International Journal of Innovation

e-ISSN: 2318-9975
https://doi.org/10.5585/2024.24381
Received: 27 Apr. 2023 - **Approved:** 30 Nov. 2023

Evaluation Process: Double Blind Review
Editor-in-Chefe: Priscila Rezende da Costa
Co editor: Isabel Cristina Scafuto
Scientific Editor: Vânia Maria Jorge Nassif
Assistant Editor: Angelica Pigola
Section: Technologial Article

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LUDUS - a process for management of academic works in information and communication technologies with a focus on innovation generation

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Author Notes

We have no conflicts of interest to disclose.

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Acknowledgements: National Council for Scientific and Technological Development (CNPq). Ludii.co Laboratory. Department of Computing. Federal University of Sergipe.

Cite as – American Psychological Association (APA)

Barreto, H. V. D., Macedo, H. T., Silva, G. J. F., & Prado, B. O. P. (2024, Jan./Apr.). LUDUS - a process for management of academic works in information and communication technologies with a focus on innovation generation. *International Journal of Innovation - IJI*, São Paulo, *12*(1), p. 1-48, e24381. https://doi.org/10.5585/2024.24381

ABSTRACT

Objective: This study proposes and evaluates an innovative process for managing and developing academic works in the Information and Communication Technology (ICT) field. The main objective is to boost innovation generation and stimulate entrepreneurship among students. In practical terms, the study aims to build a process that shapes research towards the creation of minimum viable products (MVPs).

Relevance: There is a misalignment between the University and the productive sector, mainly due to significant differences in expectations regarding the application of research and development results. These challenges hinder innovation generation and, consequently, the technological development and industrialization of the country, ranking it 64th out of 126 economies, according to the Global Innovation Index.

Methodology: This research combines quantitative and qualitative methods. A systematic literature review was conducted to identify the advantages and limitations of different comparison criteria. The created process, called LUDUS, was rigorously applied to Undergraduate Capstone Projects (UCPs) over a year in the Department of Computing at the Federal University of Sergipe (DCOMP/UFS). Three quantitative performance metrics were defined to evaluate the adoption of LUDUS: (i) project abandonment rate, (ii) MVP generation rate, and (iii) startup creation rate.

Main Results: LUDUS enabled the construction of proofs of concept (PoC) or MVPs with a 70.5% success rate, contrasting with the non-existence of successful cases in the pre-LUDUS period. In the academic sphere, LUDUS contributed to an increase in the UCP completion rate from approximately 69% to 86%.

Contributions: A new process for development and people management was conceived, tested, and validated to help mitigate the identified problem.

Keywords: development process, people management, university, market, innovation

LUDUS - UM PROCESSO PARA GESTÃO DE TRABALHOS ACADÊMICOS DE TECNOLOGIAS DE INFORMAÇÃO E COMUNICAÇÃO COM FOCO NA GERAÇÃO DE INOVAÇÃO

Resumo

Objetivo do estudo: Propor e avaliar um processo para gestão (e desenvolvimento) de trabalhos acadêmicos de Tecnologias de Informação e Comunicação (TIC) que potencialize a geração de inovação e estimule o empreendedorismo. Em termos práticos, o objetivo é o de construir um processo que molde a pesquisa realizada guiando-a para a criação de um produto mínimo viável (do inglês, Minimum Viable Product - MVP).

Relevância: A Universidade e o setor produtivo possuem dificuldades de alinhamento, principalmente pelas grandes diferenças em relação às expectativas sobre a aplicação daquilo que se investiga ou se desenvolve. Essas dificuldades prejudicam a geração de inovação e, consequentemente, o desenvolvimento tecnológico e a industrialização do país, relegando-o ao 64º lugar dentre 126 Economias, segundo o Índice Global de Inovação.

Metodologia: Esta pesquisa é quantitativa e qualitativa. De caráter qualitativo, foi realizada uma revisão sistemática da literatura relacionada com o objetivo de expor vantagens e limitações em relação aos critérios de comparação. O processo criado, denominado LUDUS, foi aplicado rigorosamente a trabalhos finais de graduação (TCCs) ao longo de um ano no Departamento de Computação da Universidade Federal de Sergipe (UFS). Definimos três métricas quantitativas de desempenho para avaliar a adoção do LUDUS: (i) índice de abandono de projetos, (ii) taxa de geração de MVPs, (iii) taxa de criação de startups.

Principais resultados: O LUDUS foi responsável por viabilizar a construção de provas de conceito (do inglês, Proof of Concept - PoC) ou MVPs com uma taxa de 70,5% de sucesso diante

da inexistência de casos de sucesso no período pré LUDUS. Em termos acadêmicos, o LUDUS viabilizou um aumento da taxa de conclusão de TCCs de ~69% para ~86%.

Contribuições: Um novo processo de desenvolvimento e gestão de pessoas para ajudar a mitigar o problema identificado foi concebido, testado e validado.

Palavras-chave: processo de desenvolvimento, gestão de pessoas, universidade, mercado, inovação

LUDUS: UN PROCESO PARA LA GESTIÓN DE TRABAJOS ACADÉMICOS DE TECNOLOGÍAS DE LA INFORMACIÓN Y LA COMUNICACIÓN ENFOCADO EN LA GENERACIÓN DE INNOVACIÓN

Resumen

Objetivo del estudio: Proponer y evaluar un proceso para la gestión (y desarrollo) de trabajos académicos de Tecnologías de la Información y la Comunicación (TIC) que potencie la generación de innovación y estimule el emprendimiento. En términos prácticos, el objetivo es construir un proceso que moldee la investigación realizada guiándola hacia la creación de un producto mínimo viable (MVP).

Relevancia: La Universidad y el sector productivo tienen dificultades de alineación, principalmente por las grandes diferencias en cuanto a las expectativas sobre la aplicación de lo que se investiga o se desarrolla. Estas dificultades perjudican la generación de innovación y, en consecuencia, el desarrollo tecnológico y la industrialización del país, relegándolo al 64º lugar entre 126 Economías, según el Índice Global de Innovación.

Metodología: Esta investigación es cuantitativa y cualitativa. De carácter cualitativo, se realizó una revisión sistemática de la literatura relacionada con el objetivo de exponer ventajas y limitaciones en relación a los criterios de comparación. El proceso creado, denominado LUDUS, se aplicó de forma rigurosa a trabajos finales de grado (TFGs) a lo largo de un año en el Departamento de Computación de la Universidad Federal de Sergipe (DCOMP/UFS). Se

definieron tres métricas cuantitativas de desempeño para evaluar la adopción del LUDUS: (i) índice de abandono de proyectos, (ii) tasa de generación de MVPs, (iii) tasa de creación de startups.

Principales resultados: LUDUS fue responsable de viabilizar la construcción de pruebas de concepto (PoC) o MVPs con una tasa de éxito del 70,5% frente a la inexistencia de casos de éxito en el período pre-LUDUS. En términos académicos, LUDUS viabilizó un aumento de la tasa de finalización de TFGs de ~69% a ~86%.

Contribuciones: Se concibió, probó y validó un nuevo proceso de desarrollo y gestión de personas para ayudar a mitigar el problema identificado.

Palabras clave: proceso de desarrollo, gestión de personas, universidad, mercado, innovación

Introduction

Universities, by their very nature, are multidisciplinary institutions dedicated to the professional and scientific training of students. This core principle, enshrined in Article 207 of the 1988 Brazilian Constitution, emphasizes the interconnectedness of teaching, research, and outreach activities. However, the social, economic, and market potential of outreach activities is often underutilized. Consequently, a significant portion of university research fails to find practical application within the productive sector. This lack of effective collaboration between universities and the private sector has placed Brazil at a concerning 64th position out of 126 economies, according to the Global Innovation Index (Dutta et al., 2018), (Brant, 2018).

Computing, as an inherently technological field, serves as a major breeding ground for innovation within universities. Computer science is not merely a discipline that employs the scientific method to understand natural or societal phenomena; it also encompasses a systematic body of knowledge with a robust theoretical foundation. This knowledge is applied to solve

practical problems related to system design and construction (Butterfield, Ngondi & Kerr, 2016). Therefore, it is crucial that final-year projects, in addition to solidifying students' technical and scientific training, contribute to their professional development perspectives.

A survey conducted among professors at the Department of Computing of the Federal University of Sergipe (DCOMP/UFS) revealed the absence of a well-established management (and development) process that integrates innovation, academic production, and the market. Without such a process, innovation becomes sporadic and infrequent. Factors like scale, frequency, engagement, and diversity are known to contribute to successful innovation efforts (Minor, Brook & Bernoff, 2017).

This research aims to propose and evaluate a process for managing (and developing) information and communication technology (ICT) academic works that fosters innovation generation and stimulates entrepreneurial spirit. In practical terms, the goal is for this process to guide research towards the creation of a Minimum Viable Product (MVP) or, at least, a Proof of Concept (PoC).

Specific objectives include:

1. Developing an illustrative and didactic process, which should be readily applicable within a short timeframe to drive innovation projects.
2. Identifying professors' needs regarding academic works aiming to create innovative market-oriented products.
3. Establishing a path for market-oriented projects within the university, positioning the department as a potential partner for the private sector.

The proposed process, named LUDUS, was implemented in a set of undergraduate capstone projects (UCPs) at the Department of Computing of the Federal University of Sergipe (DCOMP/UFS). Systematic modifications were introduced to the traditional environment to

assess whether this intervention yielded the desired results, which are presented in the monitoring of projects where LUDUS was applied. This qualifies as experimental research, where variables directly related to the object of study are manipulated.

