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DEVELOPING A FRAMEWORK FOR RAPID LEARNING DYNAMICS AND PROTOTYPING IN HIGH-PRESSURE HACKATHON ENVIRONMENTS: AN ACTION RESEARCH STUDY

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ABSTRACT

This study aims to develop a systematic framework for learning dynamics and modeling within competitive hackathon environments, utilizing them as a Procedural framework to redefine achievement in the digital age. Employing a Action Research methodology, the research tracks a multidisciplinary team during the 4th Saudi Industrial Development Fund (SIDF) Industrial Hackathon 2025. The study evaluates the implementation of physical, digital, and hybrid prototyping strategies and their subsequent impact on final product quality. Data collection utilized observation cards to monitor rapid learning mechanisms, a product checklist to document the transition from concept to reality, and a prototyping evaluation matrix to assess feasibility. Findings indicate that reliance on rapid, exploratory, and experiential learning facilitated effective knowledge transfer among team members. The feasibility and execution score improved significantly, and the application framework has proven effective in raising the efficiency of the final product by 75% through adaptive learning and hybrid modeling practices. The results highlight how high-pressure environments accelerate the bridge between conceptual design and industrial viability. The study concludes by recommending the integration of pressure-driven skill development and iterative prototyping into academic environments to empower innovators and enhance the practical relevance of design education.

1. INTRODUCTION

Today, the world of design and innovation is facing an unprecedented acceleration, as success no longer depends solely on the quality of the final idea, but on the speed with which the idea is transformed from a mere mental visualization into a tangible, testable model. Hackathon events provide a model for modern innovation within dense working environments; during which initial ideas are immediately transformed into executable products within a strict timeline. This environment: which includes teams with different vocational and specialization backgrounds, has become a real-life laboratory to discover techniques to boost effective teamwork; and accelerate the processes of creative brainstorming and information comprehension.

Hackathon environments help provide a comprehensive methodology for applying rapid prototyping techniques with a focus on the use of STL files that assist in forming and manufacturing processes with the help of digital computer control (Zivanovic et al., 2020) , Due to the importance of rapid response to market demands and the application of new concepts; hackathons have emerged as a powerful tool to evaluate the technical and design skills of interdisciplinary team members.

The challenge here is to fully understand how teams participating in hackathons achieve high levels of creativity and technical skills despite the short deadline and limited time frame. Most importantly, working in such environments requires me to work with design thinking and process-centric design, and requires integrating the skills of all members of the multidisciplinary team together to produce a prototype rather than paper models. How this is done requires in-depth research into how these individuals with different professional backgrounds share their knowledge and how they interpret their theoretical understanding into tangible results with unprecedented efficiency. (Weisel & Zultan, 2021)

This research presents a proposed framework aimed at organizing rapid learning mechanisms and prototyping dynamics By adopting an action research methodology, this study seeks to monitor and analyze these mechanisms within the hackathon environment, and then formulate them into a practical framework that can be applied in professional design practices, giving designers and startups the ability to manage innovation in the most complex and time-constrained circumstances.

1.1. Research Problem

The problem lies in the systematic gap between traditional design methods and innovative-intensive environments (such as hackathons), which impose enormous time pressure that requires immediate technical and design decisions. The study notes that designers and innovators in these environments suffer from wasted time in ill-considered experiments due to the lack of a framework that integrates rapid learning mechanisms and modeling dynamics. Therefore, this study seeks to address this shortcoming by building a framework that balances the speed of implementation with the quality of educational and technical outputs.

1.2. Research Questions

The study revolves around the following main question: "How can a methodological framework be developed to organize rapid learning and prototyping mechanisms in high-pressure hackathon environments?", The following sub-questions arise from it:

1. What cognitive and technical challenges do hackathon participants face when trying to learn new skills during implementation?
2. How does the "rapid modeling" process accelerate technical understanding and reduce the gap between ideas and application?
3. What are the key elements and processes that a proposed framework should include to ensure effective learning and dynamism at work?
4. To what extent can this proposed framework improve the efficiency of innovation outcomes in professional design practices?

1.3. Research Objectives

1. Monitor and analyze learning behaviors and prototyping mechanisms in high-pressure environments (hackathons).
2. Build and develop a proposed framework that integrates experiential learning theories and rapid modeling dynamics.
3. Testing the effectiveness of the framework through procedural research methodology to evaluate its impact on the quality of innovation and speed of completion.

1.4. Importance

Deep research studies are based on methodological foundations that constitute an intellectual foundation that clarifies the problem. The research study relies on theory, objectivity, and methodology, which work together to ensure the integrity of the research and produce solid methodological knowledge (Du et al., 2023). Procedural research is a form of participatory applied

research that combines quantitative and qualitative data collection with field observation and critical analysis, with the goal of solving direct practical problems and developing professional performance through continuous cycles of planning, implementation, and evaluation, ensuring realistic results and applicable scientific conclusions. (Weisel & Zultan, 2021). Theories are essential in guiding the study's conceptual framework, as they help analyze the phenomenon and clarify complex relationships. (Liu, 2024). The hackathon case study offers a conceptual and objective framework that demonstrates how multidisciplinary teams collaborate under time constraints and rapid prototyping conditions to conduct a design research project and develop a practically implementable prototype.

The importance of the research is further detailed in the following areas:

- Presenting a research model that applies "procedural research" in the contexts of contemporary digital and technological innovation.
- Providing designers and innovators with tools and methodologies that enable them to quickly learn and test ideas in short periods of time
- Provide a framework that can be adopted in "innovation labs to reduce resource waste and accelerate market access."
- Directing hackathon organizers towards designing work environments that support systematic learning rather than executive competition to produce functional prototypes, increasing their sustainability and the opportunity to transform them into entrepreneurial projects.

