate and postgraduate students) also depends on their skills and capacities (Hsu et al., 2016).

The PI must explore these skills in Co-Is and in other team members and accordingly assign tasks for accomplishing the key deliverables. Each one of the team members possesses their own incentives and motivation (Clark, 2003) to work in a research project and resultantly offer high quality results. Suppose, PI may have a motivation of developing a company based on invention, Co-Is may have their motivation of enriching their experience and learning and students may be motivated of accomplishing their degrees. Whatever is the reason for joining a research team a collective learning is always an outcome (Fenwick, 2008).

In order to identify the skills and capacities of the team members towards journey of inventing solutions of the real-world problem, the following two questions are proposed by this component of the LCI to be answered by the academic inventors and entrepreneurs and Principal investigators:

1. **How** skills and capacities of the team members can meet the requirement of each key deliverable?
2. **How** committed the PI and team members are towards proposed invention and its commercialization?

These two questions direct the academic inventors and entrepreneurs and Principal Investigators to look for team members having required skills and capacities with respect to distinct key deliverables. In order to create a balanced team, Meredith Belbin has proposed nine roles in a team and classified these roles in three major groups namely: thinking oriented, action oriented and people oriented (Belbin, 2012).

The PI must understand that who in a team may be considered to take responsibilities related to thinking oriented tasks, who may be considered for action-oriented tasks and who may be good with people-oriented tasks. Each of the key deliverables may or may not need all three responsibilities to be accomplished by team members.

Those who possess skills and capacities related to thinking may accomplish goals of creating research knowledge, research planning and evaluation for each key deliverable. For example, writing research proposals, designing key deliverables, developing research calendar, assigning tasks to team members and monitoring their progress etc.

Those who possess skills and capacities related to action may accomplish goals of implementing plans and looking for different approaches if earlier plans do not work effectively. For example, experimenting in labs for tasks accomplishment, collecting data and performing analysis etc.

Those who possess skills and capacities related to people may accomplish goals of research coordination and establishing multiple links. For example, coordinating with stakeholders, visiting them to conduct interviews, attending conferences and workshops etc.

Table 11.1. LCI Checklist – X: Team Capacities

	LCI Checklist – X		
Team Capacities	i.	Configuration of team members e.g. Principal Investigator, Co-Investigator, students, collaborator, Industrial expert, end users etc.	
	ii.	Names and association of each team member with its department, university or industry etc.	
	iii.	Skills and capacities of each team member in order to achieve the key deliverables.	
	iv.	Presence or absence (if any) of skills and capacities of team members in order to achieve the key deliverables.	
	v.	Background of PI in terms of research expertise and experiences in the commercialization process	
	vi.	Motivation of each team member including PI towards proposed invention and commercialization process e.g., owns and operates a company or license technology to other companies etc.	

For different types of inventions, different key deliverables are planned and for different deliverables different skills and capacities are required. To facilitate this process of exploring skills and capacities and assigning tasks accordingly, this chapter proposes the **LCI Checklist – X**. Similarly, as each checklist assists each component of the LCI, the **LCI Checklist – X** will enable researchers, academic inventors and PIs in exploring the team capacities. The expected outcome is the establishment of a team and the coordinated efforts of linking each team member with each key deliverable of the entire research process of invention. The said task is expected to be achieved after answering above two questions, exploring items of the **LCI Checklist – X** and seeking assistance from **LCI templates XXI, and XXII** designed for the hands-on activities. The six items in the **LCI Checklist – X** are given in table 11.1.

The discussion so far highlighted the need to classify each key deliverable to the level of tasks which can be accomplished by different team members possessing different skills and capacities. This classification enables the academic inventors to look for expertise within or outside the team which can exactly meet the requirements of the key deliverables. For example, for an invention related to autonomous vehicle, an academic inventor must look for team members having expertise in C++, python, image processing along with other capacities related to robotics, electrical engineering, machine learning and Artificial Intelligence etc. If all these expertise are not available within the team, then for a short duration, expertise of technical professional may be hired to accomplish the tasks.

The **LCI Template – XXI: Tasks Related Team Capacities,** given in figure 11.1, allows the academic inventors and the PI to classify this expertise for thinking, action and people-oriented tasks for each key deliverable explicitly. Once this classification is accomplished, names of team members are required to be associated with each task. Though the PI can assign tasks directly to the team members, however, in order to keep the team members motivated, it is imperative to engage them in regular discussions throughout the invention process (Wu et al., 2013). In every meeting, every team member can explore the answer to the question: ***How, as a team member, do I work to meet the key deliverables for Invention?*** George Walker and Taylor (2014) argue that for successful building of the research team capacities, a shared motivation is mandatory, and it can be achieved through collaborative concept mapping (CCM) tool (Van et al., 2002). It is proposed that CCM can assist the PI in a process of invention related exploration, articulation and negotiation with team members.

The **LCI Template – XXII: Collaborative Concept Mapping,** given in figure 11.2, facilitates the process of organizing effective meetings with team members and exploring the possibilities of assigning and accomplishing the tasks. Meetings can be very effective if these are supported by a systematically developed structure. The structure proposed in the **LCI Template – XXII: Collaborative Concept Mapping** will offer purpose to the conversation and also help in reaching the objective of establishing team with identified tasks and their connection with the team expertise.

This template presents and defines four symbols, and their linkages are also established. It is suggested that the academic inventors and entrepreneurs and PIs first discuss with the team members about the expected outcome of the research supporting invention. These outcomes are already explored through various templates and are also classified for thinking, action and people-oriented tasks.

The PI then discusses ***what types of expert capacities will be required for achieving key deliverables, who within team possesses those expert capacities and to whom a particular task may be assigned***. As this process of task assignment is supported with discussions and meeting format, there are chances of improved motivation per se. For tasks related to different key deliverables, there may be a chance that different experts may accomplish these tasks, however, there may also be a chance that a single expert can accomplish multiple tasks related to more than one key deliverable. Depending upon the nature and extent of different tasks related to invention, PI may assign roles and responsibilities to different team members.