The research employs a quantitative approach (Plit & Beck, 2004). Quantitative research emphasizes objectivity in data collection and analysis. In this study, this approach was applied in the research involving department professors and the analysis of results related to the execution of final projects from 2018 and 2019, collected through surveys. Additionally, a systematic review of the literature was conducted to identify advantages and limitations based on comparison criteria.

A critical factor for the success of this research was the real-world application of LUDUS in actual projects. To facilitate this experimentation, interested professors allowed for the monitoring of UCP guidance and intervention in the projects throughout 2018 and 2019.

The research methodology comprised four macro stages:

1. Systematic review and market research: Identifying appropriate characteristics and best practices for management and development processes (Section 3).
2. Conjuncture analysis: Analyzing the current situation, specifically the traditional UCP supervision approach in the case study department and conducting a professor survey to gain a deeper understanding of the LUDUS usage scenario (Section 4).
3. LUDUS creation: Developing LUDUS while considering all details analyzed in the previous stage, the academic environment's specificities, and deadlines and normative characteristics for UCP completion within that department (Section 5).
4. LUDUS application, review, and evaluation: Implementing, reviewing, and assessing LUDUS usage with analysis of the results. This application spanned the year 2019, with the first version implemented in 2019.1 and the second, improved version applied in

2019.2. Evaluation of experiences was conducted through specific online forms with students involved in the projects, faculty advisors, and private sector partners (Section 6).

Systematic Review and Market Research

Review of the scientific literature

This study investigated the state-of-the-art in innovative project development processes within market-oriented academic environments.

A systematic literature review was conducted across seven scientific databases (Scopus, Science Direct, IEEE Xplore, Engineering Village, Web of Science, and ACM Digital Library) covering the period January 2015 to April 2020. A comprehensive search string, tailored to each database's syntax, was developed utilizing relevant keywords:

- Process-related terms: process, method, journey, roadmap
- Project development terms: project development, project lifecycle
- Innovation terms: innovation
- Academic environment terms: academic, university, college
- Industry engagement terms: companies, business, enterprise, industry

The initial search yielded 114 articles (Scopus: 6, Science Direct: 39, IEEE: 7, Engineering Village: 8, Science Direct: 39, Web of Science: 35 and ACM: 49). Inclusion and exclusion criteria (detailed in Table 1) were then applied to refine the selection for further analysis.

Table 1

Selection criteria

Inclusion Criteria	Exclusion Criteria
Processes involved in the development of interdisciplinary projects within academic settings	Processes exclusive to specific developmental stages
Procedures governing the development of innovative academic projects	General project management procedures
Processes for academic project development in collaboration with market partners	Workflow-centric processes not encompassing broader developmental aspects
Development processes catering to projects with tangible market demand	Processes specifically tailored for projects in their acceleration phase
Procedures outlining distinct roles of participants in academic project development	Processes omitting the initial project definition stage

Source: The authors.

After applying predefined selection criteria related to research focus and methodological rigor (details in Table 2), only 5 of the 114 initially identified articles were retained for further analysis. These 5 articles underwent a critical evaluation using a thematic analysis framework to identify key themes and insights regarding innovative project development in academic environments.

Table 2

Articles accepted in the extraction stage

Acronym	Title	Authors
A1	Mobile app for cost-volume-profit analysis - An interdisciplinary student project for promoting active learning in managerial accounting and IT	BANERJEE, R. et al
A2	Collaborative approach in software engineering education: An interdisciplinary case.	VICENTE, A.J. et al
A3	Innovations assessment methodology to promote knowledge transfer.	MARCELLIN-JESUS, E.
A4	Conception, technology and methods of development of university system of innovation projects commercialization based on effectuation.	KOLYCHEV, V.D; PROKHOROV, I.V
A5	The Surgery Innovation and Entrepreneurship Development Program (SIEDP): An experiential learning program for surgery faculty to ideate and implement innovations in health care.	SERVOSS, J. et al

Source: The authors

Key characteristics were thus identified and employed to the development of LUDUS (Table 3). This systematic approach ensured that LUDUS incorporated essential features aligned with established best practices.

Table 3

Characteristics of the articles

Characteristics	A1	A2	A3	A4	A5	LUDUS
Relationship with the market		x	x	x	x	x
Demand analysis	x	x	x	x	x	x
Student Selection	x	x			x	x
Technological planning	x	x				x
Project management		x				x
Remote and face-to-face approach	x					x
Entrepreneurial culture			x		x	x
Team Engagement		x	x			x
Product Innovation		x	x	x	x	x
Academic research	x		x	x	x	x
Student Improvement	x	x	x		x	x
Professor Improvement	x	x	x	x	x	x

Source: The authors.

Below, we briefly describe the meaning of each characteristic.

- "Relationship with the market" assesses whether the project addresses a demonstrably real market need.
- "Demand analysis" evaluates the viability of the proposed development.
- "Student Selection" assesses the presence of a defined method for team selection and composition.
- "Technological planning" evaluates the planning for constructing the technological solution.

- "Project management" evaluates the presence of a method for tracking and managing project progress.
- "Remote and face-to-face approach" evaluates the support for both in-person and remote project execution and monitoring.
- "Entrepreneurial culture" evaluates the process's emphasis on fostering an entrepreneurial mindset within the project.
- "Team engagement" evaluates the presence of strategies to maintain participant motivation and involvement.
- "Product innovation" evaluates the process's emphasis on developing innovative solutions.
- "Academic research" evaluates the incorporation of academic research findings into the project development process.
- "Student Improvement" evaluates the process's capacity to promote student learning related to project development.
- "Professor Improvement" evaluates the process's capacity to enhance faculty skills and knowledge in project development.

Market research

This research aimed to characterize New Product Development (NPD) processes implemented in various settings, including market activities, workshops, internal company initiatives, and startup development centers. We identified seven distinct NPD processes and employed the classification and organization frameworks proposed by Silva, Bagno, and Salerno (2014) and Grando and Kruglianskas (2017) to analyze them. Table 4 presents the identified processes.

Table 4

Processes analyzed

Acronym	Process	Reference
P1	Fuzzy front-end (FFE)	(Kim & Wilemon, 2003)
P2	Understanding Customer Needs	(Grando, 2017)
P3	Stage-Gate™ Process	(Cooper, Edgett & Kleinschmidt, 2000)
P4	Clark and Wheelwright's Innovation Funnel	(Clark & Wheelwright, 1992)
P5	Open and collaborative innovation	(Chesbrough & Press, 2003)
P6	Guides to innovation management	(Grando, 2017), (Cotec, 1998)
P7	Specific situations and contingencies	(Salerno *et. al.*, 2015)

Source: The Authors

An analysis of the presented processes identified key characteristics related to their scope. Table 5 details these characteristics and their presence in each analyzed process, compared to what was anticipated for LUDUS.

Table 5

Characteristics of market processes

Characteristics	P1	P2	P3	P4	P5	P6	P7	LUDUS
Evaluation of ideas	x	x	x	x	x	x		x
Understanding demands		x	x	x	x	x		x
Project planning			x	x	x	x		x
Project development			x	x	x	x		x
Testing & Validation			x					x
Scale production			x		x			x
Marketing			x		x			x
Pre-defined evolution			x			x		x
Continuous improvement			x			x		x
Multi-projects				x	x		x	x
Continuous triage				x	x			
External sources of technology and innovation					x		x	
Spin-outs					x			
People management						x	x	x
Adaptability					x	x	x	x
Uncertainties and radical innovation							x	x

Source: The authors.

Three key characteristics were identified as absent in LUDUS:

- Continuous triage: the process lacks a mechanism for ongoing evaluation of project viability throughout all development stages.
- External sources of technology and innovation: LUDUS does not currently incorporate external sources of technology or innovation, such as patented technologies or collaborative partnerships.

- Spin-outs: The design of LUDUS does not consider the possibility of generating independently successful projects ("spin-outs") stemming from the main development line.

Conjuncture Analysis

During a university semester, an exploratory field research was conducted to refine the research topic, guide hypothesis development, and inform methodological choices. The selection criteria targeted undergraduate capstone projects (UCPs) that investigated real market needs or validated solutions to them, including projects initiated by professors or students.

The analysis included 16 UCPs. While none produced a Minimum Viable Product (MVP) or Proof of Concept (PoC) demonstrating functionality (in marketing terms), 11 (69%) achieved academic success by completing the project. This highlights a potential issue: the absence of a structured process connecting market needs, planning, development, support, and successful completion of innovative projects with consistency and added value.

To understand the challenges in building innovative projects and explore the context deeper, questions based on the characteristics identified in the previous review and market research were developed. Table 6 presents the responses gathered at the conclusion of the UCPs.

Table 6

Questions and answers about the conduct of the UCPs

Questions	Answers
Are there any structured and planned processes? What is the scope of this process?	*There is no structured process with strategically planned activities.*
Are students aware of the process?	*They don't. At no time was the path that would be taken until the end of the journey presented.*
What is the alignment between the academic objectives of the works and the market?	*The market and academic objectives were not aligned in a viable way that would enable an adequate relationship.*
Is there demand analysis and technological planning?	*This item does not receive support from professors; It is up to the students to carry out the technological planning.*
How are projects managed?	*There is no management tool or method to monitor the evolution of projects.*
How does project tracking work?	*Weekly group meetings, in which professors comment on students' projects.*
Is there a development of entrepreneurial characteristics?	*Yes, there is the idea of applying the scientific research carried out to start a technology-based company.*
Is there engagement of professors and students, especially in relation to the consistency and frequency of deliveries?	*No, there is no charge for frequent deliveries by professors and students do not usually present frequent results.*
Are there values of teamwork among professors, between students and between the two groups?	*No conditions were created for this to happen, as each project ended up evolving separately.*
What does innovation assessment look like?	*There is no form of consolidated evaluation, innovation is not linked to the process.*
How is the support given to the guidelines?	*The support given is the follow-up on the progress of the research.*
Is there any improvement of professors and students?	*It was verified that the process focuses exclusively on promoting student learning. In practical terms, the BMC (Business Model Canvas) and the Empathy Map were used, as well as guidance on how to conduct a systematic review.*

Source: The authors.

