

Transdisciplinary environments of learning: an initial proposal

Max C. Mattos¹, Renata M. A. Baracho²

¹ LATACI® Research Institute & Federal University of Minas Gerais, Belo Horizonte, Brazil.

² Federal University of Minas Gerais, Belo Horizonte, Brazil.

ABSTRACT

Over the past decade, we have developed and implemented a simpler Design Science Research (DSR) approach for undergraduate and graduate courses in Administration, Information Science, and Architecture, exploring the potential of transdisciplinary learning environments in both the academic and professional spheres. We have named this approach Transdisciplinary Environments of Learning (TEL) and it is based upon the concept of a complex, presented by Bogdanov – a Russian philosopher highly concerned with the “language of science”. This paper presents the foundational concepts of TEL, a proposed methodology composed of two artifacts: TELsteps and TELdict. The first one, adapted from DSR, provides a structured approach to the design and implementation of TEL, and has four steps: (1) defining the goal, (2) developing the artifact, (3) validating its efficacy, and (4) disseminating the knowledge created. TELdict offers an initial lexicon of relevant terms, concepts, and definitions: abstraction, analogy, artifact, diagram, generalization, informational complex, inner environment, methodological procedure, outer environment, and research methodology. Together, these two artifacts offer an integrated and comprehensive approach to address two major issues faced when establishing a transdisciplinary environment: methodology and language. For TEL, it is not required for the domains to change their methodology, but rather to analyze their results using a common methodology and language. This paper explores the initial concepts of TEL and provides basic steps for facilitating the creation of knowledge among diverse areas. Future research will further investigate and discuss these concepts in greater detail. Ongoing research at LATACI® Research Institute is developing the Relational Model of Informational Complexes (RMIC), exploring rules for diagram design.

KEYWORDS

*Design Science Research
Tektology
Systemic view
TELdict
TELsteps*

Ambientes Transdisciplinares de Aprendizagem: uma proposta inicial

RESUMO

Na última década, desenvolvemos e implementamos um método simplificado, a partir da Design Science Research (DSR), para cursos de graduação e pós-graduação em Administração, Ciência da Informação e Arquitetura, explorando o potencial de ambientes transdisciplinares de aprendizagem nas esferas acadêmica e profissional. Nomeamos este método TEL (Ambientes Transdisciplinares de Aprendizagem) e ele é baseado no conceito de complexos, apresentado por Bogdanov, um polímata russo preocupado com a “linguagem da ciência”. Este artigo apresenta os conceitos fundamentais da proposta TEL, uma metodologia proposta composta por dois artefatos: TELsteps e TELdict. O primeiro, adaptado da DSR, fornece uma abordagem estruturada para o projeto e implantação de TEL, contendo quatro passos: (1) definição do objetivo, (2) desenvolvimento do artefato, (3) validação da sua eficácia, e (4) disseminação do conhecimento criado. O segundo, TELdict, oferece um léxico inicial de termos, conceitos e definições relevantes: abstração, analogia, artefato, diagrama, generalização, complexo informacional, ambiente interno, procedimento metodológico, ambiente externo, e metodologia de pesquisa. Juntos, esses dois artefatos oferecem uma abordagem integrada e abrangente para tratar dois grandes problemas enfrentados ao se estabelecer um ambiente transdisciplinar: metodologia e linguagem. A metodologia TEL proposta não pressupõe que os domínios alterem sua metodologia, mas que analisem seus resultados usando uma metodologia/linguagem comuns. Este trabalho explora os conceitos iniciais de TEL e fornece etapas básicas para facilitar a criação de conhecimento entre áreas diversas. Pesquisas futuras aprofundarão e discutirão ainda mais esses conceitos. Uma pesquisa em andamento no LATACI® Research Institute trabalha com a definição de um Modelo Relacional de Complexos Informacionais, e deve explorar regras para o desenho de diagramas com base no TELdict.

PALAVRAS-CHAVE

*Design Science Research
Tectologia
Visão sistêmica
TELdict
TELsteps*

1. INTRODUCTION

The Transdisciplinary Environments of Learning (TEL) research project is an ongoing endeavor aimed at exploring and analyzing the potential of transdisciplinary learning environments in both the academic and professional spheres. Through this research, we seek to understand how the integration of diverse fields of knowledge can enrich the learning experience and lead to innovative outcomes.