2. LITERATURE REVIEW

2.1. *Rapid Learning: Psychological and Practical Techniques*

Rapid learning is a strategic educational model focused on minimizing the time required to gain complex knowledge and convert it into practical capabilities. In hackathon environments, this process extends beyond acquisition to the immediate application of skills to solve specific problems under resource-limited conditions. Rapid learning psychological techniques rely on how efficiently information is absorbed. According to Cognitive Load Theory, working memory has a limited capacity. During a hackathon, the external cognitive load is minimized by focusing solely on information essential for developing the prototype, which

accelerates mental processing. Flow Theory suggests that participants often enter a state of deep focus where they lose awareness of time and self. In this state, a process of semantic integration occurs, linking new inputs with prior knowledge and thereby enhancing the understanding of complex information. Through Social Learning, rapid skill acquisition also takes place via behavioral modeling—for instance, a designer quickly learns from a programmer through direct observation and immediate interaction. (Szymanska et al., 2020)

Practical Techniques: Rapid learning practical techniques refer to the procedural methods that turn abstract ideas into tangible outcomes. The Fast Feedback Loop enables learning through immediate error detection—when a component such as a code segment or design element is tested and corrected on the spot, it exemplifies the Experiential Learning Cycle in action. Similarly, Just-in-Time (JIT) Learning emphasizes acquiring only the specific knowledge required at a given moment. Instead of mastering an entire technique beforehand, team members focus on the precise information needed to advance the current task, significantly reducing wasted time and effort.

Rapid learning during a hackathon overcomes the "fear of failure" obstacle, because this experiential environment allows rapid errors; with more rapid corrections; which traditional educational environments severely lack. This was proven by Izabela Szymanska 2020 study, In support of the hackathon model as an effective approach to leadership development, this study suggests that intensive, short-term learning formats—such as hackathons—may more effectively foster leadership self-sufficiency than traditional semester-long educational courses. (Szymanska et al., 2020)

Teamwork Psychology within Competitive Environments: In competitive environments, interdependence is embodied when an individual realizes that his personal progress is inseparable from the team's achievement, even in the context of the quest to win. Success here shifts from the logic of personal profit to constructive competition based on challenging oneself and raising the level of group performance. Tuckman's model describes the five stages of team development in competitive environments. Teams go through stages, each of which has a characteristic and must be managed according to the characteristics. The initial stage (Forming) appears with the acquaintance of members and the clarity of goals and roles This is followed by the second stage (Storming), which is the stage in which disagreements and conflicts appear,

and motivation may decrease if the stage is not managed well. The third stage (Norming) begins to appear, and team members begin to build common working rules, and the team's collective identity crystallizes. The fourth stage (Performing) is formed by the team working with high efficiency as a cohesive unit and the ability to solve problems and make decisions However, the team reaches the fifth stage (Adjourning) to complete the project and complete the task, and then the team disintegrates or is reconstituted for new tasks. (Zulkifli et al., 2025) **(see Figure 1)**
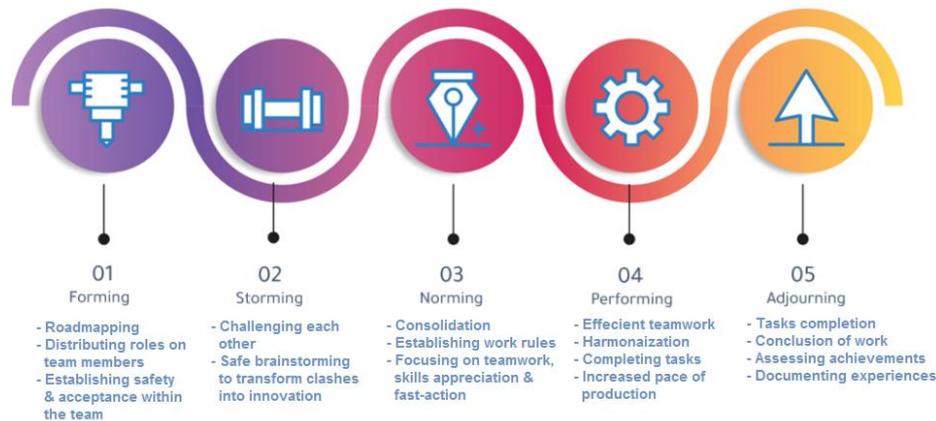

Figure 1: Working Model for Hackathon Teams.

Group Correlation under Challenges: When the team realizes that they are facing a "strong opponent" or a short "deadline"; their thinking shifts from the regular working attitude to the "mutual survival" pattern, this means that the existence of an "external challenge"; e.g. other teams; strengthen the team cohesion. This mental and psychological state stimulates correlation among team members, which reduces selfishness and increases reciprocal confidence, thus; members will evidently spend more time and effort in favor of the team interest; and only concentrate on its strategic optimum objectives instead of their personal interests. (Harel et al., 2025)

In order to achieve group correlation within the hackathon framework; tasks and cognitive loads should be properly distributed among the team members; and outcomes should be collaboratively collected. This can be accomplished by reducing the cognitive curves, conducting fast and immediate procedures towards challenges; and processing feedback more rapidly, in order to accomplish the mission in due time. (Weisel & Zultan, 2021)

2.2. Synergy of Professions

Parallel Work vs. Collaborative Work: Parallel and collaborative work in design teams can be understood through task structure and team member profiles. In large, time-constrained events such as hackathons, teams typically rely on synchronous collaboration, where members work in parallel on interdependent tasks within compressed timeframes to deliver a unified final product. This mode contrasts with strict sequential tasking and demands rapid coordination, shared understanding, and tight temporal alignment across roles.

Experiential learning in interdisciplinary settings reinforces these dynamics. Learning-by-doing in mixed team's functions as both a learning and evaluation mechanism, strengthening conceptual understanding and problem-solving abilities while producing authentic, practice-based outcomes. When embedded in interdisciplinary collaboration, such experiential processes contribute to more sustainable patterns of work, as individuals iteratively expand their skill sets, refine mutual coordination, and internalize collaborative routines. (Indra et al., 2024)

Distributed Leadership: Distributed leadership in hackathon teams means leadership shifts flexibly between members depending on the challenge (e.g., programmer in technical issues, 3D designer in fabrication tasks). The team must stay aligned around a shared goal by downplaying personal differences and fostering creative thinking. Research highlights that empathy, bottom-up collaboration, and reducing bias are key to achieving an integrated and effective work experience. (Maillart et al., 2024)

Digital Tools as a Bridge for Communication: Digital tools play a pivotal role in overcoming obstacles and achieving smoother cooperation among the hackathon team members; among the most significant of these tools are:

Figma: this is not just a design tool anymore; it has

become a platform that collaboratively gathers designers and programmers. (Frid et al., 2025)

Canva: this tool has evolved from being a mere design tool; it has become an effective tool for cooperation which allows monitoring the work progress, regardless of multiple professions.