Results of the analysis regarding the observed characteristics

Table 7 presents the connections between the identified challenges in building innovative projects (based on the observed characteristics) and the academic and market characteristics addressed by LUDUS. Bold characteristics highlight areas where LUDUS needs to emphasize support to ensure future UCPs focused on innovation avoid similar challenges.

Table 7

Characteristics of academic and market processes: coverage of the current situation

Academic characteristics	**Covered by the current situation**	**Market Characteristics**	**Covered by the current situation**
Relationship with the market	OK	Evaluation of ideas	OK
Demand analysis	-	Understanding demands	OK
Student Selection	OK	**Project planning**	-
Technological planning	-	**Project development**	-
Project management	-	**Testing & Validation**	-
Remote and face-to-face approach	-	**Scale production**	-
Entrepreneurial culture	-	**Marketing**	-
Team Engagement	OK	**Pre-defined evolution**	-
Product Innovation	-	**Continuous improvement**	-
Academic research	OK	Multi Projects	OK
Student Improvement	OK	**People management**	-
Professor Improvement	OK	Adaptability	OK
		Uncertainties and radical innovation	OK

Source: The authors.

Results of the analysis regarding professor perception

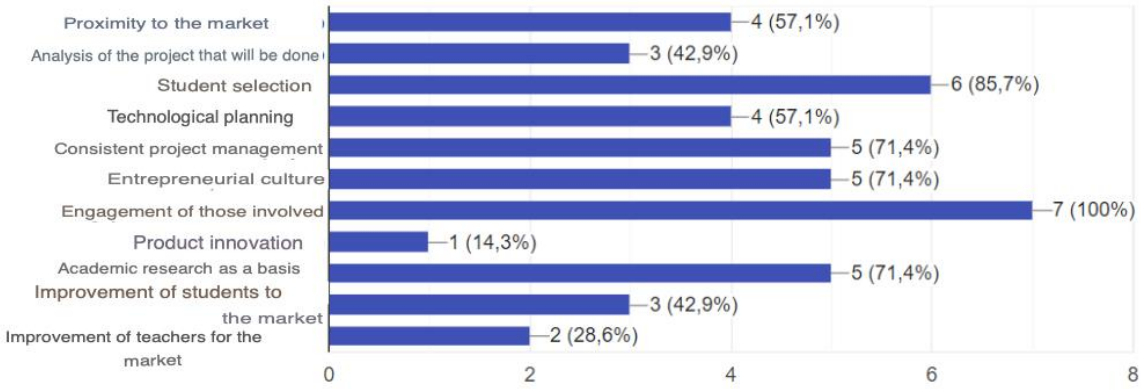
A survey (details in Appendix B) assessed the participating professors' familiarity with innovation processes, management and development tools, and their affinity for market principles. This quantitative approach enabled direct data collection on participants' behaviors and perceptions (Prodanov & Freitas, 2013).

The initial survey question addressed the use of established processes to guide Undergraduate Capstone Project (UCP) supervision. Only 57% of respondents reported using a process, whether personal or formal. The remaining 43% cited time constraints, lack of habit, and perceived lack of need as barriers to process adoption. Notably, when queried about preferred features for adopting a process, respondents emphasized simplicity, straightforwardness, and readily accessible usage guides on a dedicated webpage.

A key survey question explored the perceived relevance of various characteristics for a product-oriented UCP. As Figure 1 illustrates, all proposed characteristics received votes, suggesting their general perceived value within the academic environment. Interestingly, respondents prioritized characteristics related to project execution efficiency over explicit innovation elements. The one exception was "engagement of those involved," which received unanimous support, aligning with the observed low engagement and commitment identified in the conjuncture analysis.

Figure 1

Relevant characteristics for UCP guidance



Source: The authors

A survey assessed faculty perceptions of the department's proximity to market demands, using a 1-5 scale (5 representing highest proximity). The results revealed a significant perceived disconnect: at least 71% of respondents assigned the lowest score (2), indicating a substantial perceived distance between departmental activities and market needs. The remaining 29% scored 3, suggesting a slightly less pronounced sense of separation.

When asked about strategies to bridge this gap, professors proposed several initiatives:

1. Promoting Technology-Based Companies: Encouraging the creation of spin-offs or collaborative ventures focused on technology transfer and commercialization.
2. Early Integration of Entrepreneurial Education: Infusing core computing courses with entrepreneurial thinking and skill development to foster an innovation-driven mindset.
3. Personal Development Programs: Implementing programs from the outset of the program to strengthen student self-management and teamwork skills, crucial for market engagement.

4. Industry Partnerships: Organizing workshops and projects in collaboration with industry partners to provide students with real-world exposure and market understanding.

The survey also investigated faculty risk tolerance for supervising UCP incorporating innovative elements and targeting market needs. Again, using a 1-5 scale (5 representing higher risk tolerance), all respondents scored at least 3, indicating a generally positive attitude towards such projects. This suggests potential receptivity among faculty to engage in more market oriented and innovative UCP supervision.

The LUDUS Process

This section presents the development of the LUDUS process, designed to address the challenges identified in the previous section regarding the effectiveness of existing innovation processes in achieving market relevance.

LUDUS is characterized by its emphasis on cultural principles and guidelines that foster a market-oriented approach throughout the innovation process. It places particular importance on the development of Proof-of-Concept (PoC) prototypes and Minimum Viable Products (MVPs) to validate technical feasibility and gather user feedback early in the development cycle.

A PoC in LUDUS serves to demonstrate the technical feasibility of a specific feature or solution. It is not intended for user testing but provides internal validation of technical viability. In contrast, an MVP is a functional product with a core set of features ready for initial user testing and feedback. It may be built upon multiple PoCs focused on the same solution.

Roles within LUDUS

The LUDUS process defines clear roles for each participant to ensure efficient and effective execution.

1. **Project Manager:**
    - Leads one or more projects within LUDUS.

- Selected in the first phase by faculty based on project affinity.
- Oversees project progress, including PoC/MVP development.
- Can concurrently hold the advisor role if qualified.

2. **Academic Advisor:**
   - Guides the academic aspects of the project.
   - Ensures a UCP artifact meets scientific standards.
   - Can be separate from the project manager or combined if qualified.
3. **Demand Proponent:**
   - Possesses market expertise and interest in launching an innovative product.
   - Presents the proposal to faculty interested in using LUDUS.
   - Collaborates with the project manager on market aspects.
4. **Students:**
   - Selected by faculty based on predefined criteria.
   - Responsible for constructing the project as part of their UCP.
   - Actively participate in project development and execution.

Stages of the process

LUDUS employs a structured progression of phases and a cyclical project development stage to guide innovative projects towards market relevance.

5. **Idea Analysis (Professors & Partners):** Collaboration between faculty and potential stakeholders to assess project ideas based on market potential, feasibility, and alignment with LUDUS objectives.
6. **Selection Process:** Rigorous selection of projects based on predefined criteria to ensure compatibility with available resources and market potential.

7. **Alignment & Training:** Orientation and training for selected teams on LUDUS methodology, market understanding, and technical skills needed for successful project execution.
8. **Project Planning:** Collaborative development of a comprehensive project plan with clear goals, milestones, tasks, and resource allocation.
9. **Iteration Planning:** Cyclical planning within the project development phase, defining specific tasks, deliverables, and evaluation criteria for each iteration.
10. **Project Development (Cyclical):**
    - **Sprint Backlog:** Defining and prioritizing tasks for each iteration within the development cycle.
    - **Progress:** Active development of project components and features according to the planned iteration.
    - **Validation & Testing:** Rigorous evaluation of progress through internal and external testing to ensure functionality and market alignment.
    - **Completed:** Finalization of deliverables within the planned iteration for review and evaluation.

