SECI Model Guides the Generation and Diffusion of Knowledge in the Developing of an Innovative Product at a Small Science and Technology Institute

Amanda da Costa Marques[1*], Gláucio Bessa Oliveira[1], Meire Jane Lima de Oliveira[1], Renelson R. Sampaio[1]
[1]SENAI CIMATEC University Center; Salvador, Bahia, Brazil

This research presents a case study about knowledge management at the Plasma Dental Pen project, in its stages of prototyping, conducted by the Núcleo Avançado de Inovação Tecnológica (NAVI) from Rio Grande do Norte. It applies the SECI theoretical-practical model by Nonaka & Takeuchi (1997) to analyze the dialectic of creating organizational knowledge to generate solutions related to the lack of experience with additive manufacturing in this project. For information acquisition, semi-structured interviews were carried out with the coordinator and a researcher from the organization and then compared with the proposed theory of the seminal authors and recent literature about it. We concluded that adapted applications of the SECI model contribute to the generation and diffusion of knowledge in the institution and its innovation process.
Keywords: Knowledge Management. SECI Model. New Product Development. Small Organizations. Organizational Knowledge.

Introduction

In recent decades, the globalized context of the market has increased pressure on companies to innovate, placing innovation, and therefore knowledge, at a level of differential resource in this competitive scenario. This fact brought the need to incorporate knowledge into productive activities. However, as knowledge is an intangible resource, its management within the organization can be complex and challenging, especially considering the context of minor Science and Technology Institutions (STI) [1].

In the book Creation of Knowledge in the Company (1997) [2], the authors Nonaka and Takeuchi present a study on the capacity of Japanese companies to create knowledge and propagate it within the productive scope, called organizational knowledge. According to the authors, the ability of these companies to create and manage organizational knowledge is why they boosted their innovation process and achieved such success in a short period. In the study, the authors present a theory about the creation and diffusion of knowledge within large organizations and demonstrate this process in the SECI model, which will be exposed ahead. Several organizations work to generate innovation, so they need to manage knowledge. Among them are the Science and Technology Institutions (STI), which, in general, are institutions to create and encourage scientific and technological research to translate them into innovative solutions that meet the needs of society. However, researchers often conduct projects within research development but with no experience in managing complex projects in research, development, and innovation (RD&I). Moreover, these projects sometimes have more academic aspects. Therefore, they sometimes are developed in environments that could be better in terms of technological infrastructure. So, there is a distance between the SECI model proposed [2] and the context of these institutions. As mentioned earlier, this study aims to analyze the model acting on a project carried out by NAVI, a small STI that works with technological innovation in Rio Grande do Norte, Brazil. The analysis is made from a case study about the prototyping stage of the Plasma Dental Pen project, focusing on the generation and dissemination of knowledge related to additive manufacturing, a new resource there.

Received on 16 September 2022; revised 21 November 2022.
Address for correspondence: Amanda da Costa Marques. Rua Francisco Simplício, 145, apto 1602b - Ponta Negra - Natal/RN. Zipcode: 59090315. DOI 10.34178/jbth.v5i4.242.

J Bioeng. Tech. Health 2022;5(4):218-223

Materials and Methods

The study applied the theory of dynamic knowledge management in a small organization, interviewing the coordinator and a researcher of the investigated STI. Finally, according to bibliographic research, we did a comparative analysis between the Plasma Dental Pen prototyping process and the knowledge management theory. Evaluating how the SECI model, initially proposed for large corporations [2], we have applied the model in a small research institution to bring solutions to practical problems [3].