Generative AI Tools: these tools contribute to organizing thoughts and create photos and sketches that clearly reflect the concepts and ideas. The study of Santiago (Frid et al., 2025) confirmed the important role played by generative AI tools in accomplishing operational tasks in coherence with the concepts of open innovation and professions collaboration, before and during the hackathon.

Hackathon as an Immersive Learning Environment: Hackathons are intense training environments, in which the concept of collaborative skills (thinking while doing) is clearly manifested, because there is no time for a long planning process, instead; the team must face the unexpected challenges effectively, which is a clear application of the direct interactive learning method.

A hackathon is not just a chance event; it is a powerful stimulator for rapid learning and acquiring human and technical skills, which are additional values for the participating teams, providing them with acquired skills which will be reflected in traditional working environments after the hackathon. (Pe-Than et al., 2019)

The study of (Sotaquirá-Gutiérrez et al., 2025) indicated the role of hackathons as platforms for experimental learning; by specifically focusing on their impact in enhancing the participants' design skills within a competitive environment, to face realistic challenges during a limited timeline. The research determined that hackathons not only permit attendees to employ their design aptitudes but also encourage their progress within an exploratory context where rivalry, time limits, and engaging surroundings are vital in ability building and shared education. Moreover, the investigation verified that the primary engine for swift learning in hackathons is their combative aspect, as stated by 86.4% of participants. This discovery suggests that the competitive spirit—along with time urgency and a rigorous setting—forms an encouraging climate that boosts skill improvement.

2.3. Rapid Design and Modeling Methods in Hackathons environment

Hackathons have arisen as lively venues for open innovation, encouraging interdisciplinary collaboration and novel problem-solving. (Marrujo-Ingunza & Paico-Campos, 2025) Rapid design and modeling methods are one of the dynamic approaches that attempt to accelerate the process of developing and designing products and developing innovative solutions. These approaches are based on utilizing techniques which facilitate producing prototypes rapidly and efficiently; they include integrated collaboration among different professions to achieve the ultimate goal within a strict time frame and with a limited budget, while ensuring a high level of innovation and quality.

Design Thinking: Hackathons serve as a high-octane pressure cooker for the design thinking framework. By condensing the five-stage cycle—empathy, definition, ideation, prototyping, and testing—into a short window, these events force teams to break free from traditional biases and rapidly build solutions that address genuine human needs. (Flus & Hurst, 2021b)

Rapid Modeling Method: Innovation refers to the capacity to create and execute new ideas that generate added value, and hackathons represent a flexible and collaborative approach to achieving this. They act as "experimental laboratories" where scalable ideas, trials, and prototypes are developed, enabling universities, governments, and organizations to collaboratively advance projects and address social challenges (Marrujo-Ingunza & Paico-Campos, 2025) This approach is based on the concept of "rapid failure and reduced cost"; which means that instead of spending a lot of time developing a part of the design idea, team should work on producing a prototype for this idea. Tools, such as Figma; help identify the user path and enable precise modeling, by focusing on constructing a testable prototype for the product; using 3D-printing devices; to imitate the required main functions of the product, to verify the feasibility of the design idea. (Qiu et al., 2024)

Lean Startup Method: During a hackathon, teams are steered within the framework of the "Build-Measure-Learn Loop – BML Loop" proposed by Eric Ries in 2011; the three step of this loop are repeated every couple of hours to allow the team to recognize errors and challenges in order to provide suggestions and find solutions. It is worth mentioning that hackathons further support innovation by offering guiding sessions conducted by specialists assigned by the hackathon organizers. (Olek et al., 2023) **(see Figure 2)**
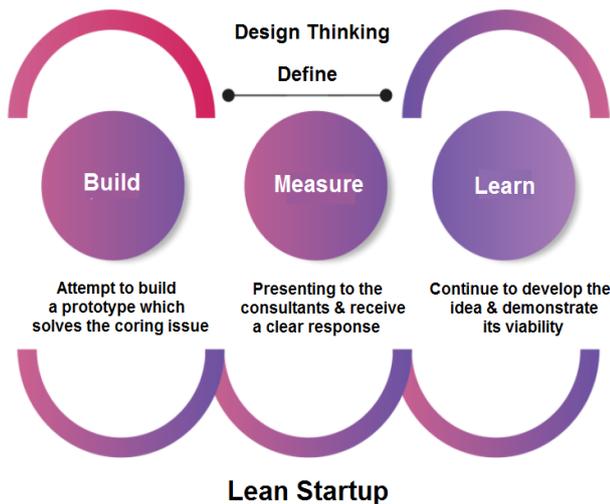
Figure 2: Design Thinking Method vs. Lean Startup Method for Rapid Learning & Modeling.

Correlation between the Methodology and the Interdisciplinary Team: Hackathon teams consist of diverse professionals, requiring effective communication and a shared language to minimize misunderstandings, enhance collaboration, and accelerate the overall teamwork process. (Ege et al., 2024) study showed that physical models are used for active learning, digital models for optimization, and graphics for communication, and that fast error learning is more successful than a rigid theoretical approach.

Teams Tactics during the Life Cycle of Prototyping: Teams participating in hackathons utilize specific methods for organization of work, as well as special tactics to execute their ideas within the hackathon deadline; (Burchardt, 2020) these tactics include Table 1.

Table 1: Analyzing Prototyping Tactics & their Impact on Interdisciplinary Teams.

