

Exploring the Success of R&D BIOTECH Innovators in Higher Education Institutions: A Case Study of UPLB Agricultural Innovation

Marivilla Lydia Bulan Aggarao,
IKI-SEA-Bangkok University, Thailand

Alex Bennet,
IKI-SEA-Bangkok University, Thailand; Mountain Quest
Institute, USA

Ronald Vatananan-Thesenvitz,
IKI-SEA-Bangkok University, Thailand

Abstract:

This study investigated why and how R&D BIOTECH innovators in higher education institutions achieve success. It used a qualitative method employing a single case study research design. The data was obtained from face-to-face, one-on-one, and open-ended interviews with eight (8) scientists-innovators in UPLB Biotechnology. Descriptive analysis was engaged using coding and content analysis which involved tagging the text to other qualitative data using a system of categories. Based on the results, external Environmental Aspects and External Relations drivers were determined to have unique characteristics related to the R&D BIOTECH agricultural sector influence innovation. Further, findings showed a unique competency pattern and specific attributes that enable successful R&D BIOTECH innovation in higher education institutions. Finally, the knowledge-sharing process significantly contributes to a successful innovation product that the end-users can utilize – farmers and the society at large – bringing social justice.

Keywords: Circular Economy, Core Competencies, Creativity, Higher Education Institution, Innovation Competencies, Innovators-Scientists, Knowledge, Knowledge Sharing, Product Innovation

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1. Introduction

Agriculture is the basis of all civilization upon which traditions and values in the Philippines are built and shaped. It is part of everything, from the food people eat to their clothing. The well-known physician and national hero, Dr. Jose P. Rizal, first embraced and introduced agriculture to the Philippines.

Moreover, driven by the need, agriculture is an area in rapid development – both technological development and the development of alternative production systems (Hansen et al., 2001). However, with the admission of economic industrialization accompanying its irresistible benefits and challenges, the agriculture-based economy of the Philippines has been left behind, unable to enhance its agricultural richness (Crost et al., 2018). In addition, Asian countries, including the Philippines, are experiencing an economic transformation—rapid growth, urbanization, and related technical and social changes (Khan et al., 2019)—and cannot escape the adversities natural disasters bring calamities. So, how are such alarming concerns besetting the state of agriculture in the Philippines mitigated or addressed?

Industries are increasingly innovatively responding to social and environmental claims from society (Briseno and Zorrilla, 2017), including Biotechnology in higher education institutions (HEIs). A major driving force behind this innovation activity is the conditions of the environment (Capon et al., 1992). Therefore, innovation practices are encouraged to attend to poverty, work equality, renewable energy, and food production, notwithstanding the hazardous effects of climate change and the necessity of frequent repetitive implementation to address impacts on sustainability.

Further, higher education institutions and other organizations must produce novel products to satisfy client needs and keep up with the current contexts to remain relevant. The constant development of new products, which most scholars call product innovation, is viewed as a gigantic indicator and leap in an organization's success and enduring growth (Shimp, 2000) and as a benefit to the clients, they serve. While HEIs are confronted with the challenge of IR 5.0 and beyond, equally important is that they can fulfill their mandate and mission within the national context. Thus, this study further explored how a premier national university approaches product innovation.

In the Philippines, institutions, including some universities, have not been adequately armed in addressing food production problems; they lack the utility in the knowledge sharing process since having the opportunity to get the proper knowledge at the right time, capturing and disseminating lead to successful product innovation.

University of the Philippines Los Banos (UPLB), colloquially termed Elbi, is a non-profit institution supported by the State. As a result, it has become a premier education and public research institution widely known in Southeast Asia. In particular, the UPLB Biotechnology group is a knowledge-rich community that addresses societal problems besetting the community's lives and wellness. Thus, the study explored the rational and practical motives for why and how R&D Biotechnology innovators in higher education institutions.

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The following are vital inputs of the study's emerging model:

1. The university's mandate is to encourage more creative researchers and innovators who will produce advanced eco-friendly technologies (Clark, 2003) and improve the users' lives to sustain every Filipino's natural and organic lifestyle.
2. Recognition that the farming industry is aggravated, as evident in the model that the societal problems are the impetus for innovation. Hence, universities offering agricultural programs must be conscious enough to instill in their graduates the remarkable contributions of their technologies in the market (Aggangan et al., 2013).
3. The agricultural industry must be attractive and provide lucrative income that will enchant more young people to pursue agriculture careers (Palanca-Tan and Gio, 2021).
4. Recognition that these successful characteristics occurring in the university may stir the mindsets of the giant and influential corporate world to be more sensitive to their corporate social responsibilities (Etzkowitz and Zhou, 2018) and take the brave step toward renewing their approaches and views on biotechnology innovation.

2. Research Methodology

The study used a qualitative method employing a single case through face-to-face, one-on-one, and open-ended interviews to obtain data to find answers to the following objectives: (1) to determine the unique characteristics of the R&D BIOTECH agricultural sector that influence innovation, (2) to determine the innovator competencies and attributes that enable successful R&D BIOTECH innovation in HEIs, and (3) to identify how innovator success in R&D BIOTECH is supported and encouraged in HEIs. Coding of all the respondents was employed to ensure confidentiality and anonymity. Secondary participants were interviewed to corroborate the findings (Bhattacharjee, 2012). Pie charts and tables were utilized to clarify data presentation using coding and content analysis which involved tagging the text to other qualitative data using a system of categories.