Theoretical Reference

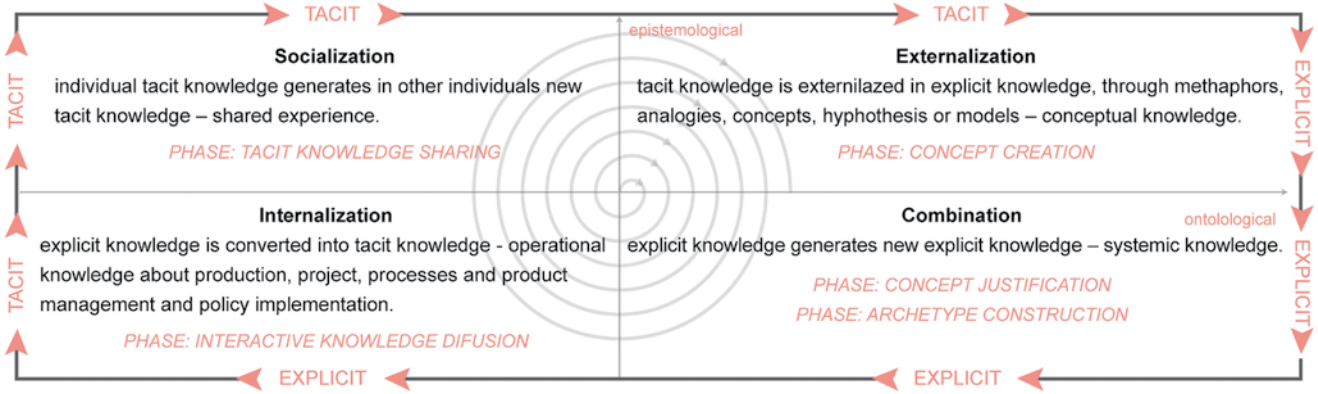
The ability to create organizational knowledge represents the primary competitive advantage for companies, as it enables the generation and diffusion of innovations. Thus, the knowledge created in organizations represents one of their main assets that impact economic, financial, and social indicators [4]. Likewise, Sanjay Dhir [5] claims that integrating knowledge, organizational learning, technological capabilities, and technical adherence are vectors for organizational development in competitive contexts.

Nonaka and Toyama [6] explain that organizational knowledge arises from a dynamic, two-dimensional process - epistemological and ontological - originating in individuals with the potential to expand throughout the organization and beyond. This idea is opposed to the static view of the firm, presented in neoclassical theory and transaction cost theory. Each organization's strategy, structure, and culture influences knowledge creation.

The epistemological dimension includes two types of knowledge: tacit, inherent to the individual and context, difficult to be formulated and communicated, and explicit, encoded, which allows its transmission in formal and systematic language. The interaction between tacit and explicit knowledge is fundamental to creating and propagating organizational knowledge. Figure 1 illustrates this dynamic process, relating four chaining modes of knowledge to five phases.

As stated, the process takes place in a dynamic system. Nonaka and Takeuchi [2] highlight the importance of adding external knowledge to organizations to promote the exchange of information so that the system is open. Furthermore, Nonaka and Takeuchi [2] explain that to generate and share knowledge; there must be a specific context, the "ba." In organizations, the "ba" can arise in individuals, work groups, informal circles, meetings, virtual spaces, and front-line customer contact [7]. A company is a collection of "ba" from different ontological levels, interacting with each other organically and dynamically. Thus, the "ba" amplifies the knowledge creation process [6], providing the energy, quality, and places to

Figure 1. SECI Model.



Source: Nonaka and Takeuchi [2].

carry out individual knowledge conversions and their movement along the knowledge spiral [7]. According to Nonaka and Takeuchi [2], there must be so-called enabling conditions to promote this process at the organizational level. They are:

1. Intent: Implemented by defining the organization's strategy, goals, and objectives to acquire, create, accumulate and exploit knowledge;
2. Autonomy: At an individual level, it stimulates the generation of new ideas and self-motivation, enabling the creation of knowledge;
3. Fluctuation and Creative Chaos: The collapse of routines, habits, or cognitive structures in organization's members to stimulate the creation of new concepts and knowledge;
4. Redundancy: Intentional superposition of information about their activities, promoting the sharing of tacit knowledge; and
5. Variety of requirements: When the necessary information is diverse and accessible, helping to solve problems.