The project uses a standard methodology (TELsteps) – adapted from Design Science Research (DSR) – across different fields. TEL is related to an Integrative Learning (IL) approach,

used to describe various methods, approaches and initiatives designed to connect different areas of knowledge, such as high school and college, general education and specialized courses, basic and advanced levels, classroom and experiential learning, theory and practice, and academic disciplines and fields of study (KLEIN, 2005).

For TEL, it is not required for the domains to change their methodology, but rather to analyze their results using a common approach (TELsteps). **Figure 1** shows that, by using the same methodology, different fields can interpret the results and reuse knowledge more easily.

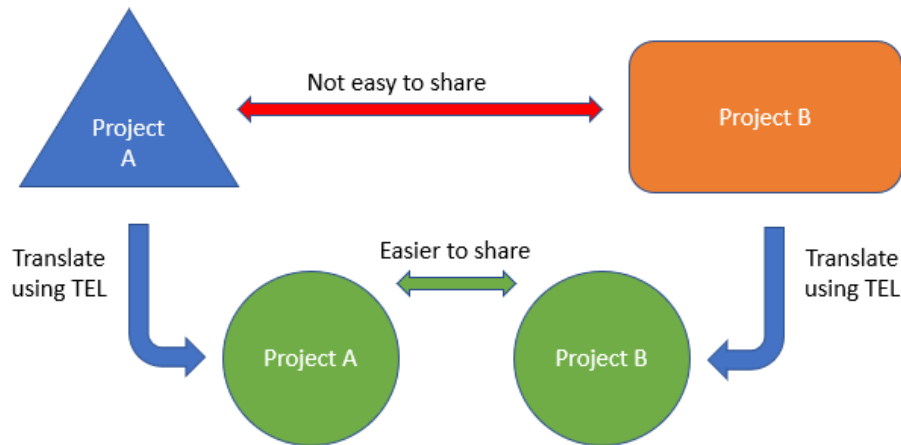


Figure 1 TEL as a common approach (Source: developed by the authors)

However, using the same methodology is not enough to interpret the results accurately; a common language needs to be established.

The structure of TEL links together some of Bogdanov's Tektology basic concepts with the definition of an artifact provided by DSR, especially the ideas of Simon (1969). These linked concepts form an initial "common dictionary" (TELdict) to act as a bridge among fields, unifying the results of each field and allowing for the generalization of the constructed knowledge – an important achievement for DSR. The first version of TELdict, presented in the following topics, will incorporate the concepts of abstraction, analogy, and generalization (MCGEE, 1959).

The proposal of TEL is to facilitate an interdisciplinary collaboration of researchers and professionals from various fields to share their knowledge and findings to advance the development of new technologies, ideas, and solutions. Through the unified effort of combining and reusing the isolated contributions made by each, we aim to create an environment that encourages innovation and creativity, while also setting a higher standard for the quality and impact of the research and development achieved.

This initial version of TELdict is merely a prototype containing only a few terms. Future research should work towards extending and modifying its content.

TELsteps is a tool that guides the process of using TELdict. It also enables users to leverage other tools, such as ontologies, to represent knowledge. We are introducing the concept of TELdict at this stage to facilitate a discussion on the initial ideas it provides.

In the following topics, we will explore the importance of a shared language, discuss the concept of artifacts in DSR, and present some of Bogdanov's Tektology concepts. We will also introduce the two artifacts that compose TEL: TELsteps and TELdict.

2. THE NEED FOR A COMMON LANGUAGE

The idea of TELdict is about "the need for a formal meta-language which allowed the transfer of knowledge between specialized fields" (DUDLEY, 1995, p. 277), or the need "to develop a body of knowledge which facilitates the integration of diverse data in an increasingly complex world" (DUDLEY, 1995, p. 280). It is not about specialization versus generalization – both are important for creating knowledge and learning – but rather about finding the right balance between them.

Dudley (1995) analyzed the early Bertalanffy's work on the definition of General System Theory (GST) and Bogdanov's Universal Organizational Science (Tektology). The author highlighted that both theorists "accept the need for detailed, specialized knowledge; it is apparent that is precisely to the extent that such specialized knowledge creates insurmountable barriers to the transfer of knowledge between disciplines that specialization is pathological." (1995, p. 276)

The author contends that the disparate terms and approaches used in various specialized fields preclude meaningful correlations between the models utilized therein. Additionally, both Bertalanffy and Bogdanov suggest a need for a method of analogical investigation: a search for formal or empirical analogies that will allow the construction of a meta-model to better understand and interpret data. This method could be used to identify patterns within the data and to facilitate the further development of theories and hypotheses.