University of the Philippines Los Banos, Biotechnology was purposely selected because its innovation paradigm is firmed up and for its proven successful innovative products. It is known for its influences on agriculture and food science throughout the country and the world. Its educational impact is mainly felt through its patented technological innovations, which focus on bringing primary food to the market and Philippine consumers in response to the rising necessity for agribusiness and the demand to take actions to attain the sustainable development goals (SDG) and Ambisyon 2040.

In a global context, the study supports the idea of a circular economy. The intent is to make better use of resources, close loops of resource flow by fully convalescing materials instead of wasting them, and design better products with longevity to prevent waste and pollution. This approach can provide a way to protect the environment and

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use natural resources more wisely, developing new sectors, creating jobs, and developing new capabilities (UNCTAD).

The selection criteria were very limpid – scientists-innovators whose technologies have been recognized, utilized, and commercialized. Initially, there were ten (10) identified respondents, but two (2) had a prior commitment abroad for training; thus, the final respondents totaled eight (8). However, the two prospective respondents assured the researcher that they supported whatever would be the result of the study based on data gathered from the respondents since they operate within a well-established set of principles, guidelines, and practices embedded in the organizational structure culture.

This sample represents the entire population in the characteristics of interests (Burns & Grove, 2017; Creswell, 2018). As construed by Neuman (2011), the sample depends upon the population characteristics, types of data, and its accuracy, such as its degree of confidence. It is not the volume or the quantifiable number of subjects. More vital is the subjects' relevance to the research topic rather than their representativeness which determines how to choose the sample.

3. Results and Findings

Following a short section providing context with demographic information on the research participants, the findings are discussed in terms of five areas: (1) Characteristics of BIOTECH that Influence Innovation, (2) Innovator Competencies and Attributes, (3) Individual Influencers, (4) Knowledge Sharing, (5) How Innovator Success is Supported and Encouraged, and (6) Why and How R&D BIOTECH Innovators in Higher Education Institutes Achieve Success.

3.1. Demographic Information on Research Participants

The eight scientist-innovators who are the principal focus of this case study are based at The National Institute of Molecular Biology and Biotechnology (BIOTECH), which serves as the national research and development (R&D) institute specializing in health biotechnology, food, and feeds, environmental, and agricultural. Recognized as a Center of Excellence for Research, it capitalizes and exploits the country's myriad collection of rich natural resources and agro-industrial waste and by-products and microorganisms to develop, cultivate and advance alternative technologies and product innovations towards improved and value-added agro-industrial productivity.

Age-wise, 38% of the population belongs to the 41-50 age bracket, implying that innovators' prime years were spent towards what the scientists-innovators described as a "noble cause." At the same time, 25% are 51-60 years old, at which age the scientists-innovators still sustained their responsibility for making viable products for society, whereas 25% fall into the 61-70 age bracket, nearing retirement age yet expressing passion about their commitment. As one innovator said, *"I have grown old helping, but I have never thought of making a profit out of this technology. Even when I am already old, I still engage myself with the people who need my*

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assistance." Lastly, 12% fall into the age bracket of 31-40, and while young in terms of experience in the university, their words and actions show that if one has a passion for working on something, one can make a difference.

In terms of educational level, the highest proportion (62.5%) is Ph.D. degree holders, 25% are post-doctorate, and 12.5% hold a master's degree. In terms of their fields of expertise (interest), four (50%) are focused on agriculture, two (25%) are focused on specific food technology, and two (25%) are focused on forestry.

Confirming their recognized success as scientists-innovators, 50% of the interviewees had received local recognition one to three times, and 50% had received local recognition four or more times. Local recognition includes awards from their respective local communities and in the national arena through recognized and accredited government and non-government agencies. At the international level, 87% of the participants have received awards from outside the country, and 13% have received more than 200 international and national awards and authored numerous publications.

4. Analysis

1. Characteristics of BIOTECH that Influence Innovation

The findings show that external drivers in the areas of Environmental Aspects and External Relations – having unique characteristics related to R&D BIOTECH agricultural sector – have a strong influence on innovation, even referred to as “fueling” successful innovation. Environmental aspects include natural calamities (emphasized by all interviewees) and societal issues (emphasized by 7 of the eight interviewees); external relations include state-of-the-art facilities and funding agencies (with each area emphasized by 6 of the eight interviewees). Table 1 includes a brief description of the emerging themes.

Table 1: Characteristics of BIOTECH that Influence Innovation

Category	Sub-category	Themes	Description	N
External drivers	Environmental Aspects	Natural Calamities	Refers to environmental problems which serve as the impetus for producing technology.	8
		Societal issues	Refers to the issues that hamper agricultural growth in attaining economic growth, achieving sustainable development, and mitigating climate change.	7
	External Relations	State of the Art Facilities	Refers to the location of technology development. There are two kinds of facilities: (1) On-site (laboratory) for the storage of specimens such as fungi and bacteria; (2) Off-site (field) where root crops, grains, or fruit-bearing trees are grown.	6
		Funding Agencies	Refers to interested parties who wish to finance the development of technology.	6

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The Philippines is prone to natural disasters and suffer significant environmental degradation aggravated by a high annual population growth rate. In addition, loss of agricultural lands, deforestation, soil erosion, air and water pollution, improper disposal of solid and toxic wastes, loss of coral reefs, mismanagement, abuse of coastal resources, and overfishing. These devastating and alarming realities compel the scientists-innovators to develop technologies that somehow mitigate the occurrence of such disasters, if not to assuage the aftermath to the society and the people greatly affected by them.