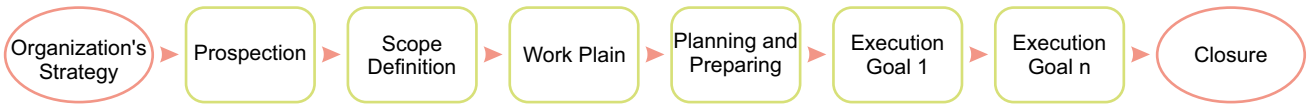
Study Execution

The study carried out in this article involves a small STI localized in Rio Grande do Norte, Brazil, named Núcleo Avançado de Inovação Tecnológica, or NAVI. NAVI has a team of about forty, including professors, students, and technicians. The project team acts as a researcher and seeks to develop innovative products and systems to meet demands, especially in health. Therefore, creating knowledge is essential to the organization's performance. The interviews were carried out with representatives of NAVI (the coordinator and a researcher) to understand the dynamics of knowledge creation and management. According to Robert Yin [8], the interview is essential to evidence the case study better. In addition, the interview allows the interviewee to contribute in ways that provide unverified information in documents or reports [9]. We asked about NAVI's strategic planning to verify if its intention is formalized in a document. We understood that the design process follows a work plan and seeks to achieve goals and objectives in the time given. However, there needs to be in-depth detailing in the planning that makes up the project since there is no systematic procedural method established in the STI. As a result, there is a certain informality between the processes, tasks, and relationships, making the adaptations carried out by the researchers recurring to find alternative solutions to solve the demands. Furthermore, it reinforces the creative character of the process, which is related to fluctuation and creative chaos. Thus, it was possible to understand the proposal development process until the prototype (Figure 2).

Since knowledge is an asset of great value, NAVI requests that every new researcher sign a term of secrecy and confidentiality to avoid the exposure of industrial secrets. In addition, if applicable, every new product has its patent and software registration. The STI is also concerned with complying with the General Data Protection Law - LGPD.

Qualitative data analysis of the captured data was carried out, specifically about the Plasma Dental Pen project, in its prototyping stage, to understand the dynamics of processes and project development. The research and development team had to learn additive manufacturing to prototype the product. In this process, it was possible to see the creation of tacit knowledge and its interaction throughout the phases of the SECI model to create organizational knowledge.

Figure 2. The design process for proposal development.



Source: Authors.

Results and Discussion

NAVI researchers interact with each other and with other research groups, characterizing a favorable "ba" for creating knowledge and, therefore, the generation of innovations. When a team struggles with an issue, it is possible to discuss it with other teams with expertise in the subject, analyzing the problem to find a solution. In addition to internal experiences of creating knowledge at NAVI, one can cite those carried out with research groups from other institutions, sometimes from other countries. As informed, this sharing can generate exchanges that improve the research, resulting in the internalization of new knowledge by the team. At these times, there is an exchange of experiences between researchers from different contexts, bringing other perspectives to the study. Therefore, contact with external data causes the socialization and the externalization foreseen in the SECI model. Furthermore, the research results are published in scientific articles, sharing the knowledge generated in the STI, which allows its systematization, and, therefore, its combination with other knowledge.

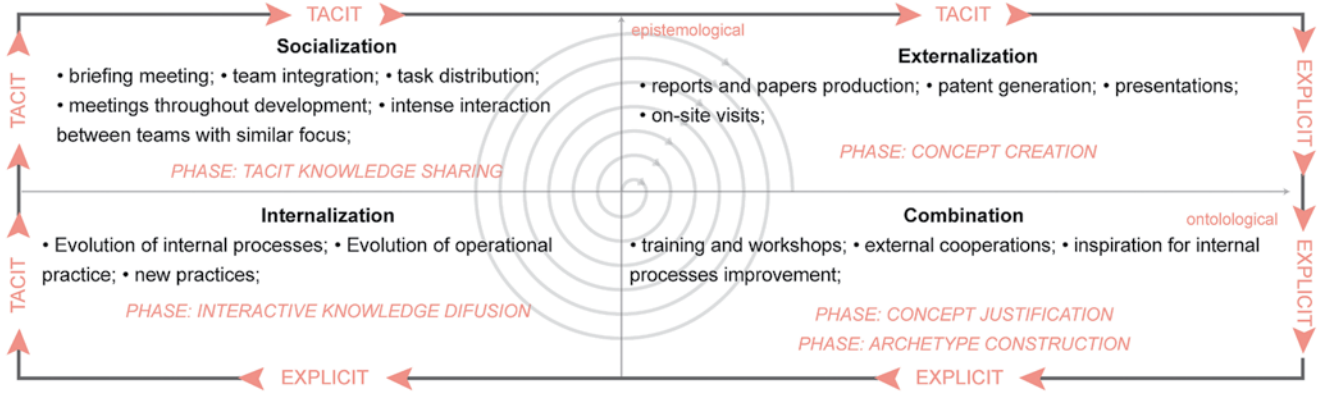
The activities carried out by the STI were organized in the SECI model proposed by the authors (Figure 3). In addition, using a product developed by NAVI, a plasma-based dental pen currently undergoing testing and improvements, as a reference to verify the dynamics of generation and diffusion of knowledge in the project, we found an adapted practice of the flow proposed by the SECI model.