Once the team members with their expertise are identified, they may initiate the process of research for making the journey of invention to innovation possible. The academic inventors, entrepreneurs and PIs must remain continuously engaged with the team members through multiple meetings for implementation and monitoring of different steps for research process.

CONCLUSION

This component is the last one to support the HOW question of the LCI, following the LCI format by answering **two questions** of the tenth component, with two hands-on activities. In summary, this chapter presents the **LCI Component – X**, supported by the **LCI Checklist – X**, and the **LCI Template – XXII: Task Related Tam Capacities** and **LCI Template XXII: Collaborative Concept Mapping** to identify team capacities and how these capacities can achieve the key deliverables required for invention and commercialization. In the next chapter the LCI process will be concluded with the last LCI Component – XI to learn in-depth about the research outcome and its relevance to the technology readiness level (TRL) to be disclosed to the technology transfer offices (TTO) and discussing about the possibilities of commercializing inventions by the academic inventors and entrepreneurs.

Key Deliverables	Skills and Capacities Required in Team Members		
	Thinking Oriented Tasks	Action Oriented Tasks	People Oriented Tasks

Figure 11.1. LCI Template – XXI: Task Related Team Capacities

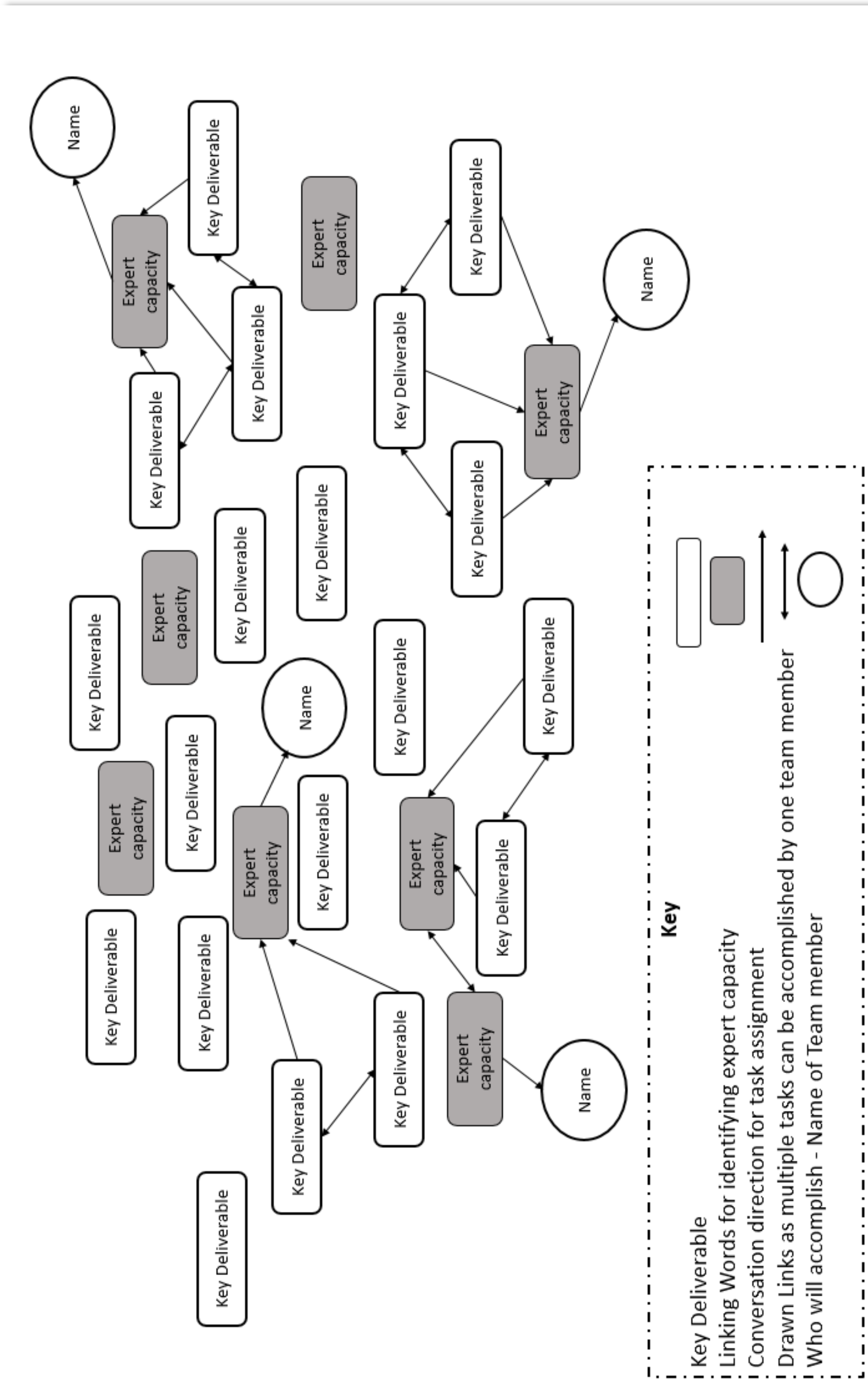

Figure 11.2. LCI Template – XXII: Collaborative Concept Mapping for Team Capacities

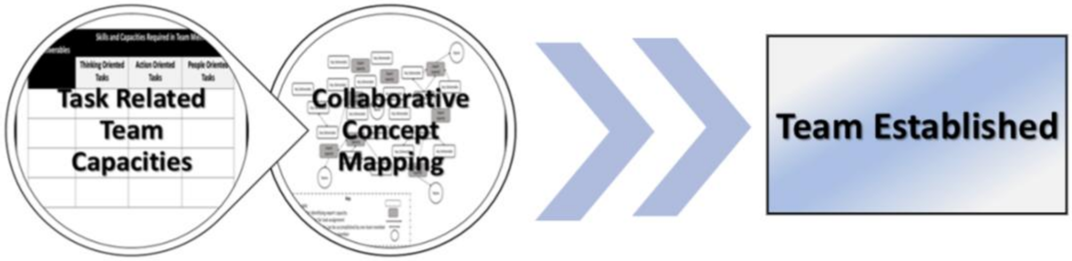

Figure 11.3. Process of the LCI Component –X: Team Capacities

Picture 11.1. LCI Teaching: Training hosted by UNDP.