While natural calamities and societal problems are beyond the control of the innovators, with pre-cognition, they can be mitigated. As one innovator shared, *“We are visited by more than 20 typhoons yearly. So, we need a technology resistant to calamities to help the agriculture sector.”* These issues are important to the innovators and fan their passions for improving living conditions across society through worthwhile technologies.

Further, the university supports the innovator’s passions by developing a Technology Transfer and Business Development Office (TTBDO), which supports the innovators working with end-users and acting as a gatekeeper for emerging issues outside the purview of the innovator focus. Focusing on these issues, the Chancellor [University President] encourages the innovators to coordinate with the TTBDO to participate in knowledge sharing by working closely with the farmers to address and mitigate these calamities. Quoting the statement of the Chancellor: *“I told my team ... to shift our focus onto food production so that we can serve the best interest of the people. The technologies they are doing respond to problems in society.”*

This support is demonstrated in developing state-of-the-art facilities (on-site and off-site) and in the TTBDO’s leading role in interacting with funding agencies to seek funding necessary to support BIOTECH’s aggressive pursuit of solutions to natural calamities and societal issues. Government funding requires following procurement laws and guidelines relative to innovation in a university. In contrast, private agency partnerships require different approaches and documentation, all of which demand a level of expertise to navigate. The innovators recognize this need. As one describes, *“To create the technology, we need funding agencies, so we collaborate with all people involved and other experts because not all are within the coverage of what we know.”*

4.2. Innovator Competencies and Attributes

To empower the workforce to increase the chances of getting ahead due to competitive advantage, innovation, and effectiveness, management groups' leaders rely much on the competencies and skills of employees, their products, and behavior (Houtzagers, 1999). Competencies refer to the skills or elements to achieve innovation, which eventually distinguishes from knowledge and creativity in higher education institutions. Competencies encompass the indispensable working habits, the entirety of an innovator's discharge of his or her duties. However, for the competencies to become meaningful and relevant to the users, they need to be well-thought-of and structured

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logically and reasonably. Thus, *competencies* are considered attributes in a person's wholeness that would support him/her attaining *innovation competencies*.

Based on the findings, the study revealed a unique competency pattern and specific attributes that enable successful R&D BIOTECH innovation in HEIs. Three key competency areas and related core competencies emerged, each of which included related innovation competencies, which are specific competencies that the scientist-innovators exhibit that led to successful innovation. Core competencies in technical skills (hard skills) include problem-solving skills (focusing and evaluating) and creativity skills (critical thinking, resourcefulness). The area of social skills (soft skills) related to leadership skills (mentoring and collaborating) and management skills. The third area of transcendence relates to the core competency of altruism (in terms of advocacy and commitment). Table 2 includes short descriptions of these competencies.

Table 2: Summary of Innovative Skills Responded to by the Scientists-innovators

Core Competencies	Competencies	Innovation Competencies Emerging from Research
Technical Skills – The ability to apply the expertise and training gained to develop a product that addresses societal issues.	Problem-solving skills - <i>The ability to recognize prevalent problems and find a solution to overcome them.</i> Creativity skills - <i>The ability to produce novel technology from the acquired information and knowledge.</i>	Focusing skills - The ability to develop products one at a time Evaluating skills - The ability to assess the impact of product innovation in the community. Critical thinking skills - The ability to discern and make sound decisions in finding effective solutions to social problems. Resourcefulness - The ability to source knowledge, think outside the box, and the maturity to deal with the complexities of the technology.
Social Skills – The ability to make extra efforts to learn on their own and learn from others (forefathers), the rigors of developing the technology, and negotiating for funds to run the project.	Leadership skills – <i>The ability to exemplify responsible leadership skills to maintain a mentor-mentee smooth interpersonal relationship in leading a transformative project.</i>	Mentoring skills - The ability to mentor and guide the next generation of innovators in producing profitable products. Collaborating skills - The ability pool various resources or expertise and forge potential partnerships to fund the project.
Transcendence –The ability to respond to the needs of the community to achieve social justice without expecting anything in return.	Altruistic skills - <i>The ability to forget oneself in favor of the much less fortunate who will benefit from the technology.</i>	Advocacy - The ability to inspire the local people to utilize the product and transform their lives. Commitment - The ability to take charge and be responsible for the notable impact of technology in the community.

The result identified technical skills, social skills, and transcendence as core competencies of innovation. The result also lists each identified innovation competency's competencies or key indicators (sub-variables) with an analysis of each sub-variable.