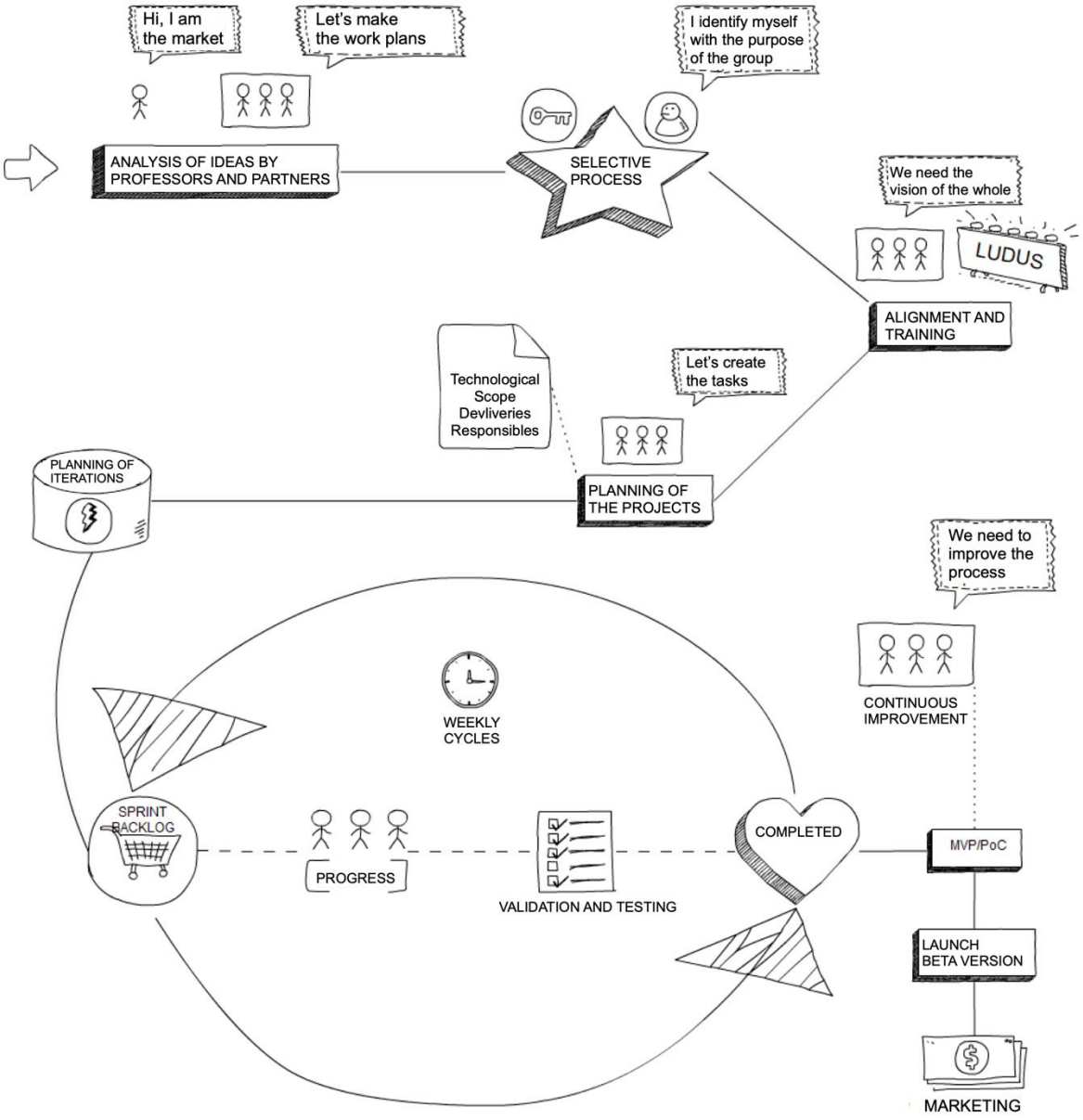
Following successful project development, LUDUS emphasizes external engagement through various pathways, including:

- **Entrepreneurial Initiatives:** Encouraging project teams to pursue entrepreneurial options for launching and commercializing their solutions.
- **Partnerships:** Facilitating collaborations with external institutions, companies, or investors to support broader impact and market success.

Figure 2 provides a visual representation of the complete LUDUS process, detailing the sequential phases and cyclical project development stages.

Figure 2

LUDUS process: overview



Source: The authors.

Analysis of ideas by professors and partners

The LUDUS process prioritizes market vision from the start. Ideally, someone with strong market understanding presents the initial ideas, ensuring their future viability. Requiring a

Business Model Canvas (BMC) for proposals could be used as a selection criterion, encouraging structured consideration of key market and commercialization aspects.

For generating ideas, two techniques are recommended:

- **Brainstorming:** This encourages a large volume of ideas in a welcoming, non-judgmental environment.
- **Synectics:** This technique delves deeper, aiming for highly innovative solutions by deliberately tapping into preconscious mental processes.

Once initial ideas are generated, a SWOT analysis helps further refine them. By mapping internal strengths and weaknesses alongside external opportunities and threats, promising ideas can be identified, and infeasible ones discarded.

Selected solutions are then transformed into detailed work plans. Each work plan can encompass a single Minimum Viable Product (MVP) with multiple Proof-of-Concept (PoC) prototypes and additional tasks to connect them. In academic terms, this translates to defining one or more well-defined research objects.

Figure 3(a) visually represents the key steps and workflow of the idea analysis phase.

Selection process

The selection stage in LUDUS assumes work plans are finalized and ready for student selection based on their profiles. To participate, students must be aware during the call for selection that their UCP will follow LUDUS methodology and aim for a market-oriented PoC or MVP. It's recommended to adopt the CHA (Competence, Habilitation, and Attitude) framework for student selection. An online form for interested parties could gather vital information such as: minimum available hours for the UCP, number of courses remaining for graduation, employment or internship status, preferred area of work plan.

Like technical skills, understanding these factors is crucial for successful project execution. Figure 3(b) visually represents the complete selection process.

Alignment and Training

The alignment and training stage aims to integrate newcomers into the team culture, clarify student roles. Here's what happens in this stage:

1. **Learn about LUDUS:** Students get a full overview of the LUDUS process and its key ideas. They learn about each stage and how it fits into the bigger picture.
2. **Deep dive into work plans:** The instructor goes through each work plan area in detail, explaining any confusing parts. They clarify how each student's work fits into the overall "macro solution".
3. **Expectations and deliverables:** Both the UCP and project expectations are clearly explained. Students know exactly what they need to do and what they're responsible for.

Project planning

This stage focuses on several crucial aspects of project planning, as shown in Figure 3(c): choosing the appropriate technologies to execute the project effectively, clearly outlining the project's boundaries and deliverables, crafting narratives from the end-user perspective to describe desired functionalities and setting realistic deadlines for project milestones. Each student takes ownership of their Capstone project and the corresponding PoC or MVP. Tasks with interdependencies require careful consideration to ensure smooth workflow. For instance, the output of one task might be necessary for another to proceed. Defining the solution scope and crafting user stories are collaborative efforts. The scope encompasses all project activities, represented by user stories.

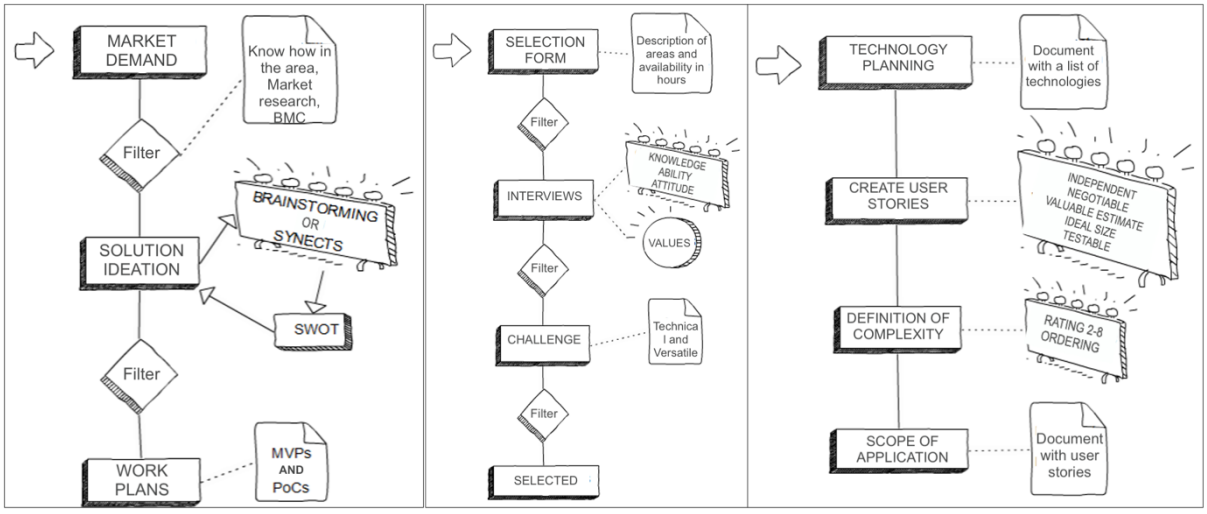
In software development and project management, user stories are informal, natural language descriptions of software features. Typically written from the end-user's perspective, they

can be documented in project management software. While the entire team can contribute to user stories, LUDUS emphasizes student creation under faculty guidance and problem analysis. User stories promote effective communication and shared understanding among developers. They provide context and meaning, enabling the team to organize themselves and grasp the software's purpose.

Following user story creation, the team collaboratively estimates the time required for each story. Through group discussions and analysis, they categorize stories based on implementation time, potentially breaking down larger ones into smaller, more manageable units. Time and effort estimation in IT can be challenging but comparing stories with diverse functionalities aids in judging relative completion times. Each story is assigned an effort score ranging from 2 to 8 points, ensuring complex stories remain achievable within a week.

Figure 3

(a) Idea analysis, (b) student selection, (c) project planning sub-process



Source: The authors

Planning Iterations

This stage serves as a crucial preparatory step for project development. Its primary objective is to distribute user stories among students and faculty, aligning them with the available timeframe of the academic term (typically 4-5 months, approximately 18 weeks). Given the project's iterative nature with weekly deliveries, effective scope management and individual productivity are paramount. User stories are distributed based on the available timeframe, encouraging students to critically assess task scope and individual workloads. This fosters consistency and promotes realistic delivery expectations throughout the project. Each user story undergoes further refinement, broken down into smaller, well-defined development tasks. This ensures that all necessary tasks are identified and accounted for within the weekly delivery cycle. The granularity of task breakdown aims to guarantee that completion of all assigned tasks within a week leads to the successful realization of the corresponding user stories.