The main difference between the foreseen practice presented by the SECI model initially proposed for large corporations, and this adapted practice in the STI, is that it occurs in a non-linear way between the stages, sometimes in a chaotic way, since there is low formalization between the processes. So the theory was visualized working inside but guided intuitively and maybe unconsciously, which corroborates with Menezes and Olave's [10] apud. Scarabelli and colleagues[4]. They emphasized that it is wrong to think that knowledge management practices work only for large corporations since such practices can lead organizations of any segment or size to better performance.

As the lack of a more deep structured development process, as indicated in the interview, the very act of innovating is risky and with many uncertains, which makes it difficult to plan every detail. However, with research development, tests are being carried out, theories and possibilities are being proven, and the project is taking a path that is not always as initially planned.

According to the interviewees, the researchers have autonomy in carrying out their work and exploring solutions as they come across problems, which is an essential stimulus to the creation of knowledge [8]. Furthermore, the uncertainty

Figure 3. SECI model on course in the STI.



Source: Nonaka and Takeuchi [2].

regarding the demands they may face, the risk inherent to innovation projects, and the informality between processes give the course the enabling conditions of fluctuation and chaos. It requires a propensity and motivation from researchers to create new knowledge and adaptations that can become innovative and benefit society.

Considering the phases of the knowledge creation process and the analysis of the plasma-based dental pen development process, we found that the project is currently in the phase of construction of an archetype. To create the archetype, the team set up a prototyping group, a "ba," where they freely exchanged tacit and explicit knowledge about the process. Several adaptations to use available materials and knowledge were made to generate and later improve the Minimum Viable Product (MVP). In a few months, from constant exchanges and practical experiments, the team evolved the functional prototype and developed new knowledge, generating innovation in confluence with the SECI model. Soon, an intense process of knowledge socialization took place.

A research group was created focusing on prototyping and additive manufacturing to solve problems about knowledge the team had not mastered. Another "ba" performed a series of actions with satisfactory results for the organization. The researchers began a process of training in 3D printing, meeting regularly in physical and virtual spaces. Figure 4 demonstrates how the "ba" created in the STI intensified the generation and socialization of knowledge about additive manufacturing, evolving a process that had been paralyzed for some time.

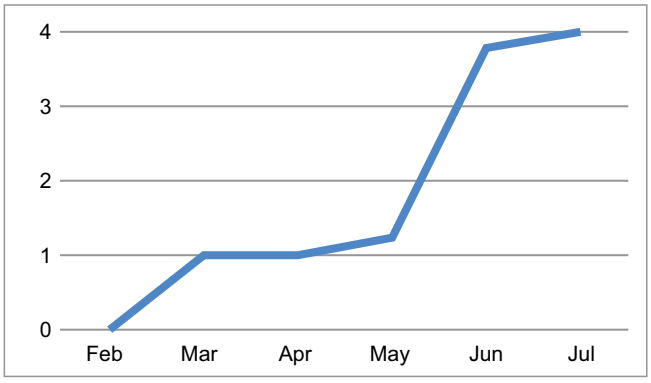
Figure 4 demonstrates the evolution of the tacit knowledge exchange between NAVI researchers during the implementation of an additive manufacturing process in a few months. The turning point, starting in May, demonstrates the effect of training made with a specialist in the area, where tacit knowledge was exchanged over two days. This fact exponentially boosted the curve in an upward movement, intensifying face-to-face meetings and the quick generation of prototypes and tests. Chiambareto and colleagues [1] said that the interactive and dynamic process of knowledge production applied to the development of the plasma-based dental pen resulted in a model of internal and external cooperation in "ba". It offers a case study of a small STI that becomes more competitive in its proposition to meet the demands of society by developing finalistic technological solutions.