The innovators were carefully selected based on their significant technologies and appear to have come equipped with these specific innovation competencies to achieve

UPLB BIOTECH's advocacy of uplifting the economic growth of the Philippines, thus bringing extraordinary breakthroughs in agricultural history. Regarding creativity, one interviewee shared, *"My creativity led me to produce something new, and that brings me up to being innovative when the people utilize the product."* A second scientist-innovator said, *"I improved the technology by recycling discarded materials [indigenous resources]."* Furthermore, the innovative competencies related to altruistic skills (advocacy and commitment) emerged again and again. As one innovator expressed this passion: *"One way of looking into national perspective is ... through our advocacy of restoring our agriculture, which is the main source of living of our countrymen. Helping the marginalized advance their lives through our technologies is our utmost good as inventors. No more, no less."*

4.3. Individual Influencers

Individual influencers and observations were those single ideas, pieces of words, or phrases shared by one or two innovators or emerging from observable behaviors that scientist-innovators confirmed attributed to their successful innovation. The ideas shared in this category were: (1) family history, (2) the concept of resonance, (3) persistence, (4) tolerance, (5) contentment over royalty and promotion, (6) title does not matter, (7); innovation is self-initiated (related to the skill of transcendence), (8) writing skills, (9) prayers matter, (10) humility, (11) the role of belief or religion, and (12) the joy of laughter. These individual influencers provide a rich context for these successful scientist-innovators; they provide a deeper understanding of individual passions and beliefs that support innovation success. For example, they display humility, having accurate views of their strengths and weaknesses – freely giving of their strengths and asking in support of their weaknesses – and at a social level, always seeking and considering the thoughts of farmers and end-users. Family history is a strong driver to succeed for several innovators who come from a family of farmers and have personal experience regarding the adversities their technologies are addressing.

4.4. Knowledge Sharing

Currently, the universities in some countries contribute to healthy and sustainable regional economies in numerous ways, such as the site of this study, UPLB BIOTECH. There is a so-called 'milieu' or co-location effect because universities produce substantial positive economic development effects by attracting and encouraging scientists, engineers, and entrepreneurs to locate in specific geographical regions. These regions have a concentration of highly educated and creative people teaching and conducting research employed by the university (Goldstein and Glaser, 2012) and developing innovation products equally valuable for society and beyond.

Whether you consider knowledge as "justified true belief" or "the capacity to take effective action" (Bennet et al., 2018), tying knowledge to action allows the identification of the quality (or effectiveness) of the knowledge, which is dependent on how well a specific action achieves its anticipated outcome. Since the future is uncertain, knowledge cannot be considered as either true or false at all times but rather is taken as having a probability of effectiveness between zero and one, and hence always open to some degree of uncertainty (Bennet and Bennet, 2007). The knowledge

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advanced by organizations is frequently vastly tacit and thus is difficult—if not impossible—to articulate and codify (Teece, 2004). Technology transfer is often difficult to accomplish without key individuals who have the knowledge and the ability to communicate that knowledge to others. This explains why the dispersion of new technology often depends on the mobility of engineers and scientists (Winter, 1987), which includes scientist-innovators.

In recent times, BIOTECH has introduced product innovations to meet industry, community, and national policy needs but has failed to discuss the knowledge-sharing flow that influences innovation. *Knowledge sharing* is "team members sharing task-relevant ideas, information, and suggestions" (Srivastava et al., 2006, p. 4). In this context, the forefather transfers knowledge sharing, which means acquiring knowledge through competent individuals for one purpose (Minciullo and Pedrini, 2015) to produce product innovation (Thorisson & Talbot, 2018).

The move towards sustainable agriculture requires a more detailed understanding of farmers' knowledge(s) and knowledge practices. Increasingly, it is crucial to understand what farmers understand and how their knowledge practices incorporate others – especially given the emerging call for environmentally-oriented policy measures to move beyond the individual farmer focus (Thomas et al., 2020). This research considers how innovators engage with, utilize, and share knowledge with the end-users, including farmers. See Table 3.

Table 3: Knowledge Sharing Process as Experienced by the Innovators

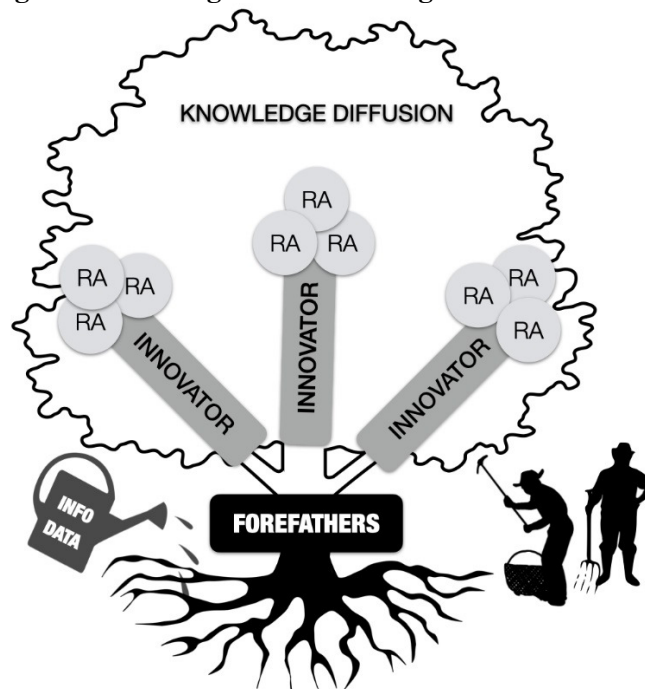
Category	Sub-category	Themes	Verbal Description	N
Prompting Stage	Stimulating Elements	Passion	This refers to the driving force, commitment, and a sense of urgency to respond to pressing environmental issues, hence the need to share the knowledge and coach one another in the team.	8
		Trust	This refers to the team leaders showing trust and confidence towards the members and vice versa and never doubting their performance capacity.	6
		Enriched Environment	This refers to the working atmosphere of the innovators as they continuously share and transfer knowledge in the completion of their journey to successful product innovation.	7
	Matching Mate	Emphatic Nature	This refers to the innovators' identifying themselves with the situation of the beneficiaries of technology and the eagerness to share information in developing technologies.	6
		Well-grounded background	This refers to the technical adeptness and preparedness of the innovators.	8
		Appreciative Inquiry	This refers to the positive recognition and reinforcement received when sharing and expanding knowledge from the gurus to the innovators and understudies.	5