Tektology has its own meta-model that provides a solid foundation for the creation of the TEL model. However, due to its complexity, we have designed TEL to be more straightforward and accessible to a wider audience.

Dudley (1995) states that a recursive and incestuous cycle is set in motion (**Figure 2**), which makes the task of interdisciplinary communication more difficult with each new generation of specialists.

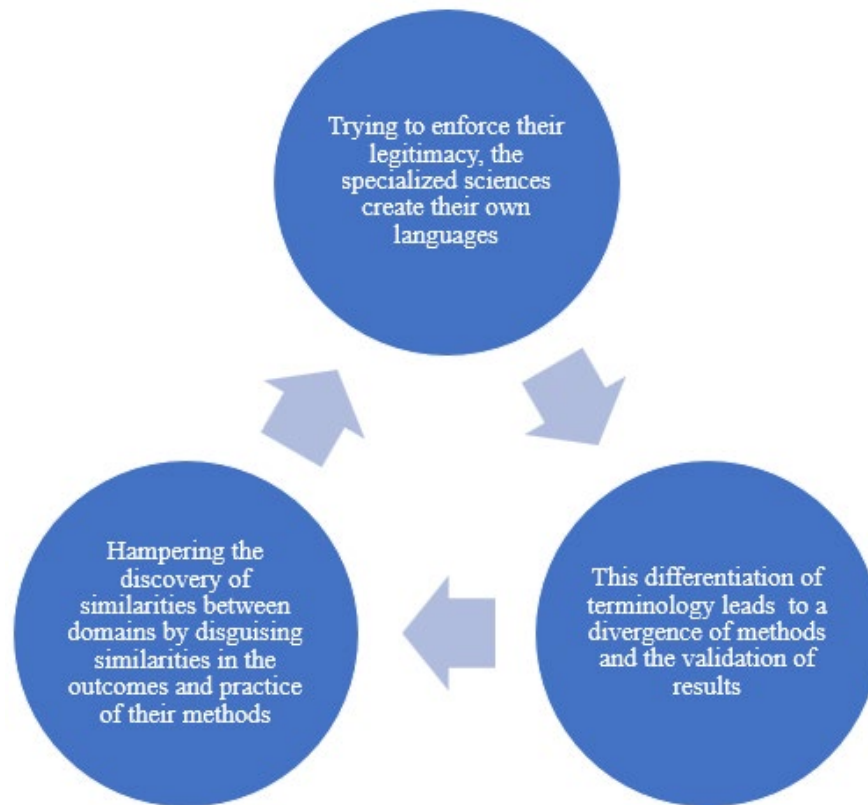


Figure 2 - A recursive and incestuous cycle of specialization (Source: adapted from Dudley (1995))

To establish and maintain their legitimacy, specialized sciences have developed their own distinct languages to express their ideas and theories. This language helps to ensure the accuracy and precision of the science being studied. Additionally, it allows researchers to communicate effectively with one another and to develop a common understanding of the concepts being discussed.

However, the use of distinct terminology results in a divergence of methods and the validation of outcomes, hampering the recognition of commonalities among domains by obscuring the shared outcomes and techniques of their approaches.

Not only a shared language, but also a shared methodology is essential for effective collaboration and communication. By establishing a unified approach (TEL), we can ensure that all stakeholders are on the same page and working towards the same objectives. By utilizing a common methodology, we can ensure clarity and consistency in our work, which will help to streamline the process and increase efficiency.

Once again, TEL suggests adapting existing field methodologies to a simpler, unified approach, rather than altering the field methodology itself. This approach is designed to streamline the process of conducting field research, making it easier to use, more consistent across disciplines, and ultimately more efficient. By simplifying and standardizing field methodologies, researchers can work more quickly and effectively, resulting in improved data accuracy and better results.

3. TELSTEPS

Design Science (DS) tackles problem-solving in a prescriptive manner, aiming to modify a situation rather than merely describing or explaining it. The artifact as a satisfactory solution (not necessarily the most optimal one, but the one that is feasible) is the tangible result of the application of principles for scientific rigor and practical relevance.