Development

The LUDUS development phase leverages Kanban, a visualization tool from the Scrum methodology, to optimize value delivery for stakeholders. As Gomes (2018) highlights, Kanban serves as a visual workflow management strategy, providing transparency into individual and team workloads. A dedicated LUDUS Kanban tool is recommended to facilitate this process.

Due to students' not having exclusive project dedication, LUDUS employs a blended approach of weekly face-to-face meetings and remote work. These meetings serve as progress review sessions during the development phase. Maintaining consistent weekly deliveries is crucial, with students presenting their previous week's accomplishments and upcoming plans each week.

This phase also necessitates a project manager who actively promotes and supports task progress. Kanban's holistic visualization empowers each faculty member to act as a manager for

their advisees, aligning with LUDUS's principle of fostering student self-management development (Schwaber & Sutherland, 2011).

As illustrated in Figure 4, the cyclical LUDUS development phase comprises four stages:

1. Sprint Backlog: All user stories and associated tasks planned for the week are added here.

2. Progress: This section houses only currently active tasks and stories, reflecting the ongoing development activities.

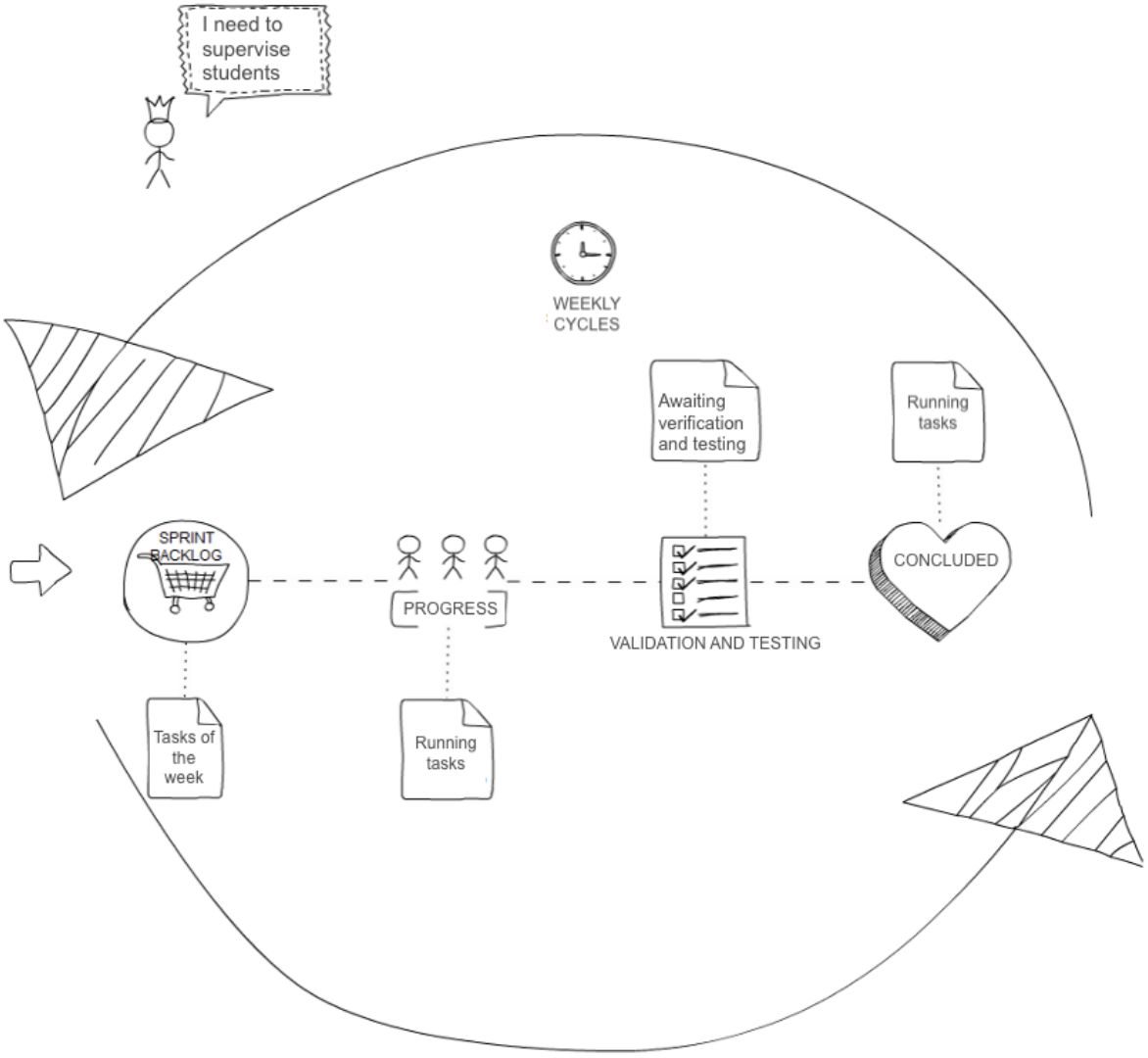
3. Validation & Testing: Completed tasks undergo technical testing and functionality approval by the manager and demand proponent.

4. Completed: This stage stores all tasks successfully finalized within each development cycle.

Transparency is a key feature of this phase. Kanban's visual nature grants the entire team visibility into project progress, motivating slower-performing students to analyze potential roadblocks and implement efficiency improvements.

Figure 4

Development sub-process



Source: The authors

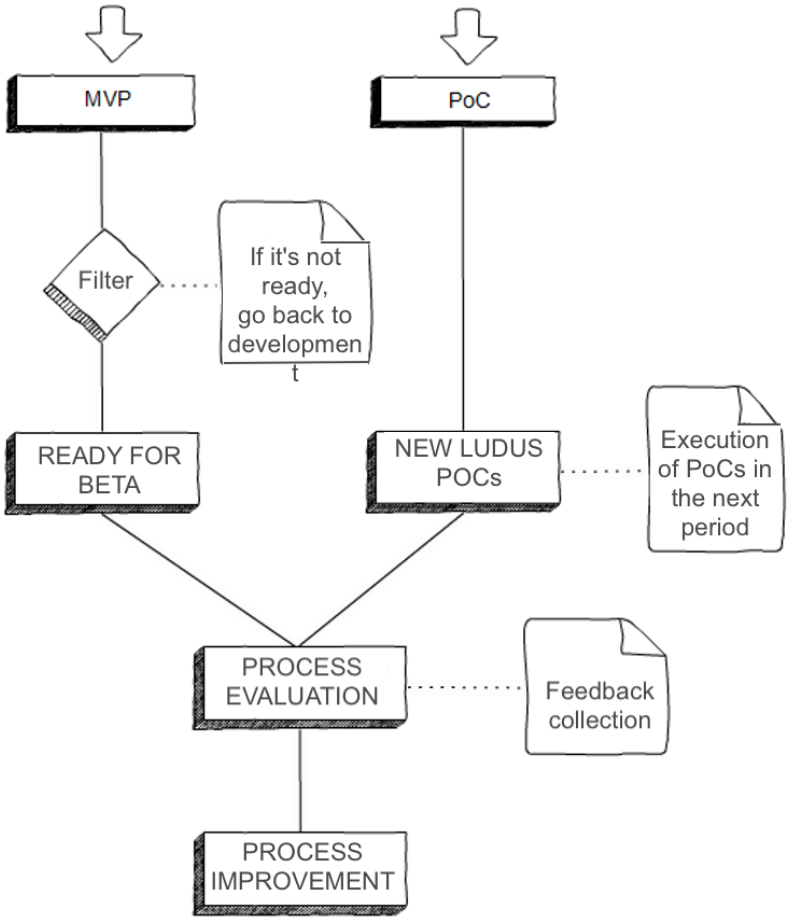
MVP & PoC

The LUDUS evaluation phase focuses on comprehensively assessing the entire project, regardless of whether it culminates in a PoC or MVP. This stage offers valuable insights for future project enhancements, as summarized in Figure 5. A thorough evaluation confirms if all planned functionalities and features are successfully implemented within the MVP.

Comprehensive testing involving all project stakeholders ensures the MVP's technical soundness and operational efficiency. Based on successful alpha testing results, the MVP progresses to beta testing for broader audience involvement. If deemed necessary, additional PoCs in subsequent academic periods might be planned to refine the solution and pave the way for a future MVP. For interested applicants, the PoC can serve as a springboard for developing a commercially viable project.

Figure 5

MVP and PoC sub-process



Source: The authors

The LUDUS evaluation process prioritizes gathering comprehensive feedback from all stakeholders involved. To facilitate this feedback collection, a structured online form can be implemented. This form should capture both positive and negative aspects of the experience, guiding improvements for future LUDUS iterations in the following academic periods.

Beta release

The LUDUS beta testing stage is reserved exclusively for projects that have successfully achieved Minimum Viable Product (MVP) status. At this point, the core LUDUS requirement is launching the beta test itself. The MVP is tested with carefully selected groups to gauge user interest and gather valuable feedback. This controlled environment allows for rigorous data collection and analysis. All project stakeholders, including the demand proponent, actively participate in developing a go-to-market strategy and business plan for the commercialization of the solution.

Applying LUDUS

This section showcases the implementation of LUDUS in a project involving five UCPs aiming to develop a Minimum Viable Product (MVP). It begins with a clear overview of the chosen project, followed by a detailed report on LUDUS application during the institution's 2019.1 and 2019.2 academic terms. Finally, the results achieved through LUDUS implementation are presented and discussed.

Case study: LIA, the Real Estate Virtual Assistant

This section presents a case study involving the development of LIA, a virtual assistant for buying and selling real estate. The project, initiated by a local businessman, was executed under the guidance of one of this article's co-authors across two academic terms (2019.1 and 2019.2).