Conclusion

This article aimed to explore and analyze the dynamics of knowledge generation and diffusion in a small-size STI, seeking to describe the development dynamics of a product based on the SECI model.

We verified a connection between the proposed theory and the actual practice of generating and

Figure 4. Relation between socialization and the generation of knowledge at the STI.



Feb	Kickoff meetings
Mar	Group creation
Apr	Group interactions online
May	Training workshop
Intensification of meetings	
Jun	Intense physical socialization
Jul	Online meetings

spreading organizational knowledge in the project's phase analyzed. The main difference is that the practice works in a non-linear way, sometimes with chaotic processes due to low formalization between phases. The theory was seen acting on the project's stages but intuitively or unconsciously. It was possible to perceive the direct relationship between knowledge management at NAVI, and the generation of innovation, as proposed by the model mentioned above. This interrelation was dynamic in an organization's knowledge's epistemological and ontological dimensions.

Moreover, it occurs internally and externally with other organizations and society. Regarding the social dimension, it is relevant to highlight it as the origin and end of NAVI's effort to generate knowledge and innovation, as well as in this study. In addition, the findings of the seminal authors stand out as current. We also observed the lack of studies that deal with the creation of knowledge in STIs characterized as small organizations from SECI's approach, which opens the possibility of deepening this topic in future research.

References

1. Leonidou E, Christofi M, Vrontis D, Thrassou A. An integrative framework of stakeholder engagement for innovation management and entrepreneurship development. Journal of Business Research 2020;119:245-258. DOI:10.1016/j.jbusres.2018.11.054. Available at: https://www.sciencedirect.com/science/article/pii/S0148296318306088. Accessed on: 13 Jun 2022.
2. Nonaka I, Takeuchi H. Criação de conhecimento na empresa: como as empresas japonesas geram a dinâmica da inovação. 13. ed. Rio de Janeiro: Elsevier, 1997.
3. Silva EL, Menezes EM. Metodologia da pesquisa e elaboração de dissertação. 3ed. Florianópolis: Laboratório de Ensino à Distância da Universidade Federal de Santa Catarina, 2001.
4. Scarabelli BH, Sartori R, Menegassi CHM. Práticas de gestão do conhecimento em pequenas e médias empresas. In: Anais do Congresso Internacional de Conhecimento e Inovação-ciki. 2019.
5. Dhir S et al. Integration of knowledge and enhancing competitiveness: A case of acquisition of Zain by Bharti Airtel. Journal of Business Research 2020;(119) Oct:674-684. DOI:10.1016/j.jbusres.2019.02.056. Available at: https://www.sciencedirect.com/science/article/pii/S014829631930147X. Accessed on: 14 Jun 2022.
6. Nonaka I, Toyama R. A firm as a dialectical being: towards a dynamic theory of a firm. Industrial and Corporate Change 2002;11(5):995-1009.
7. Nonaka I, Toyama R, Nagata A. A firm as a knowledge-creating entity: a new perspective on the theory of the firm. Industrial and corporate change 2000;9(1):1-20.
8. Yin RK. Estudo de caso: Planejamento e métodos. 3ed. Porto Alegre: Bookman Companhia, 2005.
9. Chizzotti A. Pesquisa em ciências humanas e sociais. São Paulo: Cortez, 1995.
10. Menezes CRC, Olave MEL. Práticas de gestão do conhecimento em micro e pequenas empresas de Sergipe. Gestão & Regionalidade 2016;32(94). Available at: https://seer.uscs.edu.br/index.php/revista_gestao/article/view/2698. Accessed on: 14 Jun 2022.
11. Chiambaretto P et al. Small and large firms' trade-off between benefits and risks when choosing a competitor for innovation. Long Range Planning 2020;53(1) Feb DOI:10.1016/j.lrp.2020.03.002. Available at: https://www.sciencedirect.com/science/article/pii/S0024630118301122. Accessed on: 13 Jun 2022.