Design Science Research (DSR) is a widely implemented methodology among various disciplines, such as Information Technology (GREGOR; HEVNER, 2013; HEVNER, 2007; HEVNER et al., 2004; VAN AKEN, 2004), Neurosciences (BALTERS et al., 2023; BROCKE; RIEDL; LÉGER, 2013; HU; SHEPLEY, 2022), Architecture and Engineering (ABURAMADAN; TRILLO, 2020; GOECKS et al., 2021; MONICA TAVARES, 2011), Business (KALAIARASAN et al., 2022; LI et al., 2022; VAN AKEN; CHANASEKARAN; HALMAN, 2016), Health (GASPAR; LAPÃO, 2022; HARAHAP; HANDAYANI; HIDAYANTO, 2022; JOHNSON; BURGESS; SETHI, 2020; SUBRAMANIAN, 2022), and Education (ROMME; HOLMSTRÖM, 2023). It is used to support the development of DS projects.

The DSR approach integrates theoretical and practical approaches, transcending the dichotomy between them to create a more holistic understanding. It acknowledges that theory and practice are intertwined, and that neither can be fully understood without reference to the other. Further, it recognizes that the relationship between theory and practice is dynamic, and that both are constantly changing and adapting in response to the changing needs of the environment. This allows for the development of innovative solutions to complex problems that would otherwise be inaccessible.

We propose the use DSR to integrate theory and practice in a way that transcends the theoretical versus practical dichotomy that has structured most debates about transdisciplinarity (RIGOLOTTI, 2020). Instead, we seek to explore new and creative ways of reconciling the two. By doing so, we hope to push the boundaries of transdisciplinary thought, furthering our understanding of the subject and its implications.

To implement DSR, many authors (GREGOR; HEVNER, 2013; HEVNER, 2007; HEVNER et al., 2004; SEIN et al., 2011; VAN AKEN, 2004) suggest a variety of steps. As a starting point, we chose to use four essential steps (Figure 3): (1) defining the goal, (2) developing the artifact, (3) validating its efficacy, and (4) disseminating the knowledge created. These steps do not

necessarily need to be followed in a linear sequence; at any point one can review the previous step in relation to any of the four steps.

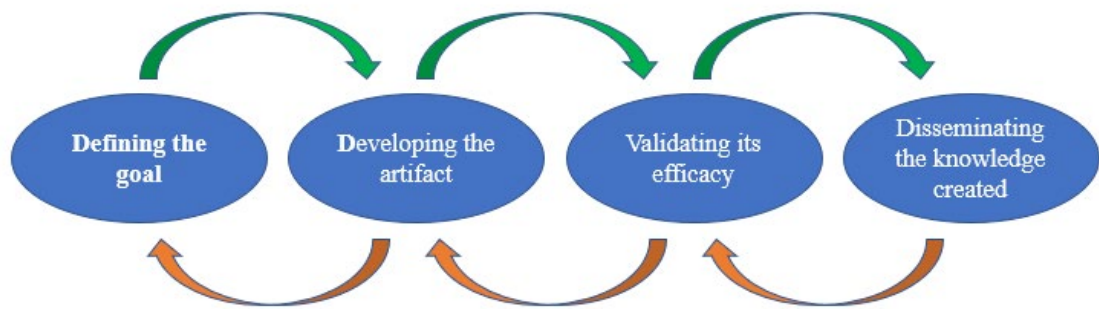


Figure 3 - TELSteps (Source: developed by the authors)

Through this process, TELSteps will contribute to both practical and theoretical aspects of the problem. Requirements for the project and its artifact must be identified and met for it to be successful. Once the artifact has been developed and validated, strategies for sharing the knowledge and the artifact itself must be implemented.

Detailed information about TELSteps is as follows.

1 – Defining the goal: it is essential to be aware of the context of the problem to ensure successful outcomes. By outlining the purpose of the project, all stakeholders can gain a shared understanding of the objectives and expected results. This will ensure that everyone is aligned and that resources are used effectively to reach the desired goal. This can include the use of tools for collecting and analyzing data, such as systematic literature review, conducting user interviews, and so on. At this point, it must be evident that the project has practical relevance. It is also important to define the requirements and limitations of the artifact – the feasible expected solution.