The Project scope and goals were (1) to build a virtual assistant named LIA, specializing in real estate transactions, (2) demonstrate LIA's ability to converse within the real estate domain, (3) construct the virtual assistant using the Rasa framework, (4) enable LIA integration with various communication channels (web, WhatsApp, Slack) and (5) create a real estate database and recommendation API (to be integrated with LIA).

Each semester focused on specific objectives through individual work. For 2019.1:

- Work 1: LIA's domain of action and conversational ability.
- Work 2: Construction of LIA using the Rasa framework.
- Work 3: Integrating LIA across web, WhatsApp, and Slack.

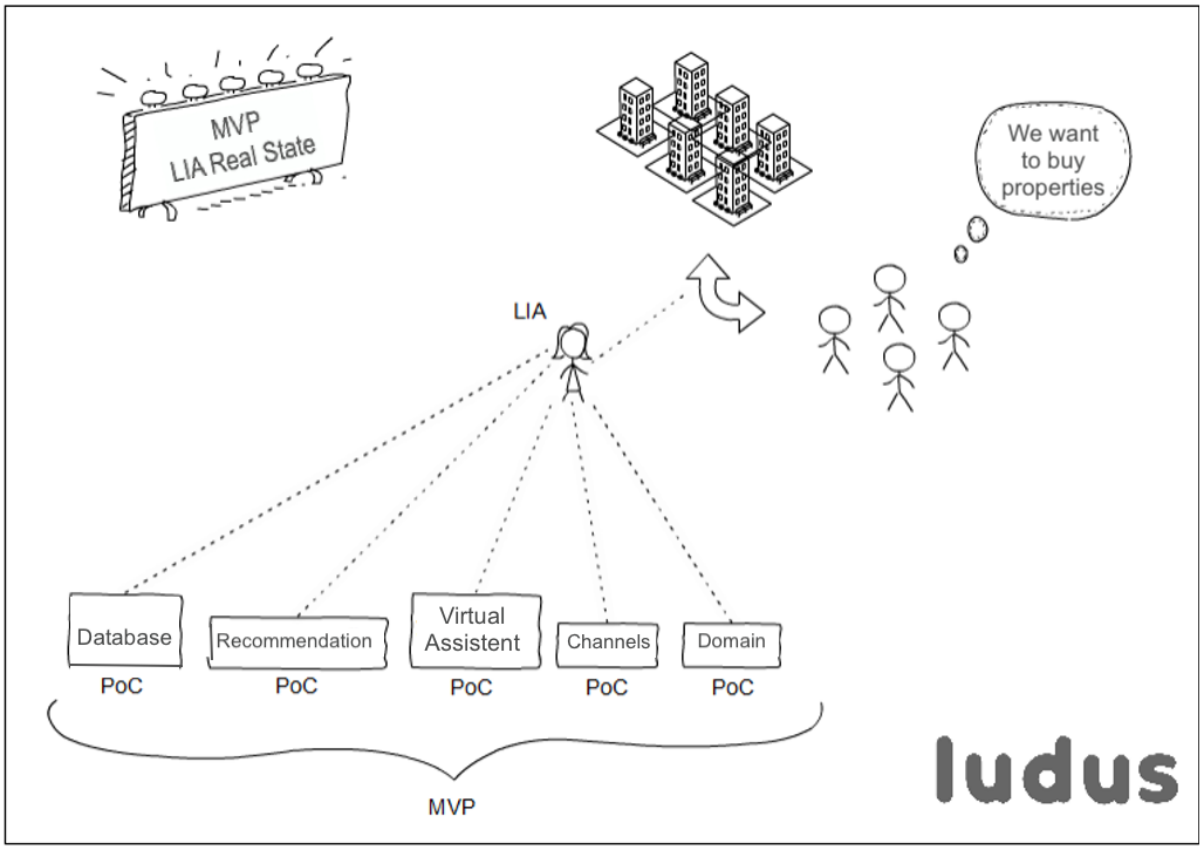
For 2019.2:

- Work 4: Building a real estate database.
- Work 5: Developing a real estate recommendation API.

Each work functioned as a Proof-of-Concept (PoC), demonstrating the feasibility and construction of key functionalities for the final MVP (Figure 6).

Figure 6

Visualization of the MVP LIA according to LUDUS



Source: The authors

Report of use of LUDUS in 2019.1

The first iteration of LUDUS was applied to the 2019.1 semester's UCPs, spanning approximately four months. This initial version omitted certain stages, including selection, alignment & training, and commercialization, with minor variations in the planning phase.

The semester yielded three PoCs that served as foundational elements for subsequent work:

- Chatbot Integration across various human-computer interfaces
- Real estate buying/selling interest domain ontology for chatbots
- LIA, an intelligent real estate chatbot

Project monitoring used Trello, a collaborative tool, to ensure transparency and facilitated project monitoring. LUDUS development stages were represented as dedicated columns on the Trello board (sprint backlog, progress, validation & testing, completed).

Refining LUDUS in 2019.2: Iteration, Selection, and Progress

Building upon the final version of LUDUS, the 2019.2 semester saw significant advancements in the project's implementation. Key developments included:

1. **PoC Continuity and Enhanced Focus.** Two new PoCs emerged: 1) analyzing LIA's performance with a graph database, and 2) exploring recommender systems for the real estate domain. Renewed emphasis on prioritizing essential project activities and consistently presenting their progress.
2. **Refined Selection Process.** Strict adherence to LUDUS principles ensured alignment with the project's needs when selecting students for remaining PoCs. A streamlined online application process attracted 8 candidates. Selection criteria balanced enthusiasm for building a marketing solution with technical experience and alignment with LUDUS values.
3. **Comprehensive Training and Alignment.** LUDUS principles and practices were presented clearly and objectively. Experts provided valuable insights on relevant technologies and market trends. Previous semester students shared their experiences and knowledge to facilitate a smooth handover.
4. **Effective Planning and Collaboration.** A dedicated technology document outlined development needs for each project. User stories were meticulously crafted using INVEST guidelines and the Five Ws template. Collaborative effort estimation ensured realistic timeframes based on story complexity.

5. **Optimized Iteration Planning and Development.** User stories were strategically distributed across the 116-day semester, considering available time and team capacity. Each story was further broken down into actionable development tasks for clarity and focus. Trello served as a central platform for managing workflow, with user stories represented as cards assigned and due-dated. The PoC development cycle witnessed intense team interaction and collaboration. Unforeseen events were swiftly addressed with the support of the manager, professors, and the demand proponent. Each development stage had a dedicated Trello column (backlog, progress, validation, testing, completed), ensuring transparency and efficiency.
6. **Successful Evaluation and Moving Forward.** All PoCs and the MVP underwent thorough evaluation, including satisfactory alpha testing for the MVP. As the MVP demonstrated readiness for beta testing, no further PoCs were required at this stage.

The 2019.2 experience underscored the potential of LUDUS in guiding successful project development. Continuous improvements and adaptations will further optimize its effectiveness for future semesters. The refined selection process ensured students aligned with LUDUS values and project requirements. Consistent progress presentation fostered transparency and accountability. Collaborative development facilitated effective problem-solving and knowledge sharing. Clear planning and task breakdown led to a more efficient workflow.

Results and discussion

For evaluation purposes, questionnaires were prepared and applied to obtain the view of students and professors about the applicability of LUDUS and the possible improvement of the process of conducting UCPs in relation to the analysis of the situation carried out in the 2018.2 school term. The perspectives of the students and professors involved were separated into subsections.

Student Perspectives and Feedback

This section dives into the student perspective on LUDUS's impact on UCPs, based on questionnaire responses. The questionnaire design focused on understanding LUDUS's influence on several key aspects of the UCP development process:

1. **Market Focus Awareness:** Were students informed about the intention for a more market-oriented UCP profile before applying?
2. **Dropout Rates and Causes:** Did students drop out during the process? If so, what were the primary reasons?
3. **Process Clarity and Instruction:** Was the LUDUS process effectively explained and delivered?
4. **Entrepreneurial Knowledge:** Did LUDUS contribute to students' understanding of entrepreneurial culture?
5. **Behavioral Skills Awareness:** Did the process cultivate understanding of the importance of behavioral skills?
6. **Outcome Satisfaction:** Did the final UCP project achieve its set objectives?
7. **Improvement Suggestions:** What potential improvements or adjustments could be made to the LUDUS process?

Analyzing student responses from 2019.1

This section dives into the detailed analysis of student feedback from the 2019.1 semester, providing valuable insights for refining the LUDUS process. 10 students participated, all responding to the questionnaire. Distribution of research themes across Capstone 1 and 2 stages is shown in Table 8.

Table 8

Research topics and number of papers in 2019.1

Theme	Number of people involved
Blockchain	3
Chatbots	3
IT Management	1
Machine Learning	1
Sports Trading	1
Code Similarity Detection	1

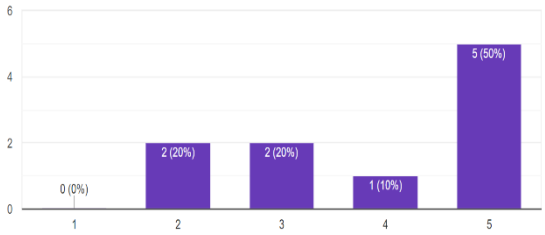
Source: The authors

Most students felt the project themes' proximity to the market was clear, despite the absence of a formal selection process in this period (Figure 7a) and 60% of respondents fully complied with the LUDUS process (Figure 7b); the main reasons for non-compliance included: inadequate academic work, mid-semester withdrawal, lack of focus and competing priorities (employment). Only 10% significantly emphasized LUDUS's contribution to the marketing project (Figure 7c). This suggests room for improvement in communicating and realizing the value of connecting LUDUS to marketable solutions. 70% of respondents rated process clarity and didactics highly (Figure 7d). This indicates students generally grasped the LUDUS framework and its implementation. All respondents positively evaluated LUDUS's impact on understanding entrepreneurial culture (Figure 7e). This highlights the success of LUDUS in fostering market-oriented thinking and project development. 70% expressed high satisfaction with their project outcomes (Figure 7f). However, 10% rated their results poorly, suggesting potential aspects for improvement.