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Chapter 12

Eleventh Component of the LCI: Research Outcome

ABSTRACT

This chapter discusses the eleventh component of the Lean Canvas for Invention and explores in detail answers to three questions, the checklist and templates. This chapter guides the academic inventors, entrepreneurs and product developers that what will be research outcome and at which technology level it can readily be available to solve the real-world problem.

Research Outcome, LCI Checklist – XI, seven Items, LCI Template – XXIII, Technology Readiness Level and Probability Scale, LCI Template – XXIV, Invention Disclosure, LCI Template – XXV, Two Minutes Pitch.

RESEARCH OUTCOME

The eleventh and the last component of the LCI is termed as the **Research Outcome**. In previous chapters, the four components of the LCI were continuously dealing with statements associated with the **HOW question**. In this component the LCI is again reverting to the **WHAT question**. This component allows the academic inventors, entrepreneurs and product developers to present the significance of the expected invention with respect to the technology readiness level (TRL). In addition, this component also answers how much potential impact, on a probability scale (from 0 to 1), the invention may have for solving the real-world problem. The TRL defines the readiness of an invention for its commercial application (Straub, 2015). If academic inventors and entrepreneurs prepare their inventions to depict its readiness for commercialization, then ultimately it also strengthens the probability of solving the real-world problem.

Once TRL is known to the academic inventors and product developers then a process of invention disclosure to the technology transfer office also simplifies. There is in-depth information that technology managers at the technology transfer offices demand from the academic inventors. Each component of the LCI, so far learned, have guided to gather such required information, prior meeting the technology managers. Once this required information is gathered, a format offered for the invention disclosure in this chapter can be filled out for presentation to the technology transfer offices. At TTOs, the managers then can assist the academic inventors in the process of patent grants, market viability, establishing startup and looking for investors (Wu, Welch, & Huang, 2015). Therefore, this chapter also offers a format for developing a two-minute pitch for the market to assist in the launch of the technology-based company.

Each component of the LCI have empowered the academic inventors and entrepreneurs to plan for research having impact on society and saving their precious time, effort and grants from wasting on inventions that may look fascinating theoretically but lack in terms of applications. In this chapter a TRL of the invention will be depicted to be shared with the stakeholders along with the invention disclosure document (Xu, Parry & Song, 2010) and a way of presenting the two-minute pitch (Daly & Davy, 2016) for the market. As per the LCI format, here the following three questions are proposed by this component of the LCI to be answered by the academic inventors and entrepreneurs:

1. **What** will be the rating scale of the proposed invention on the Technology Readiness level (TRL)?
2. **What** are the characteristics of the invention to be disclosed to the Technology Transfer Office (TTO)?
3. **What** chances the proposed invention possesses towards commercialization through the Business Model Canvas (BMC)?

These three questions persuade academic inventors and entrepreneurs to plan for inventions with high capacity of application. In order to judge the capacity of application of any technology, NASA has proposed nine levels of technology readiness (Héder, 2017). These levels initiate with TRL 1 and move stepwise towards TRL 9. With every step an invention takes towards the higher number of these levels, the chances of successful commercialization of such invention brightens.

Though taking every step towards the higher level of TRL requires more and more dedicated resources, each step pave a way forward for the technology commercialization, resultantly saving time, effort and grants. The academic inventors and entrepreneurs must have clear understanding for every level for supporting the application of their invention. For example, at TRL 1, TRL 2 and TRL 3 the invention is observed at its research phase only where most of the time the laboratory tests are carried on. As an invention moves towards TRL 4, TRL 5, and TRL 6, it enters the phase of development, where proof-of-concept is ready for testing in an environment reflecting simulations to the real-world. Finally, progress towards TRL 7, TRL 8 and TRL 9, the invention gets ready for deployment within systems already exiting in the real-world.

These all steps gradually prepare the invention to be commercially launched in the market. The academic inventors and entrepreneurs can share this entire information on a format specifically designed for the invention disclosures and present their idea in a two-minute pitch with more compact and complete information in a much-simplified language.

To facilitate in this process of presenting the readiness of the invention for solving the real-world problem, this chapter proposes the **LCI Checklist – XI**. Similarly, as each checklist assists each component of the LCI, the **LCI Checklist – XI** will enable academic inventors and entrepreneurs in presenting the invention to the real-world. The expected outcome is a complete proposal for an invention with brighter chances of receiving funding for technology development and its commercialization. The said task is expected to be achieved after answering above **three questions**, exploring items of the **LCI Checklist – XI** and seeking assistance from **LCI Templates XXIII, XXIV and XXV** designed for the hands-on activities. The items in the **LCI Checklist – XI** are given in table 12.1.

Table 12.1 LCI Checklist – XI: Research Outcome

Research Outcome	LCI Checklist – XI		
	i.	Expected outcome e.g., product, process, service, training for process accomplishment or composition of matter etc.	
	ii.	Expected outcome with respect to technology readiness level e.g., concept, basic principle, proof of concept model, simulation, functional prototype, product etc.	
	iii.	Expected outcome e.g., full design or 3D drawing, functional prototype and on-demand production etc.	
	iv.	Expected outcome e.g., publication in conference proceedings and research journals or applying for patent.	
	v.	Expected outcome in any form proving the validity of science behind it and a convincing proof that it is good enough to be implemented.	
	vi.	Invention disclosure to the Technology Transfer Office.	
	vii.	Interest towards founding a company developing a business model canvas in future and describing proposed mechanisms for it.	