Tactic	Advantages	Learning Dynamics & Prototyping processes	Ideal Time	Additional Value
Moscow Matrix	Sort & categorize priorities.	Evaluative learning based on assessment of priorities. Estimating the relative weight to produce the prototype.	Participate in the hackathon in due time.	Invest time to add required prototype improvements.
MVP	Solve core issue. Manifest product aesthetics & its visual identity.	Analytical learning. Examine the visual display of the product.	Continuous.	Ongoing prototype improvements.
Trade-off between feasibility & timeline	Focus on product testability.	Learning through awareness of time. Ensure prototype production in due time.	Second day of the hackathon	Ongoing prototype inspection based on awareness of resources.
No code developers	Solve skills gap between team members.	Innovative balance. Participation of all members in the prototyping process.	6-12 hours during 1st & 2nd hackathon days	Learn from others. Minimize team skills & technical gap.
Rapid AI tools	Atomize complex tasks & develop a real simulation of the product.	Imaginary learning. Conceptualization of the final product.	Short time, maximum two hours.	Qualitative improvements of prototype vision.
Transition test	Validate product usability.	Communicative learning. Ensure user comprehension of the product.	After every product update.	Discover errors & improve prototype.
Instructors' guidance	Achieve strategic advantages, avoid technical & time waste.	Critical learning. Arrange priorities for prototype execution.	When needed.	Improve prototype & focus on core values

2.4. Analyzing the Research Gap

Despite their massive popularity, hackathons remain a largely overlooked goldmine for design research. These events offer a unique, concentrated environment where researchers can observe rapid problem-solving and user-centric innovation in real-time. (Flus & Hurst, 2021a) Despite the increasing use of hackathons as creative motivational areas, there is a lack of addressing the dynamics of accelerated learning as part of the modeling process within time-compressed hackathon environments, as well as the lack of a procedural framework that links the speed of acquiring technical skill with the quality of the prototype

2.5. Hypothesis

The study is based on the following hypotheses:
• H1: There is a positive association between the existence of a "structured framework for rapid learning" and the ability of designers to overcome technical obstacles in record time.
• H2: Prototyping is not just a representation of an idea, but a learning tool that accelerates the assimilation of complex technical requirements under pressure.
• H3: Applying the "procedural research" methodology within hackathons contributes to building a flexible framework that is adaptable to the variables of real-life professional design projects.

3. RESEARCH METHODOLOGY

3.1. Research Design

This research adopts Action Research to develop and test a framework. The procedural cycle began with diagnosing the gap between conceptual design and manufacturing capacity, followed by developing strategies for rapid modeling, then monitoring and analyzing the results through the developed evaluation matrix, leading to the final formulation of the proposed framework

3.2. Research Approach

This study is based on the action research approach and aims to solve real-time practical problems (time challenges and learning in hackathons) while generating theoretical knowledge (proposed framework). This approach is flexible and adaptable to the rapid changes that occur during intense hackathon hours.

3.3. Research Setting

The study is conducted within the techniques that enable interdisciplinary teams to transit from the phase of "innovative concepts" to the "application of concepts" phase; and to manifest creative ideas through prototyping methods; to discover the manner by which they practice mental synchronizing and teamwork during crisis and when faced with limited resources

The research is limited to applying the proposed framework through analyzing procedures cognitive and practical learning during the 72-hour SIDF 2025 hackathon, with a focus on redesigning packaging "Miska Chewing Gum". It excludes post-hackathon phases and is spatially and temporally limited to the location and duration of the event.

3.4. Research Limitations

The research focuses on analyzing accelerated learning and design manifestation within the 72-hour SIDF Hackathon 2025, limited to the cognitive and practical aspects of redesigning "Miska Chewing Gum" packaging. It is confined spatially to the hackathon venue, temporally to its duration (23–25 October 2025), and humanly to an interdisciplinary team of graphic and product designers, excluding later production or marketing stages.

3.5. Population and Sampling

The population consists of: Innovators and designers participating in the hackathon through a team framework during accelerated learning and prototype production SIDF Hackathon 2025.

Sample Size: The study uses an action research approach to analyze how hackathon environments enhance participants' knowledge and skills development (Milicevic et al., 2024) It focuses on organizational and environmental factors that enable rapid learning in multidisciplinary teams.

Sampling Technique: A Purposive Sample with Cross-functional Team participating in SIDF Hackathon 2025 named of: New Vision Team , Hackathon Project: Miska Moments

Justification for choosing a single team: This is due to the deep focus on precise learning dynamics, and monitoring real-time interactions that may be lost if large samples are studied, which ensures the quality of the data extracted to build the proposed framework

3.6. Action Research Cycle

The study applies the procedural research cycle in a hackathon environment and uses the framework as a practical tool to improve their performance and understand their problems more deeply by following an organized and flexible cycle of planning, implementation, observation, and continuous reflection., which is an iterative cycle every 12 hours **(see Figure 3)**
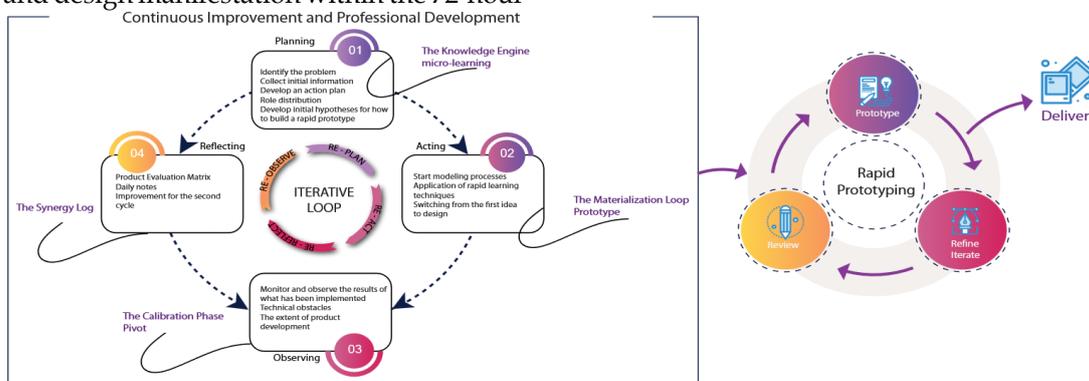

Figure 3: Proposed Framework for Rapid Learning and Modeling Mechanisms for Cognitive (Learning), Process (Product), and Psychological (Obstacles) Aspects in A Hackathon Environment.

Planning: Data Collection Methods

Description of Participation: The case study took place during the "SIDF Hackathon 2025 – 4th edition," held from 23–25 October 2025 by the Saudi Industrial Development Fund, featuring four main tracks and twelve challenges. The "New Vision" team joined the design track focused on innovative product design and user experience. They selected the "Miska" chewing gum packaging challenge, studied its criteria, and developed a structured work plan for participation. **(see Figure** 4)

Miska chewing gum (1)   Miska chewing gum (2)

Figure 4: Empathize & Problem Definition (human centered).