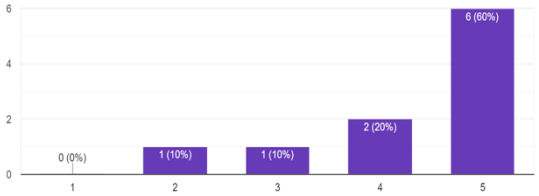
Figure 7

Questionnaire responses from 2019.1 Capstones participants (histograms)

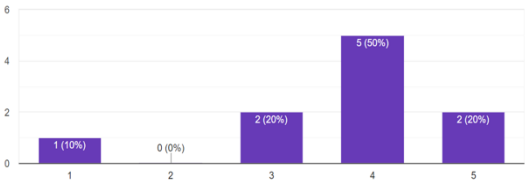
(a) Evaluation of prior knowledge about the proximity of the teaching group to the market.



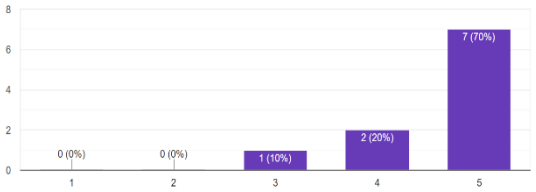
(b) Evaluation of participation in LUDUS until the end of the process.



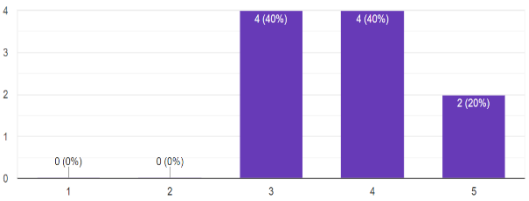
(c) Evaluation of the contribution of LUDUS to the UCP



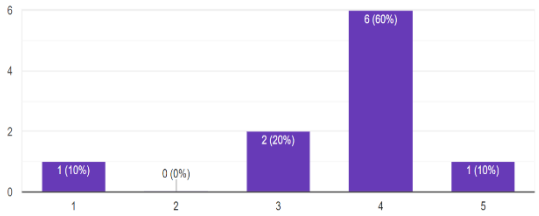
(d) Evaluation of the didactics and clarity of the process



(e) Evaluation of the impact of LUDUS on the understanding of entrepreneurial culture



(f) Evaluation of the academic objectives of the UCP.



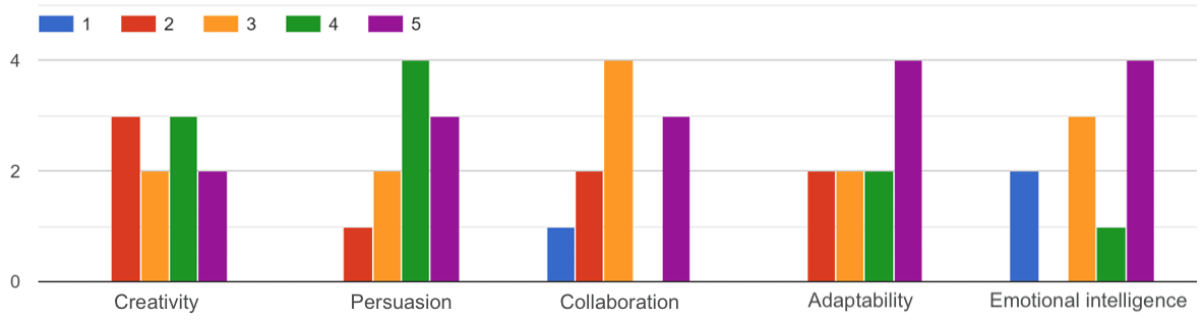
Source: The authors

All evaluated behavioral skills (creativity, persuasion, collaboration, adaptability, emotional intelligence) were seen as important (Figure 8). Adaptability and emotional intelligence received slightly higher scores, indicating areas for potential emphasis. In regard to

project completion rates, 60% of submitted papers resulted in PoCs, 60% of students completed their UCP artifacts and 20% completed with a semester delay. Notably, students who successfully completed the market project also completed the UCP artifact (though extra effort was required for PoC/MVP development). This correlation suggests the additional work may contribute to overall project success, rather than leading to dropouts as initially feared.

Figure 8

Evaluation of the impact of LUDUS on the understanding of behavioral skills in 2019.1



Source: The authors

The 2019.1 results reveal positive student experiences with the LUDUS process, particularly in terms of clarity, market awareness, and entrepreneurial understanding. Areas for improvement include:

- Encouraging wider recognition of LUDUS's contribution to marketable solutions.
- Addressing aspects contributing to the 10% of students with less satisfactory outcomes.
- Refining the communication and emphasis on specific behavioral skills.

The correlation between successful market projects and UCP completion requires further investigation. Researching causal factors could inform future process adjustments.

Analyzing student responses from 2019.2

This section analyzes student responses from the 2019.2 semester, drawing comparisons with 2019.1 and revealing valuable insights for further process development. 7 students

participated, with 6 responding to the questionnaire. Like 2019.1, research themes across Capstones 1 and 2 are shown in Table 9.

Table 9

Research topics and number of capstones in 2019.2

Theme	Number of people involved
Computer Vision	2
Sports Trading	1
Recommendation algorithm	1
Database	1
Code Similarity Detection	2

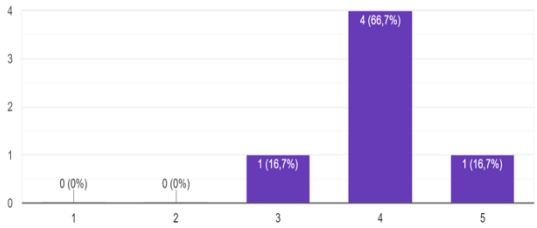
Source: The authors

The implemented selection process in 2019.2 clearly influenced market focus awareness, as demonstrated by histogram (a) in Figure 9 compared to Figure 7. Process completion rates rose to 67% in 2019.2 (Figure 9b), likely due to the selection process. Reasons for non-compliance remain unreported, requiring further investigation. Interestingly, none of the respondents saw significant value added by LUDUS to the marketing project (Figure 9c). This highlights the need to bridge the gap between LUDUS and its practical application in marketing efforts. Similar to 2019.1, students generally perceived the process as clear and well-taught (Figure 9d). Maintaining strong clarity and didactics remains crucial for future iterations. Evaluations were even more positive compared to 2019.1 (Figure 9e), suggesting LUDUS continued to effectively foster entrepreneurial thinking. Satisfaction rates declined to around 50% in 2019.2 (Figure 9f), possibly indicating areas for improvement in project guidance or support.

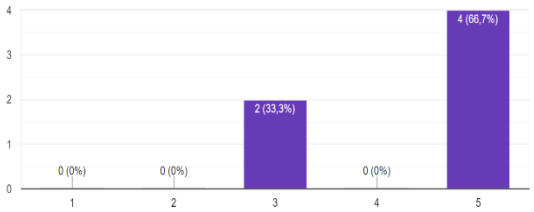
Figure 9

Questionnaire responses from 2019.2 Capstones participants (histograms)

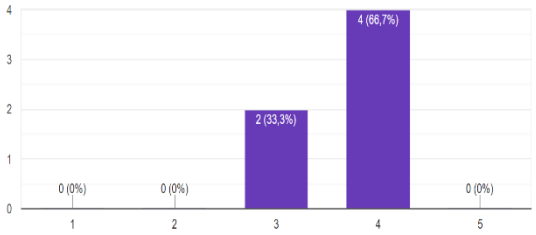
(a) Evaluation of prior knowledge about the proximity of the teaching group to the market.



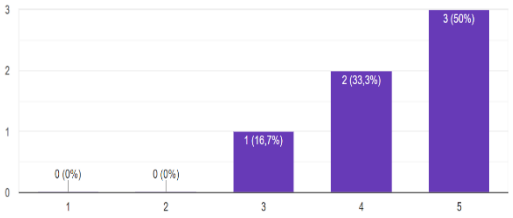
(b) Evaluation of participation in LUDUS until the end of the process.



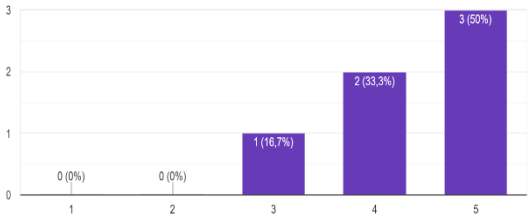
(c) Evaluation of the contribution of LUDUS to the UCP



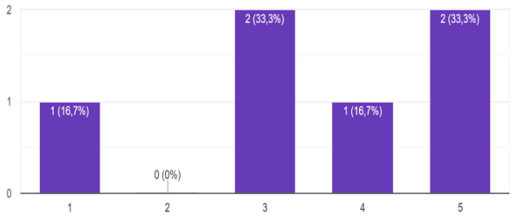
(d) Evaluation of the didactics and clarity of the process



(e) Evaluation of the impact of LUDUS on the understanding of entrepreneurial culture



(f) Evaluation of the academic objectives of the UCP.