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Expendig Stage	Viability Analysis	Foresight	This refers to looking beyond and becoming proactive in knowledge sharing to curate and design relevant product innovations.	8
		Feedback	This refers to the ability to clarify and point out missed things.	6
		Multiple Administrative Tasks	This refers to the increased workload that delays their duties to create technologies.	5
	Knowledge Ground	Constant Search for Knowledge	This refers to the continuous exploration of traditional and scientific knowledge in creating remarkable technology	8
	Knowledge Transmission	Community of Practice	This refers to innovators who share a concern or a passion for creating technologies and learn how to do it better as they interact regularly.	6
	Knowledge Exposition	Research Skills	This refers to the ability to converting traditional knowledge into scientific knowledge to create sustainable product innovation.	8
	Knowledge Amalgamation	Demonstrate Skills	This refers to the ability to take their time out to teach and demonstrate how to use the technology to the end-users	8

The innovators were motivated, affirmed, and supported to engage in knowledge sharing. There were certain gurus (called forefathers, the first handlers of technologies) who conscientiously mentored the innovators, guiding them through product development. Knowledge comes from converting collected data and information and passed on emerging from the historical background of the technology.

Figure 1: The diagram of knowledge diffusion



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Figure 1 refers to the positive recognition and reinforcement received when sharing and expanding knowledge from the gurus to the innovators and research assistants. Innovator G shares: *I owe so much and am very grateful to our forefathers who started the technology and passed on to us the indigenous knowledge behind this technology. Now it is my turn to share and transfer the knowledge by training our RAs. Such a process sustains the legacy of passing on the technology from one generation to generation.*

4. 5. How Innovator Success is Supported and Encouraged

There were elements in the organizational system in BIOTECH that were essential to subsist successful innovation. Organizational elements represent the central innovation path to success. As part of UPLB – declared a Center of Excellence (COE) in Agriculture by the Commission on Higher Education – the Institute of Biotechnology continues to outgrow its innovation platform and value chain to sustain its designation and significantly influence its community and the country.

The innovation platform lies at the university, focusing on agriculture. Scientist-innovators, farmers, university officials, government entities, and significant others join forces in coming up with viable technologies or product innovations in response to their current thrust on food production as one of the societal concerns of the Philippine government. Each entity plays a crucial role in the governance of knowledge, and with their contributions, knowledge sharing comes to fruition. For instance, the innovators used feedback from the farmers to tighten and affirm their farming knowledge. In addition, University officials supported advanced training in this context and other related activities. The unparalleled interplay of these entities made knowledge-sharing governance a smooth vehicle for innovation needed in this time of uncertainty.

Biotechnology's organizational performance in product innovations improved and advanced, becoming exemplars, with knowledge located within and shared among the team members. The organizational elements scientist-innovators identified that led to their success are in the areas of context, culture, and values. See Table 4.

Table 4: Organizational Elements that lead to Successful Innovation

Category	Sub-category	Themes	Verbal Description	N
Organizational Elements	Organizational Context	Management Style	Refers to the interplay of the institution, administration, and innovators in responding to the vision-mission to be a globally competitive graduate and research university contributing to national development through the produced technologies.	8
		Innovators Know-How	Refers to the technical and soft skills acquired through various exposures to produce the technologies responsibly for the people.	6
		Procedural Process of	It refers to the systematic function of gatekeepers who put a premium	8