Formation of the Interdisciplinary Team: The "New Vision" team was carefully formed to cover all required expertise for the hackathon challenge. It included specialists in product design, visual and 3D design, and creative strategy to ensure functional, aesthetic, and strategic project success.

Team Workflow and Development: The team coordinated through three weeks of preparatory meetings to analyze the challenge and build an innovative concept. Using design thinking, they began with user empathy—studying "Miska Chewing Gum" users, market products, and conducting surveys to identify user issues. **(see Figure 5)**
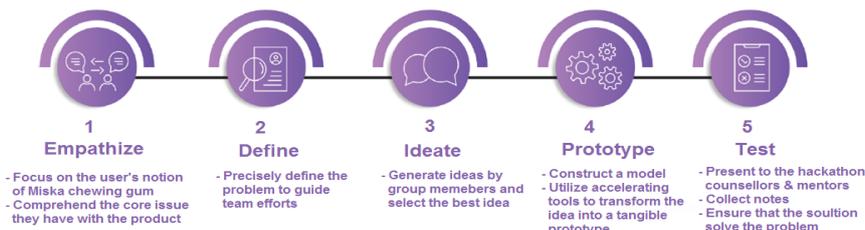

Figure 5: "New Vision Team" Design Thinking Method.

The team surveyed 60 Saudis from diverse backgrounds, revealing that 93% of Miska chewing gum users are females aged 20–45. Results showed purchases are mostly spontaneous at checkout points, emphasizing packaging as a major influence on buying decisions. **(see Figure 6)**
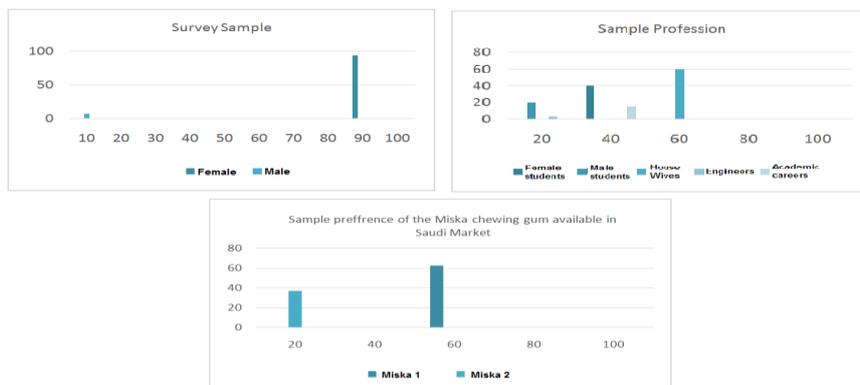

Figure 6: Analysis of the Random Sample from Saudi Users of "Miska" Chewing Gum.

Survey findings revealed key user pain points: 76% struggled to open the pack, 50% disliked its design, and 60% wanted better materials. Additionally, 70% preferred reusable packaging, and 80% sought a design suitable for daily portability. These insights helped the team identify user needs and guide innovative solutions aligned with market and company expectations. **(see Figure 7)**

Figure 7: Analysis of the Sample Opinions on the Product Current Packaging; and their Suggestions for Improvement.

The team used brainstorming, individual ideation, and an inspiration board to generate and refine concepts, selecting the best idea for prototyping. **(see Figure 8)**

Figure 8: Inspiration Board and Construction of the Idea.

The team proposed two innovative designs: a multi-part large container for organized daily use and a refillable keychain pack for portability and style. The keychain design combined practicality, aesthetics, and sustainability. Both designs ensured hygiene through individually wrapped gum pieces and delivered a distinctive, user-centered experience. **(see Figure 9)**

Figure 9: Designs Proposed by "New Vision Team".

Acting: Data Analysis Procedures

Analyzing the Knowledge Gap: Despite strong design and research skills, the team faced challenges in 3D printing and prototype execution, prompting rapid learning to bridge technical gaps during the hackathon.

Constraints of Time and Resources: The team faced several challenges, including strict 72-hour time constraints, limited fabrication resources, and high mental pressure, requiring the adoption of rapid learning and prototyping strategies. They managed these by dividing tasks efficiently, coordinating closely, and seeking mentor guidance to accelerate technical problem-solving. To optimize resources and time, they produced scaled prototypes and creatively utilized available materials to deliver a viable, well-presented product. **(see Figure 10)**
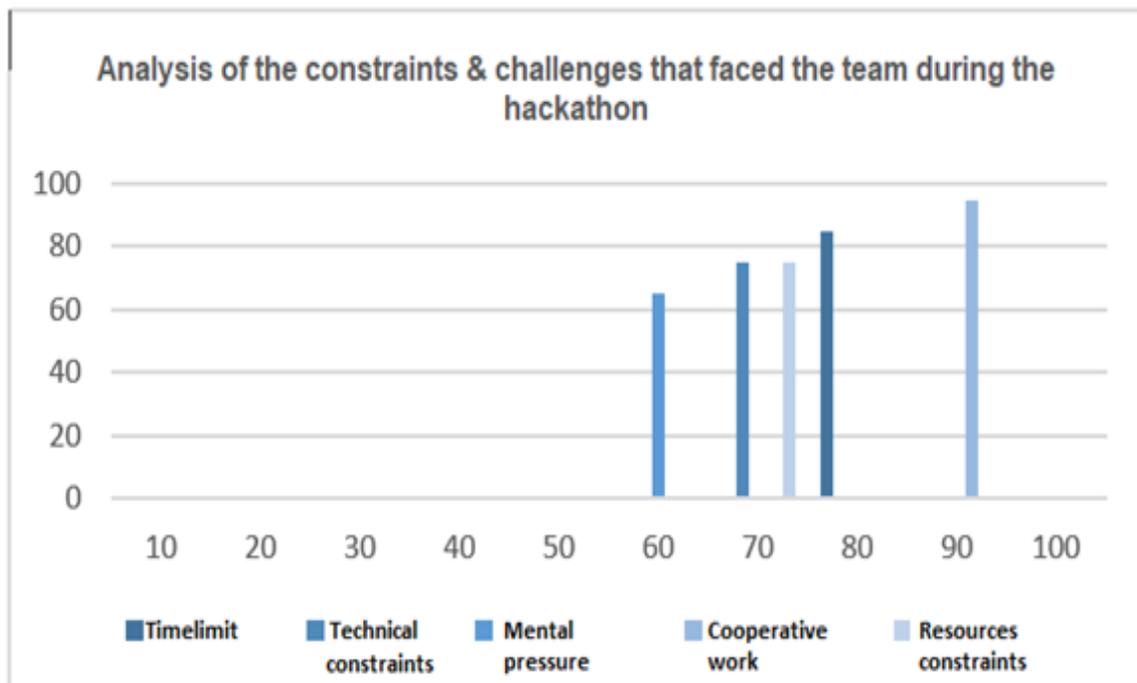

Figure 10: Constraints & Challenges Facing the "New Vision" Team during the Competition.