The seven items in the checklist mainly demands the academic inventors and entrepreneurs to present the expected outcome in different forms including a written paper or patent and a tangible prototype or 3D drawing etc. These presentations enable the academic inventors to plan and dedicate time, efforts and grants that can meet the levels of expected outcome. For example, an invention related to nanoparticles for diagnosing cancer needs a strong research background to be supported by granted patent for its credibility. Additionally, an invention related for checking the genuineness of an object in the metaverse, needs strong research for developing a beta version of a computer program. The variety in types of inventions require variety in planning for the expected outcome.

The **LCI Template – XXIII: Technology Readiness Level and Probability Scale,** given in figure 12.1**,** allows the academic inventors and entrepreneurs to associate these expected outcomes with research, development and deployment stages of the TRL. Once this association is accomplished, it becomes easier for academic inventors and entrepreneurs to demand grants (Kobos et al., 2018). As much as the TRL increases in number as much as the time, dedication and grants will be required in support.

There seems a direct relationship between TRLs and the probability of successfully solving the real-world problem with the proposed invention. At the earlier levels of TRLs, any invention needs support from scientific laws to add to its credibility. However, demonstration of such an invention in the practical environment can even add more certainty towards its success. The Probability Scale therefore allows the academic inventors to decide whether scientific laws will only be utilized, or practical demonstration will also be carried out for the proposed invention. The probability scale varies between 0 and 1 (Shepherd, Li & Liu, 2016) and as invention moves upwards on this scale, chances of solving the real-world problem with this invention will animate.

Ultimately, academic inventors and entrepreneurs must present their entire story in a much-simplified way to the managers and directors of the technology transfer office to really make their technologies work in the practical environment. This task is accomplished by developing a comprehensive invention disclosure document. Though the requirements of the invention disclosure documents may vary with respect to the technology transfer offices, however, there are few major components which are integral to be a part of every invention disclosure. Every invention disclosure document must answer: ***What real-world problem this invention will solve, what existing solutions are available, what prior art exists, and which market will be interested in invention?***

Grimaldi et al., (2011) argue that writing an appropriate invention disclosure is an issue for the academic inventors, university management and policy makers. It is therefore proposed here to devise certain important questions to ease the academic inventors in the process of writing the invention disclosure. The **LCI Template – XXIV: Invention Disclosure,** given in figure 12.2, proposes these questions. Though the exact utility of this template arises at the time when the invention is already conceded, however, keeping this template as one of the expected outcomes can increase the chances of commercialization.

Along with the invention disclosure document, **LCI Template – XXV: Two Minutes Pitch,** given in figure 12.3, is also provided in this chapter to prepare the academic inventors and entrepreneur for transferring their invention related knowledge to the managers in a much-simplified language. For startup companies a two-minute pitch is usually developed for appropriate investors by discussing details of potential customers and modes of making money, however, here it is proposed as an innovative way for bridging the knowledge asymmetry between the academic inventors and the TTO managers.

Each of the questions that is asked through the invention disclosure document or in the two minutes pitch can easily be answered if the academic inventors and entrepreneurs have followed all the earlier templates from the previous chapters. These two templates summarize the previously gathered knowledge and present it in a storytelling format. At the one hand, the invention disclosure document concludes all the previous steps taken for converting an idea of invention to a reality in the physical world, but at the other hand, the two-minute pitch begins a new journey of taking this invention ahead to the market for solving the real-world problems. Though this new journey now needs some more skills and capacities in addition to those utilized already for converting the idea to real invention, however, the continuous connection of this invention with the knowledge supporting innovative actions can strengthen and ease the process of upcoming journey for the academic inventors and entrepreneurs.

Once the invention is disclosed to the managers and the directors at the technology transfer office then their team members can initiate the process of getting the intellectual property rights, looking for appropriate customers and hunting for interested investors. Osterwalder and Pigneur (2010) present the Business Model Canvas (BMC) which is usually adopted by the team members of the TTOs for developing feasibility of the company supporting invention. In the absence of the LCI, the TTO managers need to acquire more information from the academic inventors for developing the business model for new inventions, however, the presence of the LCI has a potential of automatically answering the questions discussed already in previous chapters. Extracting knowledge from the LCI and appending it to the BMC can ease and expedite the process of commercialization for the TTO managers. As a result, a new company based on technological inventions will be formed to solve the real-world problem. The academic inventors and entrepreneurs then may remain continuously engaged with the team members at TTOs but at the same time it is suggested to initiate the LCI process again in search of new ideas and reaching to new inventions.

Deployment	TRL 9	Actual system product proven through successful mission operation
	TRL 8	Actual system completed and product qualified through test and demonstration
	TRL 7	System prototype demonstration in a practical environment
Development	TRL 6	System/sub-system or prototype demonstration in a relevant environment
	TRL 5	Component and/or broadband validation in relevant environment
	TRL 4	Component and/or breadboard validation in laboratory environment
Research	TRL 3	Analytical and experimental critical function and/or characteristic proof-of-concept
	TRL 2	Technology concept and/or application formulated
	TRL 1	Basic principles observed and reported

Probability Scale (Encircle) Invention can solve the real-world problem	
Certain	1.0
	0.9
Likely	0.8
	0.7
	0.6
Even Chance	0.5
	0.4
Unlikely	0.3
	0.2
	0.1
Impossible	0.0

Figure 12.1. LCI Template – XXIII: Technology Readiness Level and Probability Scale

Invention Disclosure (Cont…)	
Define the real-world problem to be solved with invention.	
Illustrate existing solutions solving this problem with the companies names?	
What limitations are observed in the exiting solutions.	
Illustrate advance features of your invention.	
What advantages your invention may offer over existing solutions?	
Which company may be interested in your invention?	