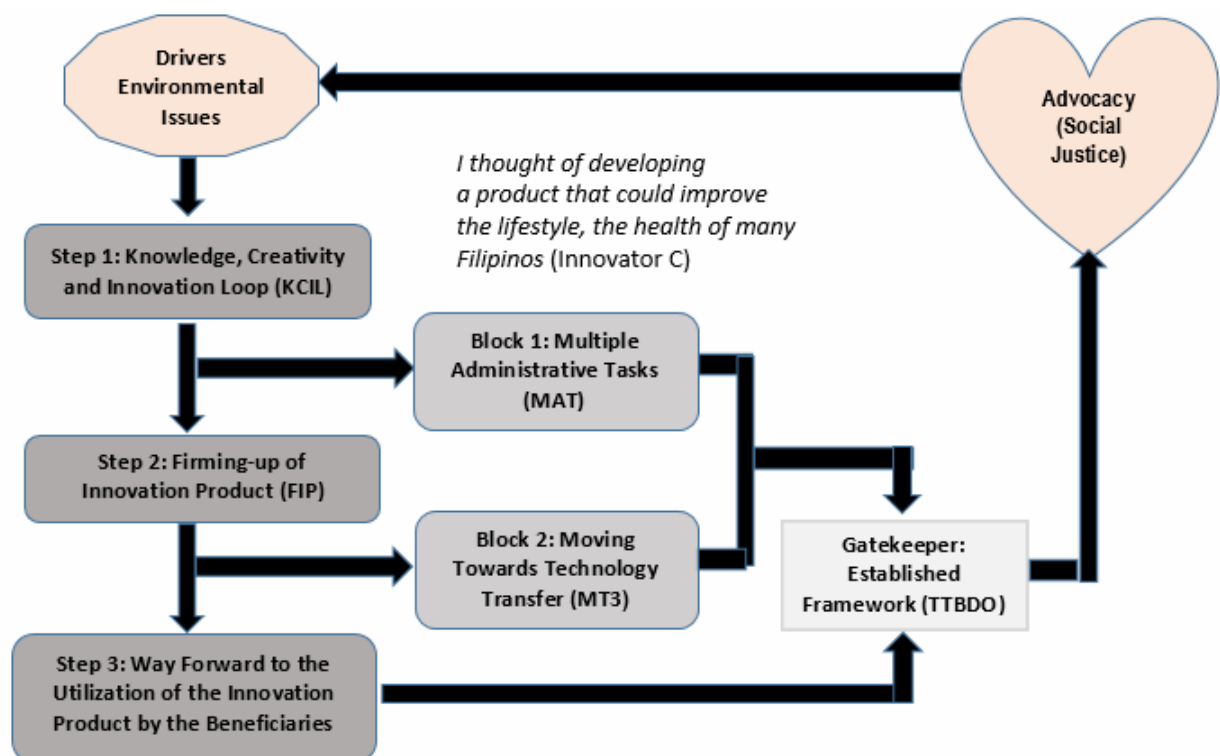
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Organizational Culture	Technology Utilization Cohesive Teamwork	on the technology to serve its purpose to the fullest. Refers to the teamwork demonstrated by the individuals in sharing their expertise to create substantial technology.	7
Organizational Values	Concern for Beneficiaries of Technology Consistent Appreciation of Mentors	Refers to the driving force to produce technology and leaves an extraordinary impact on people's lives. Refers to the behavior exhibited towards their mentors, such as appreciation and credit for the insights/ideas shared in starting the technology through community immersion, consultations, and formal training abroad.	8

4.6. Why and how R&D BIOTECH innovators in HEIs achieve success

While all the innovation factors, competencies, and individual influencers certainly contributed to the successful innovation of BIOTECH, a straightforward question allowed innovators to focus specifically: What did UPLB BIOTECH attribute as a driver to innovation success. The elements to which innovators felt UPLB BIOTECH contributed to their success were grouped loosely into two areas: the first is related to environmental problems, while the second area relates directly to the UPLB Biotechnology innovation process.

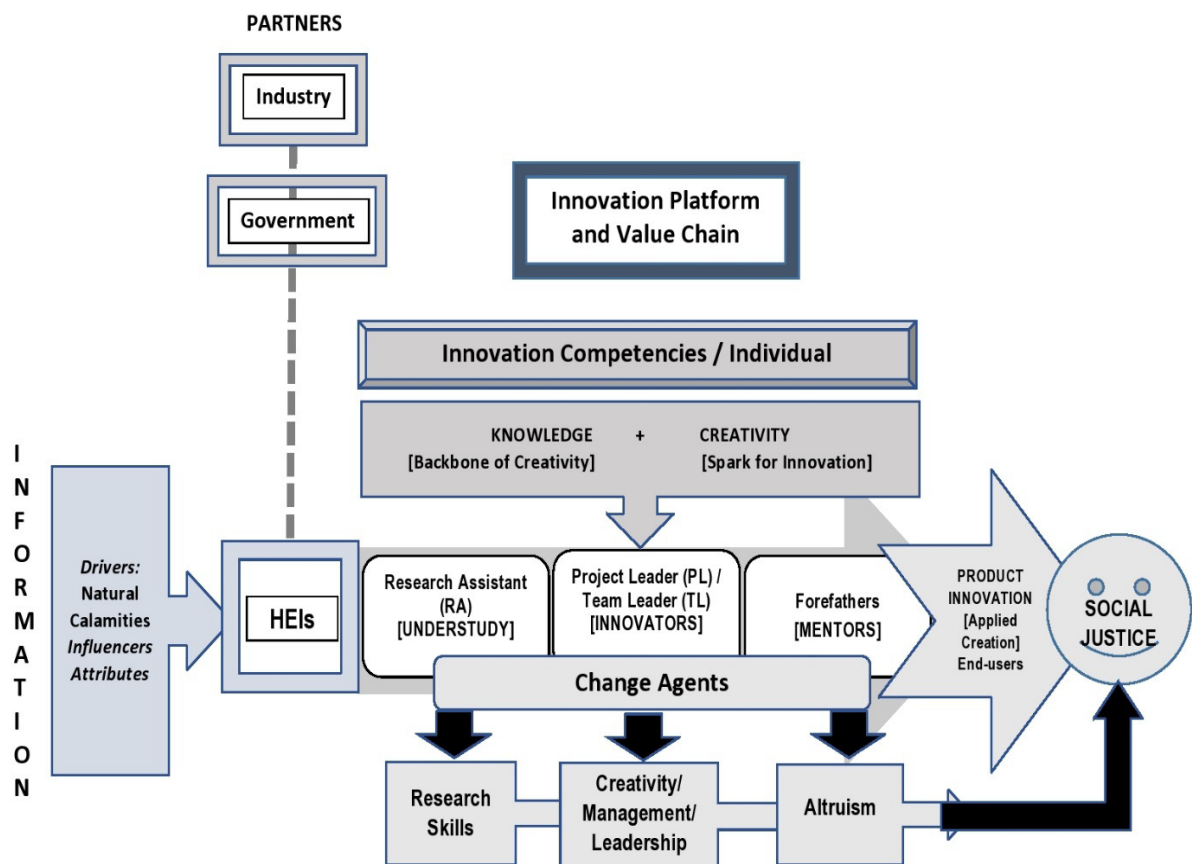
Figure 2: Three steps or processes involved in the development of the technology