Observing: Instruments of the Study

Data collection tools refer to the methods and instruments used to gather and systematically organize information. In this study, field data were collected through observation of team member roles to ensure active participation and the effective integration of all stakeholders in developing the prototype presented to the jury (Sukmawati et al., 2023), Data-Collection Tools:

1. Notes card; to detect and analyze the rapid learning techniques of the team during the hackathon.
2. Product checklist: to register the phases through which the product transformed from an imaginary idea into a tangible reality.
3. Team daily notes record: to detect the obstacles which faced the interdisciplinary team; and how they overcame them.
4. Prototype evaluation matrix; to assess the idea; and its capability to be implemented; during different stages of work.

Analyzing Rapid Learning Techniques (according to the notes card):

Measuring H1. (the connection between the organized framework and overcoming obstacles)

The "SIDF Hackathon 2025" was held from 23–25 October 2025, where the team submitted their project file ahead of the event and worked on validating its feasibility. They prepared for the final presentation by refining their concept and workflow. During the hackathon, their performance was evaluated based on rapid learning, problem-solving, and 3D prototyping skills under real-time constraints. Table 2

Observation showed that the hackathon fostered rapid, iterative learning as the team tested, validated, and refined their idea through continuous experimentation. Using 3D printing, they identified and corrected design flaws collaboratively, integrating technical accuracy with production feasibility. **(see Figure 11)**

Table 2: Entries of the Notes Card to Monitor & Analyze the Team Rapid Learning Techniques.

| Time / Stop Points	Event / Observation	Observed Behavior / Response	Response Type	Notes
1st day of the hackathon 23/10/2025	Team gathered at the hackathon designated location. Initiating free work sessions. Proceed with preparing the digital prototype file to be processed and printed.	Attending guidance session by a technical advisor assigned by the hackathon.	External learning	Quick response to the remarks of the technical advisor. Developing an alternative plan to adjust the prototype, to ensure its readability for printing.
2nd day of the Hackathon 24/10/2025	Preparing the prototype experimental edition for printing.	Team work to digitalize the prototype.	Trial & error	Transforming the idea into reality, experimental printing of the prototype in the FabLab using the materials provided by the hackathon. After the first trial printing, some defects appeared in the opening & closing technique for the second product. Printing was redone using another material until the idea of success & validity were completely confirmed.
End of 2nd day	Attending all guiding sessions on how to prepare the final presentation file & how to measure the feasibility of ideas. Final presentation file was completed & delivered to the judging panel in due time (end of the hackathon second day).	Teamwork. Design discussion.	Guided Consultation	The team reached an ideal level of communication. They completed the required file and presented it to the judging panel in due time.
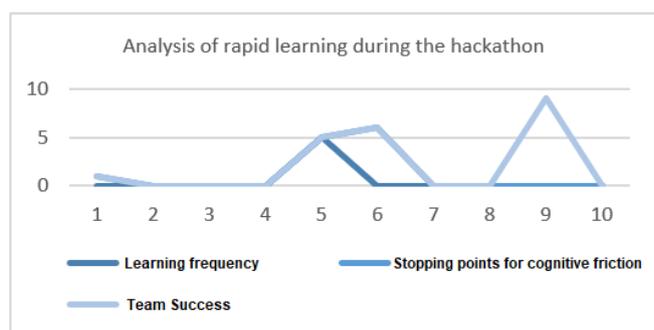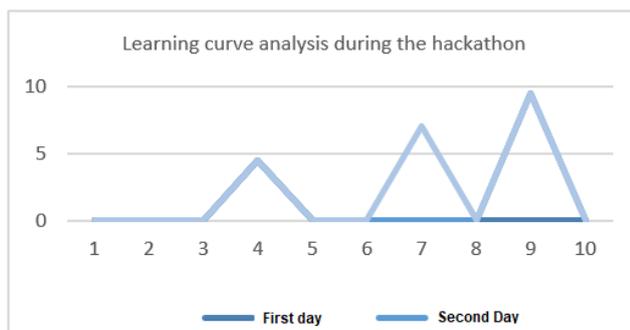
Figure 11: Analysis of Rapid Learning Techniques during the Hackathon Operational Camp.

Reflecting: Stages of Prototyping and Repetition (according to the product checklist):

Measure H2. (modeling as a learning tool and not just representation)

The team went through four stages to transform their imaginary idea into a tangible reality as follows. Table 3

Table 3: Prototype Development Stages.

Stage	Model Type	Selected Advantages / Alternations	Outcomes
First Brainstorming / generating ideas	Sketch	Solve users core issue	Attempts to design a prototype which reflects the main idea
Second Initiating practical procedures	Creating a digital prototype which effectively manifests the chosen idea	Easy to open & close Easy-to carry Environmentally & economically sustainable	Set design dimensions Formulate visual perception of the concept
Third Design improvements & corrections	Initial functional prototype	Light-weight thin horizontal rectangular packet Easy to carry or put inside a bag	Preparing final presentation & ensuring feasibility
Fourth Applying guided suggestions. Final prototype.	New printed prototype for the first product following the advice of the guiding mentors in regards to improving the product quality to ensure a better fulfillment of users need	Alter the box open & close technique Change the design to a vertical rectangular packet with thickness appropriate for the number of gum pieces	Presenting the proposal during the final visual presentation to the jury, along with innovative graphic ideas and treatments for the product presentation, with the aim of highlighting aesthetic aspects and promoting the concept of sustainability.