Invention Disclosure	
Present any IP related to your invention?	
Did you disclose your invention in conferences or in journals?	
Which TRL is suitable for your invention?	
Are you willing to move towards next TRL?	
What resources may be required to move towards next TRL?	
Is funding available for next TRL?	

Figure 12.2. LCI Template – XXIV: Invention Disclosure

Two Minutes Pitch

Company Name and Logo

My proposed company, _______________ (name of company) is offering a ___________ (product/service) for ________________ (customers) to solve a ___________ (problem) with _________ (distinct features).

The company's competitors are in______________ (market), having annual growth of _________ ($) and with future prospectus of _________ (CAGR).

Though the company's direct competitors, ___________ (names of a few competitors) are offering similar solutions but this invention has an added feature offering added ______________ (value) to meet the limitations of the competitors' solutions.

Currently, this product/service is in a form of ______________ (technology readiness level). But it is highly intended to move forward to the next level.

We are looking forward for help in assistance in _____________ (Intellectual Property or investor etc.), so a company may be established.

Figure 12.3. LCI Template – XXV: Two Minutes Pitch

Figure 12.4. Process of the LCI Component –XI: Research Outcome

CONCLUSION

With this last component of the LCI, once again the **WHAT question** of the LCI is answered. This chapter follows the LCI format by answering **three questions** of the eleventh component, with three hands-on activities. In summary, this chapter presents the **LCI Component – XI**, supported by the **LCI Checklist – XI**, and the **LCI Template – XXIII: TRL and Probability Scale, LCI Template – XXIV: Invention Disclosure** and **LCI Template – XXV: Two Minutes Pitch** to present the research outcome, disclose the invention to the TTO managers in a much-simplified language and begin a new journey of commercializing the invention. This process is depicted in the figure 12.4. The next chapter will conclude this book with a story of winning the startup competition for commercializing the Lean Canvas for Invention (LCI) itself with the proposed name of a new company along with its logo.

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Chapter 13
Conclusion

This book presents an academic tool, the Lean Canvas for Invention (LCI) to offer a process of systematic thinking and building attitude for innovation in researchers, academic inventors, entrepreneurs and product developers who are willing to dedicate their time, effort and research grants for technological developments ready to solve the real-world problems through commercialization. This book is an outcome of my postdoc journey spent at the technology transfer office of an entrepreneurial university at USA. The journey begins with observations and collection of 101 questions raised by the technology managers who look for definite answers from academic inventors and entrepreneurs at the time of invention disclosures. These questions are usually not explored by the academic inventors and therefore missing their answers become a major cause of knowledge asymmetries that presently exists between technology developers and technology managers. Resultantly, it leads towards developing technologies and inventions which are causing wastage of time, effort and grants with bleak future of commercialization and getting trapped in the valley of death. This book therefore converts these 101 questions in a systemic training guide helping through the LCI, a canvas on a sheet having 11 components, each guided with questions and supported with 11 checklists and 25 templates for hands-on activities.

This book can be used as a manual for organizing extensive weeklong training sessions to be offered to the seasoned academic inventors and entrepreneurs and can also be used as a part of regular curricula for STEM and Business students. Every chapter has explicitly discussed each component of the LCI and offered templates to progress in a journey of invention to innovation. The introduction chapter has discussed utility of the LCI for trainings already conducted with the postgraduate students and the academic inventors for their technological developments with potential of commercialization. The emphasis is given for establishing teams where researchers, academic inventors and entrepreneurs can play a role of Principal Investigator (PI) and with the support of postgraduate students and other relevant stakeholders begin a journey of invention leading towards innovation. The journey begins with identifying the real-world problem and ends with the development of a product or service as a solution. The end-product can be tangible or non-tangible, depending upon the nature of problems and the developed solutions.

For tangible or intangible products, an analogy can be established here from the journey of a development of LCI itself. Though it is established as an academic tool for guiding the academic inventors and entrepreneurs for development of their products and services, however, the training guide of the LCI itself is a product ready for commercialization. The idea of LCI, after being successfully tested at University of Utah, Mehran University of Engineering and Technology and at other universities has been further tested as a training guide for the faculty development program at National Academy of Higher Education (NAHE), Pakistan. During this training program, each of the faculty members learned the process of LCI for supporting their own research and also teaching it as a resource to their research teams and postgraduate students. In addition, National Science Foundation, US has recognized the importance of this new curricula under its funding program of Innovative Graduate Education (IGE). This funding enables the LCI to be further developed for three years and be converted as a global curriculum supporting invention to innovation processes. The course can be accessed at https://utah.instructure.com/courses/888685/pages/about-the-lean-canvas-for-invention-lci-project

Furthermore, Ministry of Science and Technology (MoST), Pakistan has endorsed the teaching of LCI for STEM graduates in a new National Science, Technology and Innovation policy (2022). This endorsement is already adopted by the Pakistan Engineering Council (PEC) for offering LCI trainings to the faculty members of engineering universities in Pakistan. Resultantly, an award is won as a women engineer from Pakistan Engineering Council for developing this innovative curriculum for all engineering universities.

In addition, the idea of LCI has also won the startup competition organized by the National Idea Bank (NIB). The NIB program is launched under patronage of the President of Pakistan for gathering of many ideas which can change the fate of technological development and contribute towards knowledge economy. The NIB competition has grown in three phases where ideas were first pitched at the city level competition then at the provincial level competition and finally at the national level competition. The LCI won all three competitions amongst more than 2000 ideas and prove its worth of getting commercialized. Resultantly, a new logo is introduced, shown in figure 13.1 and is depicted here as “INVENT-C” for commercializing the trainings and consultancy services based on the Lean Canvas for Invention. Today, a YouTube Channel named “Arabella Bhutto” is available as a resource for the academic inventors and entrepreneurs who are willing to learn more about the systematic process of the LCI learning.