There are three steps in the formal innovation process used in UPLB BIOTECH involved in the development of successful innovation: (1) The intertwining of knowledge, creation, and innovation tightened knowledge absorption; (2) The firming-up of the innovation product along with the available set of emerging influencers; and (3) The way forward to the utilization of the innovation produced by the beneficiaries. See Figure 2. This process provides the context from which the answers to our research questions emerged. Details and examples – beyond the four contexts of this paper – emerged throughout the study, supporting the effectiveness of this foundational approach to innovation.

External drivers, influencers, attributes, and organizational elements push BIOTECH in HEIs to pursue successful innovation. Innovation in universities could either be context-responsive or transformative approaches. In the first approach, the innovation path was influenced heavily by the need to respond appropriately to external drivers. In contrast, in the transformative approach, certain factors exclusive to the institution like its vision-mission-goals and objectives and institutional culture dominate the path of innovation. Both are present in UPLB. Figure 3 illustrates the path towards agriculture innovation.

Figure 3: A HEI Journey on the Path toward Agriculture Innovation



According to Etzkowitz (2003), the triple helix model postulates that the interaction between industry-university-government is the key to improving the conditions for innovation and the university as a source of new knowledge and technology. The university serves as the technology provider (rooted in the indigenous knowledge passed on by the forefathers to the innovators), which happens in an innovation platform through the value chain. Moreover, the government provides the financial aspect to achieve successful product innovation. The industry's role is to adapt the product for mass production. The innovators themselves are the first and foremost change agents in academe who vehemently respond to the environmental problems surrounding the community. Pre-cognition can mitigate natural calamities and societal problems beyond the innovators' control. As a result, BIOTECH continues to outgrow its innovation platform in making significant contributions to its community and the country.

A unique competency pattern, specific attributes, and significant individual influencers enable successful R&D BIOTECH innovation in HEIs. Finally, knowledge sharing complements this competency set—specifically, the upright passing down of knowledge from the forefathers to the current innovators, which led to their creativity to produce product innovation.

In addition, through the identified and well-established organizational elements composed of organizational context, culture, and values in BIOTECH, with leadership from the top of the university, R&D supports and encourages innovator success. These organizational elements were essential to innovation and form the first significant innovation path to success.

5. Conclusion

The world in which we live has changed drastically as this research progressed. Challenged by the complex environment, aggravated by a pandemic, an economic downfall, and continuing and perhaps even increasing environmental challenges, there is a demand for sustainable technologies. Indeed, there is an even greater need and opportunity to build upon existing technologies, create new technologies in service to humankind, and mitigate the occurrence of natural and manufactured calamities. Essentially, we need to choose technologies that will restore the natural vastness of the planet earth. Where disenchanted creatures will no longer live in poverty and where organic food will be abundant, breathing in the clean and fresh air and bringing back the harmonious relationship between the ecosystem and biodiversity.

A shortcoming of this research is its specific focus on one BIOTECH group in one culture. It would certainly be worthwhile to explore the Innovation Model in terms of other domains of knowledge and, indeed, in terms of other cultures. However, there is a greater need for more focus on technologies to support food security and food safety in our volatile environment. The influencers that surfaced in this study affect innovation. There would be value in exploring those connections more deeply in future research.