The team demonstrated a remarkable ability to move early from the idea phase to the practical implementation phase, which helped significantly reduce misunderstandings among members and overcome technical obstacles as soon as they arose. **(see Figure 12)**
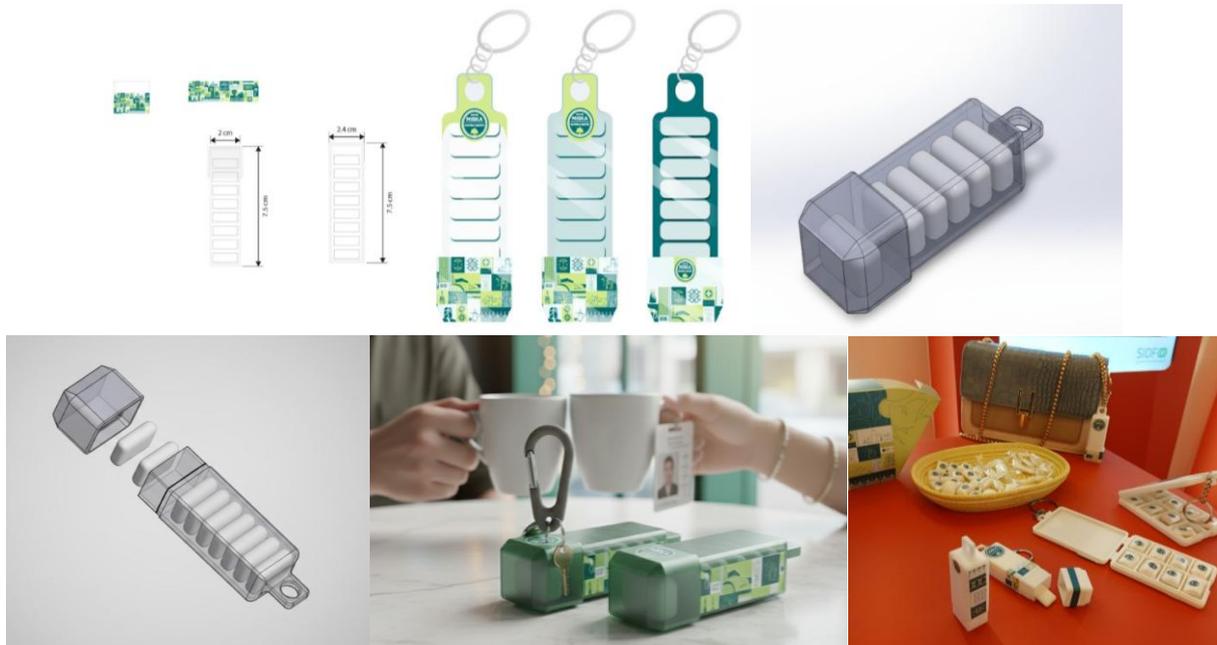

Figure 12: Steps of Developing the Proposed Design of the Selected Idea.

Outcomes of the Interdisciplinary Interaction Dynamics (*According to the Team Daily Notes Record*)

Measuring H3. (framework flexibility and adaptability in professional practice)

The techniques which led to the success of "New Vision team" have been identified by analyzing the impact of the team diversity on the prototype quality, which can be explained in the following notes record. Table 4

Table 4: "New Vision Team" Daily Record during the Hackathon Camp.

Obstacle	Interdisciplinary Interaction	Notes
Main challenge: design an accurate 3D prototype applicable for 3D-priniting.	The two members specialized in 3D design supported the integration between technology & design, by developing the prototype design and validating its readability & appropriateness to 3D-printing in the "FabLab"	A momentary challenge was overcome by the collective cooperation within the learning process; the idea was successfully applied and the work continued within the hackathon timeline.
Skills challenge	The team overcame the skills challenge by continuous work during brainstorming sessions on the 3rd hackathon day. Roles were distributed and opinions were exchanged to determine the ideal method to professionally present the idea to the judging panel.	The team members successfully learned the skill of final presentation during the last few hours before the deadline. This enabled them to review their notes and improve their performance based on the feedback, which enhanced the quality of the presentation & reinforced their confidence. Focusing on the basic points and good coordination among the team members were the key factors in their success.
Team harmony during the hackathon	Time & multi-skills management	The team maintained a medium level of harmony during the first two days of the hackathon, due to the challenges related to technical & design skills. But they achieved a very high level of harmony on the third hackathon day during their presentation to the judging panel; resulting in deservedly winning second place.

Analysis of the team's daily data produced a heat-map illustrating interactions across 12 four-hour periods during the hackathon. Early phases (T1–T3) showed skill gaps in 3D printing, which improved over time through rapid learning. Communication issues peaked during brainstorming but eased once roles were defined. Technical challenges intensified mid-event (T4–T6) during prototype development. Learning was high initially, then declined as focus shifted to packaging and presentation, while harmony dipped mid-course but rose again toward completion. **(see Figure 13)**
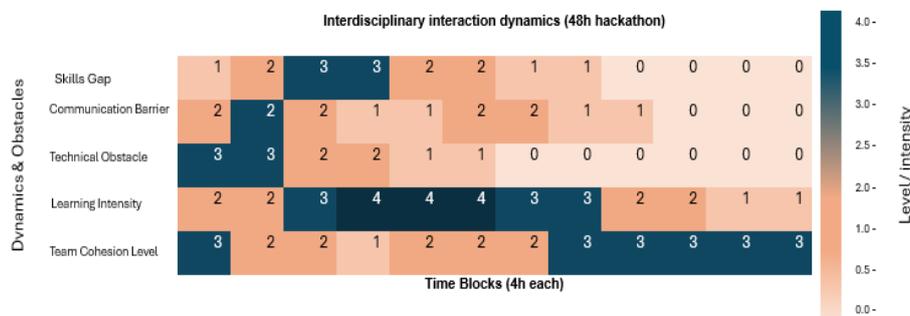

Figure 13: Heat-map Reflecting the Track of the Interdisciplinary Mutual Interaction during the Hackathon.

First Prototype Evaluation Matrix: The team developed a matrix to evaluate and validate their idea during the stages of work during the hackathon. Table 5

Table 5: Evaluation Matrix of the Proposed Product.