Figure 13.1. LCI Based Company: INVENT-C Logo

I wrote this book with a hope that it will guide you and make you understand and apply each step discussed in all chapters for conducting research and developing technologies with the intention of solving the real-world problems. If by the end you have developed a research proposal having most of the questions of the LCI already answered, then I feel it as my and yours great success. I hope since beginning you remained focused and invested your prestigious time and effort in reaching an idea of invention with high potential of commercialization. Because such inventions are at the one hand, are serving society in solving the real-world problem and at the other hand, making you successful in achieving your goal of being a founder of your own company based on your own invention.

Though establishing a company and then managing its every process need added learning with the help of other canvases including the Business Model Canvas (BMC) of Osterwalder. However, the LCI have already paved a way forward for your invention to get commercialized by realizing and proving its potential to other stakeholders. Therefore, it is proposed to build your concept of invention through the LCI training guide before building it on a Business Model Canvas, as shown in figure 13.2. It is expected that the LCI learning will quadruple the chances of your success.

Although more emphasis of this book is targeting universities and research institutes, however, this systematic approach is also relevant to product development and innovation in industrial research divisions. The target audience are all those involved in near market research and its exploitation. However, it is important to acknowledge that not all research is immediately exploitable. The book is not aimed at developing basic research which is focused upon extending our understanding of the science governing the nature of our universe (so called blue skies research).

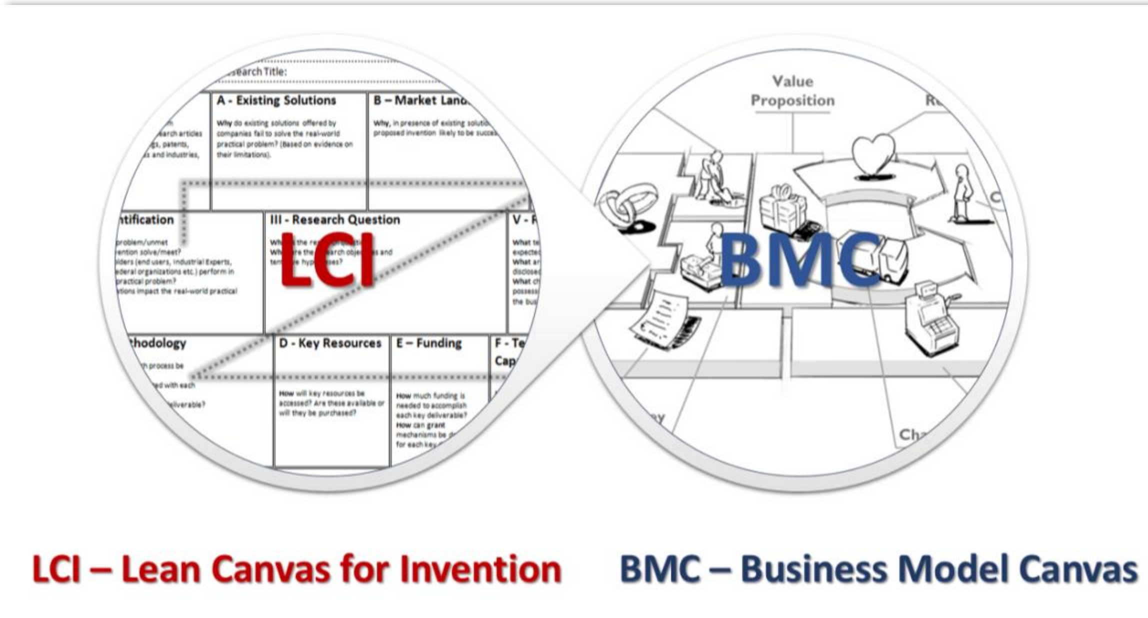


Figure 13.2. LCI followed by BMC: A process of developing technology-based company.