6. References

1. Aggangan, N.S., Tamayao, P. J. S., Aguilar, E. A., Anarna, J. A. and Dizon, T. O. (2013), "Arbuscular Mycorrhizal Fungi and Nitrogen-fixing Bacteria as Growth Promoters and As Biological Control Agents Against Nematodes in Tissue-cultured Banana Variance Lakatan", *Philippine Journal of Science*, Vol. 142, No. 2, pp. 153-156.
2. Bennet, A. and Bennet, D. (2007). *Knowledge mobilization in the social sciences and humanities: Moving from research to action*. USA: MQI Press.
3. Bennet, A., Bennet, D. and Avedisan, J. (2018). *The course of knowledge: A 21st century theory*. MQI Press.
4. Bhattacharjee, A. (2012), *Social Science Research: Principles, Methods, and Practices*. University of South Florida Textbooks Collection 3. Available from: https://digitalcommons.usf.edu/oa_textbooks/3 [Accessed on 11 Nov 2022].
5. Briseno, A, Zorrilla. A. (2017), "Internal and External Influences on the Firm Objective", *World Academy of Science, Engineering and Technology, International Journal of Economics, and Management Engineering*, Vol. 11, No. 6, pp. 1493-1497.
6. Burns, N. and Grove, S. (2017), "Qualitative research", In: Gray, J. R., Grove, S. K. and Sutherland, S. (Eds). *The practice of nursing research: Appraisal, synthesis and generation of evidence*, Elsevier, pp. 88-93.
7. Capon, N., Farley, J., Lehman, D. and Hulbert, J. (1992), "Profiles of Product Innovators Among Large U.S. Manufacturers", *Management Science*, Vol. 38, No. 2, pp.157-169. <https://doi.org/10.1287/mnsc.38.2.157>
8. Clark, B. R. (2003), "Sustaining Change in Universities: Continuities in Case Studies and Concepts". *Tertiary Education Management*, Vol. 9, No. 2, pp. 99-116. <https://doi.org/10.1080/13583883.2003.9967096>
9. Creswell, J. W. (2018). *Qualitative inquiry & research design: choosing among five approaches*. 4th Ed., California: Sage.
10. Crost, B.; Duquennois, C.; Felter, J. H.; Rees, D. I. (2018), "Climate change, agricultural production and civil conflict: Evidence from the Philippines", *Journal of Environmental Economics and Management*, Vol. 88, pp. 379-395. <https://doi.org/10.1016/j.jeem.2018.01.005>
11. Etzkowitz, H. and Zhou, C. (2018), *The Triple Helix University–Industry–Government Innovation and Entrepreneurship*. New York: Routledge.

12. Etzkowitz, H. (2003), "Innovation in Innovation: The Triple Helix of University-Industry-Government Relations", *Social Science Information*, Vol. 42, No. 3, 293-337. <https://doi.org/10.1177/05390184030423002>
13. Goldstein, H. A. and Glaser, K. (2012), "Research Universities as Actors in the Governance of Local and Regional Development". *The Journal of Technology Transfer*, Vol. 37, No. 2, pp. 158-174. <https://doi.org/10.1007/s10961-010-9193-4>
14. Hansen, B., Aloe, F. H., and Kristensen, E.S. (2001), "Approaches to Assess the Environmental Impact of Organic Farming with Particular Regard to Denmark". *Agriculture, Ecosystems & Environment*, Vol. 83, No. 2, pp. 11-26. [https://doi.org/10.1016/S0167-8809\(00\)00257-7](https://doi.org/10.1016/S0167-8809(00)00257-7)
15. Houtzagers, G. (1999). "Empowerment, Using Skills and Competence Management", *Participation and Empowerment: An International Journal*, Vol. 7, No. 2, pp. 27-32.
16. Khan, K.W., Zaman, K. Shouky, A.M. and Sharkaw, A. (2019), "Natural Disasters and Economic Losses: Controlling External Migration, Energy and Environmental Resources, Water Demand, and Financial Development for Global Prosperity". *Environmental Science and Pollution Research*, Vol. 26, pp. 14287-14299. <https://doi.org/10.1007/s11356-019-04755-5>
17. Minciullo, M. and Pedrini, M. (2015), "Knowledge Transfer Between For-Profit Corporations and Their Corporate Foundations", *Nonprofit Management and Leadership*, Vol. 25, No. 3, pp. 215-234. <https://doi.org/10.1002/nml.21125>
18. Neuman, W.L. (2011), *Social Research Methods: Qualitative and Quantitative Approaches*, Boston: Pearson.
19. Palanca-Tan, R. and Gio, L. (2021), "Small Farm Households' Vulnerabilities in South Cotabato, Philippines", *Agricultural Sciences*, Vol.12, No.3, pp. 247-258. <https://doi.org/10.4236/as.2021.123016>
20. Shimp, T. A. (2000), *Advertising promotion. Supplemental aspects of integrated marketing communications*, 5th ed. San Diego, CA: Harcourt College Publishers.
21. Srivastava, A., Bartol, K. M. and Locke, E. A. (2006), "Empowering Leadership in Management Teams: Effects on Knowledge Sharing, Efficacy, and Performance", *Academy of Management Journal*, Vol. 49, No. 6, pp. 1239-1251.
22. Teece, D.J. (2004), "Knowledge and competence as strategic assets. In: Holsapple, C.W. (Ed). *Handbook on Knowledge Management 1. International Handbooks on Information Systems*, Vol. 1, Springer: Verlag, Berlin, pp. 129-152. https://doi.org/10.1007/978-3-540-24746-3_7
23. Thomas, E., Riely, M. and Spees, J. (2020), "Knowledge Flows: Farmers' Social Relations and Knowledge Sharing Practices in 'Catchment Sensitive Farming'",

Land Use Policy, Vol. 90. 104254.
<https://doi.org/10.1016/j.landusepol.2019.104254>

24. Thorisson, K. R. and Talbot, A. (2018), “Cumulative learning with causal-relational models”, *International Conference on Artificial General Intelligence*, pp. 227–237.
25. UNCTAD Policy (2018), *Circular economy: The new normal*, available at: <https://unctad.org/topic/trade-and-environment/circular-economy> (accessed on 05 June 2018).
26. Winter, S. (1987), “Knowledge and competence as strategic assets”, In: Teece, D. (Ed.), *The competitive challenge: strategies for industrial innovation and renewal*, New York: Harper & Row, pp. 59-184.