Model number	Model Technical Description	Evaluation Criterion	Evaluation
1	Preliminary paper version to verify the idea compatibility with reality	User experience	3
2	Final paper version to ensure smooth interaction with the product & its opening & closing method	User experience	3
2″	Another proposed design to a more convenient opening & closing method	User experience	4
3	Digital-drawing version to confirm the product size & function	Function	4
3″	Final digital version to confirm the product size & function	Function	5
3″″	Digital version for the final shape & professional presentation	Aesthetic & packaging	5
4	3D-printed version to confirm the product manufacturability	Manufacturability	3
4″	Another altered 3D-printed version	Feasibility	5

Evaluating the prototype modeling process showed that paper and digital sketches minimized design errors and helped identify potential user interaction issues. This process streamlined development and supported the successful creation of the final prototype presented to the judges. (see Figure 14)
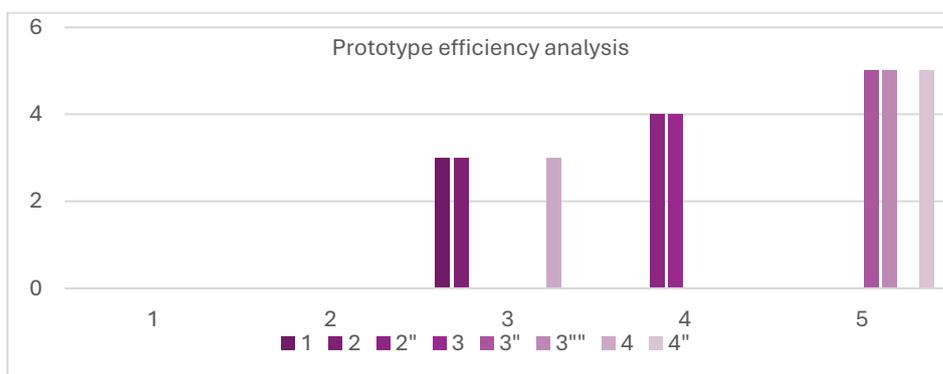

Figure 14: Prototype Efficiency Analysis to be Presented to the Hackathon Judging Panel.

4. RESULTS

After completing the procedural research courses and analyzing the data extracted from the tools, the study achieved the following results:

- Modeling has transformed from an end to a learning tool. The results of the model evaluation matrix proved that starting with quick prototypes in the first

hours contributed to uncovering 75% of the technical obstacles that were not clear during the brainstorming phase. This confirmed that modeling was the first driver of the team's deep technical understanding

- The efficiency of learning mechanisms, as the observation card indicated that the team used directed learning and moved from random search to learning based on momentary need

- Reducing the gap between specializations, as the team's daily observations showed that the proposed framework helped create a common language between the team members' specializations, which greatly reduced technical conflicts over the hours of the hackathon

- Product Maturity and Beyond Imagination Through the product checklist it was found that the framework allowed the product to evolve organically as the team added innovative features imposed by modeling dynamics that were not present in the initial concept

5. EFFECTIVENESS OF THE FRAMEWORK

The effectiveness of the proposed framework was measured based on a performance comparison before and after its implementation, and according to "high-pressure" criteria. The study concluded the following:

1- Time Efficiency: The framework proved effective in time management through, enabling the team to produce a " Functional Prototype " in 25% less time than usual rates in similar environments.

2- Cognitive Effectiveness: The framework contributed to reducing the cognitive load on team members; They did not have to learn everything in advance, but rather their energy was directed to learning only what served the next step in modeling, which kept the flow of creativity (Flow State) without frustration.

3- Adaptability: The framework has proven to be highly adaptable to "sudden variables". When the evaluation matrix detected the technical futility of a particular feature, the framework allowed the team to transform (Pivoting) quickly without significant time loss, which is the essence of success in professional design practices.

Summary of Key Findings

The New Vision team's practical experience during its participation in the 2025 Industry Hackathon revealed pivotal results that confirm the efficiency of innovative practices under pressure. The experience proved that adopting an early error detection strategy contributes to investing time and effort and improving design and technical solutions. Parallel modeling techniques and design thinking methods played a role in overcoming technical obstacles The effectiveness of the methodology used was embodied in the team's ability to transform the abstract idea into a professional first model ready for 3D printing, which culminated in the team obtaining second place in the design track, which is tangible evidence of the success of the rapid learning strategies and applied creativity that the team adopted.

6. CONCLUSION

This study examines the application of a framework for analyzing the dynamics of rapid learning and prototyping within intense "hackathon" environments, as an entry point for redefining the concept of achievement and innovation in the digital age. The study highlights the essential role of prototypes not only as technical outputs, but also as strategic tools for testing hypotheses and quickly adapting to variables.

The results showed that a direct transition from theory to procedural practice contributes to overcoming communication obstacles between different disciplines and transforms technical challenges into rich educational opportunities. The study recommends adopting methodologies based on the "hackathon" philosophy in educational sectors and institutional environments, with the goal of building resilient human cadres capable of leading and innovating under high-pressure and accelerating conditions.

7. RECOMMENDATIONS

Based on the research findings and the effectiveness of the framework, the study recommends the following:

Recommendations for academic and educational institutions

• Integrating "mini hackathons" as part of design curricula, to develop students' rapid learning skills away from academic stagnation.
• Adopting "modeling as a research tool" (Research through Design) in graduation projects, and not just as a final output step.

Recommendations for practitioners and designers

• Adopting the concept of (Just-in-Time Learning) instead of trying to master all the technical tools in advance, which reduces the distraction of the creator.
• Use "periodic evaluation matrices" while working

to ensure you don't get carried away with "fictional" ideas that aren't technically feasible.

Recommendations for organizers of hackathons and innovation laboratories

• Design work environments that support "multidisciplinary teams" while providing them with documentation tools (such as daily records) to enhance self-awareness of the innovation process.
• Providing a mutual language of communication between the various professions of members of

multidisciplinary teams to reduce time and effort; and generate actionable ideas.

Recommendations for researchers (future research)

• Study the impact of this framework on the "quality of user experience" (UX) in the final outputs of hackathons.
• Test the effectiveness of the framework in "remote" work environments (Remote Hackathons) and compare the results with in-person environments.

RELEVANCE TO DESIGN PRACTICE: This research bridges the gap between conceptual thinking and industrial feasibility to bridge the gap between theory and practice by presenting a framework that transforms time pressure from an obstacle to creativity into an engine for more efficient learning and smarter modeling.

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