Source: The authors

Behavioral skills importance remained consistent, with a potential subtle emphasis on collaboration (Figure 10). The 2019.2 results support the positive impact of LUDUS on market

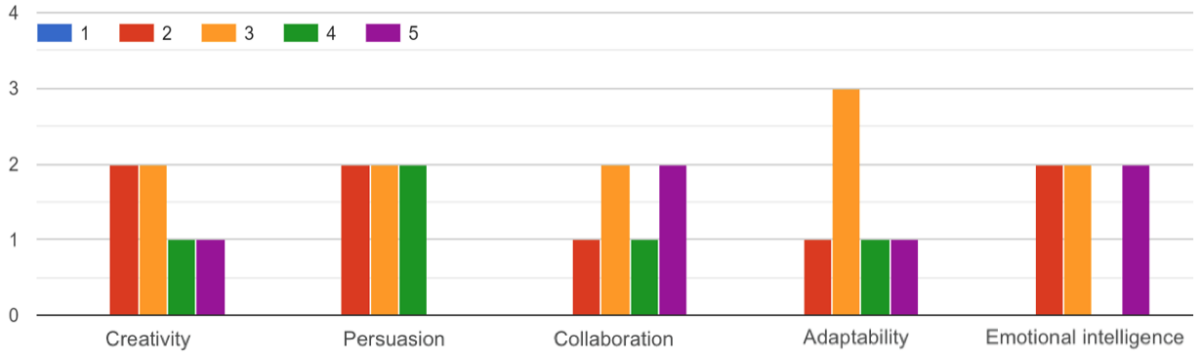
focus awareness, process clarity, and entrepreneurial understanding. Areas requiring attention include:

- Bridging the gap between LUDUS and its practical application in marketing.
- Investigating reasons for lower satisfaction rates in 2019.2.
- Exploring potential factors influencing the subtle shift in perceived importance of specific behavioral skills.

Further research on the causal relationship between process compliance, market project contribution, and Capstone projects satisfaction could inform valuable adjustments.

Figure 10

Evaluation of the impact of LUDUS on the understanding of behavioral skills in 2019.2



Source: The authors

Analyzing professor feedback on LUDUS's impact on Capstone projects

This section explores the feedback provided by professors involved in UCPs to understand the perceived effects of the LUDUS process on project development. Six professors who actively supervised projects both before and after LUDUS implementation participated in the evaluation.

Table 10 summarizes professor assessments of various LUDUS characteristics using a 1-5 rating scale. Notably, "improvement of students and professors for the market" received the highest average score (bold), highlighting LUDUS's potential in aligning academic and market dynamics. Similarly, "relationship with the market" was well-rated, reinforcing this focus. However, "market validation" received the lowest average (italicized), indicating a need for incorporating validation practices within LUDUS.

Table 10

Evaluation of the characteristics of LUDUS by professors/advisors

Characteristics	Note 1	Note 2	Note 3	Note 4	Note 5
Relationship with the market	0	0	0	**3**	**3**
Market Demand Analysis	0	0	0	6	0
Creating Work Plans	0	0	2	2	2
Student Selection	0	0	0	5	1
Technological planning	0	0	1	3	2
Project development	0	0	0	**3**	**3**
Remote and face-to-face approach	0	1	2	1	2
In-market validation	0	*1*	*4*	1	0
Entrepreneurial culture	0	0	1	4	1
Engagement of those involved	0	0	2	2	2
Product Innovation	0	0	2	2	2
Academic research	0	0	2	1	3
Improvement of students and professors for the market	0	0	0	**2**	**4**

The values in the cells represent the number of votes for that particular grade. Bold prominence was given to traits with the highest weighted averages, while italicized prominence was given to trait with the worst rating.

Source: The authors

Table 11 presents professor evaluations on three crucial aspects of LUDUS's impact:

1. Capstone objective fulfillment: Overall, professors perceived that LUDUS facilitated achieving Capstone objectives.
2. Department needs: The potential of LUDUS in addressing departmental needs related to market-focused projects and partnerships was positively evaluated.
3. Entrepreneurial understanding: Professors perceived a positive impact on students' understanding of entrepreneurial culture due to LUDUS.

Table 11

Evaluation of some impacts of LUDUS by professors/advisors.

Impacts	Note 1	Note 2	Note 3	Note 4	Note 5
LUDUS made it possible to meet the objectives of the UCP	0	0	1	3	2
LUDUS meets the department's needs in terms of market development and partnerships	0	0	1	3	2
Impact of LUDUS on the understanding of entrepreneurial culture	0	0	1	3	2

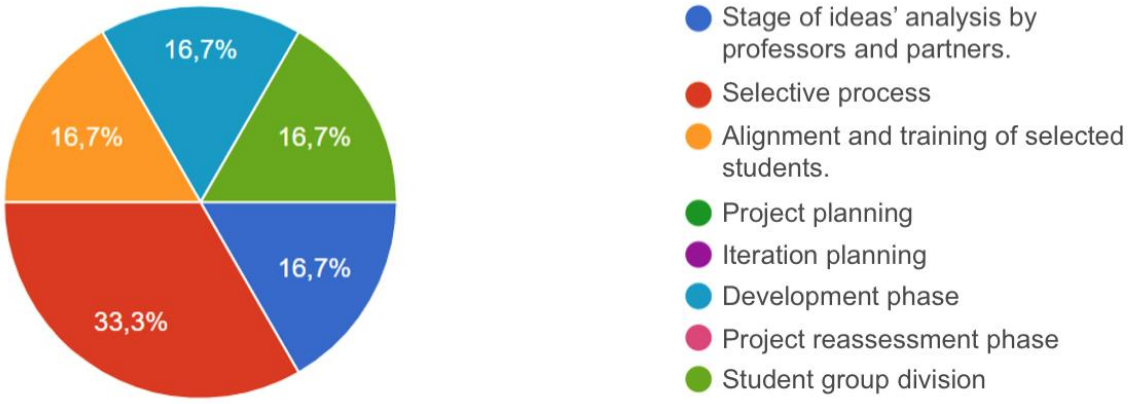
Source: The authors

These findings collectively suggest a generally positive perception of LUDUS by these professors. Interestingly, the table also hints at the possibility of applying LUDUS beyond its initial scope, potentially serving other departmental needs or supporting computational solutions across the institution.

Figure 11 illustrates the key areas identified by professors for improvement in LUDUS. Interestingly, the student selection process continues to be the most concerning aspect, requiring continued attention.

Figure 11

Indication of improvements to LUDUS by professors/advisors



Source: The authors

This analysis indicates that professors perceive LUDUS to be positively impacting Capstone development, particularly by fostering market-oriented skills and project planning. Identifying "market validation" as a weakness necessitates incorporating relevant practices into the LUDUS framework. The potential for broader departmental application raises intriguing possibilities for future exploration. Moving forward, addressing the selection process concerns identified in Figure 11 is crucial. Additionally, considering quantitative analysis of the feedback data and investigating the longer-term impact of LUDUS on both students and professors could provide valuable insights.

Conclusion

This research addressed the critical concern identified in a university undergraduate course, namely the lack of a well-defined process integrating innovation, academic production, and market considerations. This gap often leads to inconsistencies in scale, frequency, engagement, and diversity within research endeavors.

The primary objective was to design and evaluate a process, named LUDUS, for managing and developing ICT-related academic work that fosters innovation and stimulates entrepreneurial spirit. In practice, LUDUS aims to guide research towards the creation of a minimum viable product (MVP) or at least a proof of concept (PoC).

The implemented case study demonstrated the effectiveness of LUDUS in guiding the development of market-oriented academic works. Notably, five PoCs linked to undergraduate capstone projects (UCPs) were successfully completed, alongside the expected deliveries and defenses of associated academic documents. Furthermore, a stark contrast was observed in innovation artifact (product) completion rates compared to the pre-LUDUS period. Previously, none of the 16 analyzed proposals yielded even one PoC, while with LUDUS (after its second iteration), the success rate for completion of academic artifacts raised from approximately 69% to 86%.

It's important to emphasize that LUDUS wasn't just built to bridge the gap between academia and the market. It's intrinsically a "market-biased" project leveraging innovation, people management, project management, and software development approaches. LUDUS provides departments with a playful and didactic framework to navigate project development despite complex academic nuances. Determining the specific application context for LUDUS was a critical step, as optimal solutions vary depending on individual challenges. Through analysis of the broader environment and engagement with both students and faculty, this work identified and addressed key characteristics relevant for UCPs aiming to produce marketable products, with particular emphasis on the selection process and fostering an entrepreneurial culture.

Engagement is another noteworthy aspect of LUDUS, achieved by providing learners with a clear purpose: building a project and potentially launching their own startup. In future iterations, establishing a defined protocol for validating MVPs with external users represents a

key limitation to address. Additionally, plans are underway to develop a scalable computational platform to transform LUDUS into a digital market product.

AUTHORS' CONTRIBUTIONS

Contributions	Macedo, H.	Barreto, H.	Silva, G.	Prado, B.
Contextualization	X	X	X	X
Methodology	----	X	X	----
Software	----	----	----	----
Validation	X	X	X	X
Formal analysis	X	X	----	----
Investigation	X	X	----	----
Resources	----	X	X	----
Data curation	----	X	----	----
Original	X	X	----	----
Revision and editing	X	----	X	X
Viewing	X	X	----	---
Supervision	X	---	----	----
Project management	X	X	----	----
Obtaining funding	----	----	----	----

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