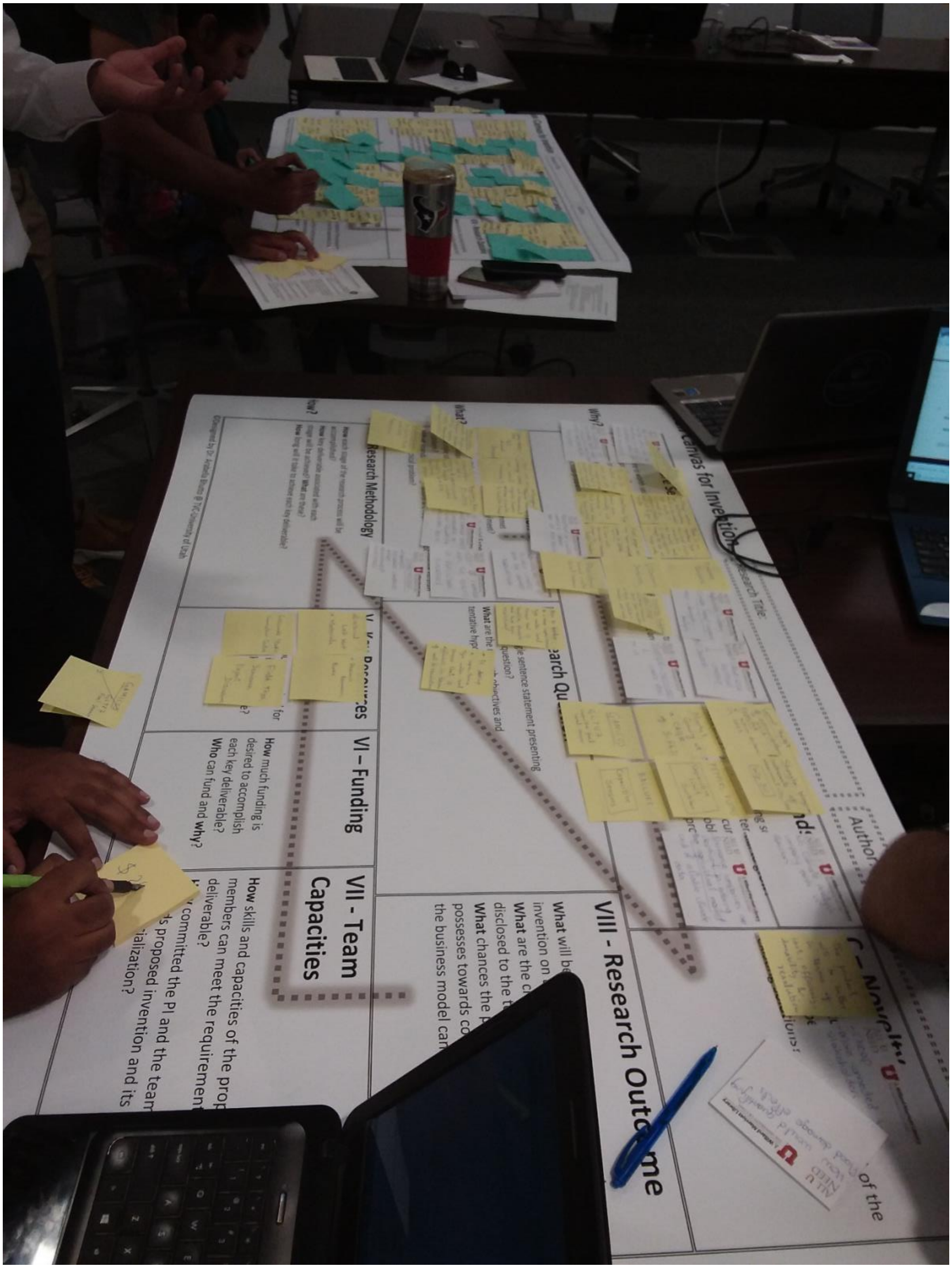
More Resources are added to help you in the process of developing your invention related to LCI. Please visit invent-c.com to download 25 LCI templates. This website also allows you to upload your filled templates and can seek further consultation on how to improve these templates for really reaching towards invention with high value and potential for commercialization.

You can leave some comments there for continuous improvement of these resources and for adding examples for the training guide. I look forward for your help in sharing the website and other resources with other academic inventors and entrepreneurs and with the STEM and Business graduates and on social media or leave an Amazon review.

Best of luck for your invention to innovation journey. You can stay in touch through:

- Email to bhuttoarabella@gmail.com
- Following me on Facebook at facebook.com/InventC
- Commenting on Youtube channel "Arabella Bhutto"
- Connecting me through LinkedIn account at linkedin.com/in/prof-dr-arabella-bhutto-58b041b3

Finally, picture 13.1 offers another view of the Lean Canvas for Invention.



Picture 13.1. Lean Canvas for Invention (LCI)

APPENDIX A

THE BUSINESS PARTNER
FOR YOUR IDEAS

Dear Dr. Muhammad Aslan Uqaili,

I am writing on behalf of the University of Utah's Center for Technology & Venture Commercialization (TVC) to express our pleasure in hosting Dr. Arabella Bhutto. Dr. Bhutto exhibits a genuine passion for her chosen area of study and has made a positive impression among her peers and TVC's leadership.

TVC is widely recognized among the leading technology transfer offices in the United States. Annually, TVC receives approximately 200 invention disclosures and executes 20-30 licenses, half of which are with the 10-15 startups we help launch each year. Since 1981, TVC has returned over $280M to the University of Utah through licensing royalties and equity positions in companies.

Since arriving, Dr. Bhutto has interviewed every TVC employee to develop a deep understanding of what we do and how we do it. She then looked at contemporary and historical data to develop an intuitive understanding of how strategies and behaviors translate into success. Dr. Bhutto combined those findings with additional interviews she conducted throughout campus to develop her insightful concept – Lean Canvas for Invention.

In addition to her work on the Lean Canvas for Invention, Dr. Bhutto has shown a keen interest in the broader work that goes into creating a campus culture that embraces technology commercialization, particularly through startup companies. From standard operating procedures to marketing campaigns, Dr. Bhutto has applied her talents and energy to consuming as much information as possible. She has challenged assumptions and developed creative hypotheses in ways that have benefited TVC's overall strategic planning and daily operations. This has been an unexpected, though much appreciated incremental benefit to her time here.

We will miss Dr. Bhutto's presence at TVC when she departs, but are grateful for the positive impact of her work while here. We also look forward to watching as her influence on research habits and outcomes shapes technology commercialization well into the future.

Sincerely,

Paul J. Corson
Director of Entrepreneurship
Center for Technology & Venture Commercialization
The University of Utah

CENTER FOR TECHNOLOGY & VENTURE COMMERCIALIZATION | UNIVERSITY OF UTAH | 615 Arapeen Drive, Suite 310 | 801.581.7792

APPENDIX B

VICE PRESIDENT FOR RESEARCH
THE UNIVERSITY OF UTAH

August 13, 2018

Dear Dr. Muhammad Aslan Uqaili,

I am writing to let you know what a fabulous experience I am having working with Dr. Arabella Bhutto as a visiting scholar here at the University of Utah. Dr. Bhutto has tremendous knowledge about technology commercialization, and we have been working together on some specific challenges that we think are paramount in all academic entrepreneurial ecosystems.

Dr. Bhutto has been working with the University of Utah (UofU) Technology Venture Commercialization Office (TVC) to document and better understand the entrepreneurial ecosystem at the UofU. Dr. Bhutto's unique perspective and knowledge base have been extremely helpful, both to her objective of defining the steps a university must take in order to create an effective entrepreneurial ecosystem, and to our understanding of what has made the UofU so effective in supporting faculty entrepreneurs. And, although the UofU is already top-ranked in technology commercialization, we have room for continued improvement. Dr. Bhutto has particularly grasped the need for improved communication and knowledge development/transfer between the academic inventor and technology managers. This has led to a major project that she and I have been working on the past several months – development of a Lean Canvas for Invention.

The concept of a Lean Canvas for Invention is based on the success of the Lean Canvas for Business (the basis of the National Science Foundation iCorps program, for instance), which helps academic entrepreneurs reach out to stakeholders and potential customers for products based on their research, to better plan the minimum viable product that could support a commercialization of the research. Through interviews with both academic inventors and technology commercialization managers at the UofU, Dr. Bhutto identified ten key challenges that often stall this commercialization process at the time of invention disclosure. In many of cases, addressing these challenges much earlier in the research process, such as at the time proposals are written for grant funding, could lead to dramatically improved technology commercialization results. We have developed the Lean Canvas for Invention to meet this need, and Dr. Bhutto has developed both the curriculum and materials and taught this to a first group of six post-doctoral students this summer. This fall (2018), we plan to teach this material to a full graduate student seminar, as well as three faculty-led research teams. The initial feedback on this program is excellent, and assessment of the student proposals after exposure to the Lean Canvas show that the students are now incorporating content that could ultimately enhance the potential of successful commercialization of their research output. We anticipate that this Lean Canvas for Invention could be used as a regular part of the research experience at the UofU, and potentially elsewhere as well. It addresses key challenges in the technology commercialization process and would be an early part of the academic entrepreneurial ecosystem.

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VICE PRESIDENT FOR RESEARCH
THE UNIVERSITY OF UTAH

Working with Dr. Bhutto has been a fantastic experience. She is extremely knowledgeable about technology commercialization worldwide, is a creative and energetic thinker, and a wonderful colleague. This has been an extremely productive research exchange thus far, and we expect two significant outputs from this work. The first is the Lean Canvas for Invention, and content that can be used to train academics in this research development approach. The other is a plan and process for an overall entrepreneurial ecosystem that could be applied either to a university starting with little or no such ecosystem, or a university like ours where a significant ecosystem is in place but where small changes may make big differences. In addition, we are completing a first manuscript on the Lean Canvas, and will be submitting it this week. A second manuscript on the ecosystem is in preparation.

Only rarely have I experienced the sort of vibrancy and energy that Dr. Bhutto brings to her work, and the strong creativity that comes from such an academic exchange. Working with Dr. Bhutto has been an exceptional experience, and I wanted to be sure that you knew how much we, at the University of Utah, have enjoyed and benefitted from Dr. Bhutto's work here.

Very sincerely,

Cynthia Furse

Cynthia Furse
Associate Vice President for Research
& Professor of Electrical Engineering

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APPENDIX C

THE UNIVERSITY OF UTAH

ECE

Department of Electrical and Computer Engineering

50 South Central Campus Drive, Room 2110, Salt Lake City, UT 84112-9249 (801) 581-6941 FAX (801) 581-5281

August 11, 2022

Dear Prof. Dr. Tauha Hussain Ali,

I am writing to let you know what a fabulous experience I am having working with Dr. Arabella Bhutto as a collaborator on a National Science Foundation funded project here at the University of Utah. This collaboration with Mehran University of Engineering and Technology is extremely beneficial, and we are grateful for the support and expertise provided by Dr. Bhutto and your University.

This project, The *Lean Canvas for Invention (LCI): A Team Based Framework for Research Development and Mentoring* is a bold, new, and trasformative approach to STEM graduate education and training. In this proposal, we pilot, test, and validate the effectiveness and feasibility of the Lean Cavas for Invention framework, hosted within a course for research teams (faculty plus students). The LCI is a new program to help research teams identify and think through a key research problem and its *most valuable research questions*, and plan and implement both their joint and individual research and career trajectories. Their exploration will reach beyond the traditional scientific literature and experience and will include innovation triggers such as patent literature, business reviews, and personal interactions with key stakeholders. We have recently piloted the basic LCI, with excellent success. Faculty have readily adopted this approach with their teams. In this project we propose to add mentoring and career development aspects to the LCI. Thus, the LCI can provide a program that fits naturally with the way engineering research is typically done and provides a structure that enhances the team research experiences, and the quality of mentoring and career preparation.

Dr. Bhutto has tremendous knowledge about technology commercialization, and we previously worked together to develop an innovative Lean Canvas for early stage research. Dr. Bhutto has taken this to fruition at MUET, where she is teaching this course regularly to your students, and has prepared both video and written resource material for this course. Her written materials are quickly becoming a textbook for this course. Dr. Bhutto was a (virtual) lecturer in our LCI course in spring semester 2022, and will be again as we teach it this semester (fall 2022). She is the lead instructional support for the business development aspects of the LCI, and in fact the LCI process itself. The students use the many templates and support tools she has developed, and find them very helpful. We are planning that she will visit the University of Utah in the coming year, with travel funded by the grant. Collaborating with her is absolutely essential for the success of this project, and we are grateful for her help and expertise.

Only rarely have I experienced the sort of vibrancy and energy that Dr. Bhutto brings to her work, and the strong creativity that comes from such an academic collaboration. Working with Dr. Bhutto and Mehran University of Engineering and Technology is an exceptional experience, and I wanted to thank you for the collaboration and expertise provided by your University and Dr. Bhutto.

Very sincerely,

Cynthia Furse

Dr. Cynthia Furse