2 – Developing the artifact: create the artifact that is required to achieve the desired outcomes with scientific rigor and accuracy. Develop a well-defined and rigorous methodological procedure, considering all the identified requirements and limitations from the previous step. It includes the prospection of other artifacts, literature review, and the use of other techniques.

3 – Validating its efficacy: test the effectiveness of the artifact to ensure it meets the goal. To do this, create a plan for validating the artifact, which should include steps such as collecting and analyzing data, setting up test scenarios, conducting user tests, and running simulations. Additionally, monitor the results of the validation process to identify any areas that need improvement, and use the findings to refine and improve the artifact. Improve the methodological procedure with detailed information from this step.

4 – Disseminating the knowledge created: the concept of scientific dissemination is closely linked with the idea of knowledge sharing, which is present in both Tektology and DSR. Knowledge sharing involves the process of making knowledge created by experts accessible and usable by other people, including those who may not be experts themselves. This could include publishing papers in scientific journals, delivering public lectures, and taking part in media interviews. The primary goal of knowledge sharing is to increase public understanding of scientific topics and to inform decision-making on matters of science and technology.

DSR is not opposed to traditional qualitative or quantitative methodologies. In fact, it can incorporate elements from both into any of its steps. For example, a survey, interviews, literature review, or statistical models can all be

employed to define the problem, while statistical models or interviews could be used to validate the initial requirements.

Reflecting on these traditional methodologies, it's clear that defining a project's goal is essential – and necessary – before choosing among a qualitative, quantitative, or mixed-method approach. Thus, they act more like problem-solving methodologies. Conversely, DSR is designed to provide researchers with an initial step to define goals, and the other stages are beneficial and aligned with the research process, making it a true research methodology.

TELdict makes a distinction between research methodology, which refers to the methodology used throughout the research process (e.g., the steps of TELSteps), and methodological procedure, which outlines the steps needed to create and validate the artifact.

4. ARTIFACTS

Although the approaches to DSR can vary in some respects, the concept of an artifact is essential for it. An artifact can be defined as anything created by humans that has a purpose or goal, a character, and performs in a particular environment – like (but not restricted to) a concept, a theory, a system, a maquette, a prototype, a piece of equipment, or a building. To fulfill the artifact requirement of adaptation (utility), it depends on the purpose or goal, the character of the artifact, and the environment in which the artifact performs.

To describe the utility of an artifact, the author states that an artifact can be conceptualized as an 'interface' - a point of contact - between the 'internal' world of the artifact's material and design, and the 'external' environment in which it operates. If the inner environment is suitable for the outer environment, or the other way around, the artifact will fulfill its desired purpose (SIMON, 1969).

The first version of TELdict will cover the concepts of an artifact and its inner and outer environments. It will provide an overview of these topics, including definitions and examples to illustrate the key ideas.

TEL is an environment where all other fields compose the surroundings for each one. TELdict and TELSteps are two such artifacts that serve as interfaces between the inner and outer environment. By converting and analyzing the results of the inner field to a common language, these artifacts ensure that the concepts are understood and available for reuse. In this way, the artifacts can fulfill their intended purpose and bridge the gap between the inner (one field) and outer environment (the other ones).

This paper is another example of an artifact. Its internal environment corresponds to the structure of the manuscript, not only in terms of the topics discussed but also in its language. Its purpose is to disseminate partial results of a research project

to the scientific community and hopefully to other audiences. As a helpful interface between its structure and the learning process of its audience, this paper can be useful in furthering knowledge. Dissemination is the fourth step in the TELsteps and is a fundamental part of the DSR process.

5. TEKTOLOGY

Klein (2014) argues that transdisciplinarity has shifted away “from traditional epistemology to problem-solving, from the pre-given to the emergent, and from universality to contextuality and subjectivity” (p. 74).

TELsteps is an artifact concerned with problem-solving and emerging issues, both of which are essential components of DSR. To address this challenge, we can examine how Tektology's fundamental concepts can provide a simple useful framework. By considering contextuality and subjectivity, we can gain a better understanding of how to approach this issue.

It is important to note, as reported by various sources, that the Russian philosopher Bogdanov (1873-1928) was highly concerned with the “language of science”. Despite recognizing the progress made possible by the specialization of the scientific disciplines in the first quarter of the 20th century, he believed that it was necessary to create a form of dialogue among the various fields, based on a shared terminology. This was one of the motivations that drove him to develop his theory of Tektology. The term “tekton” is derived from the Greek language, meaning “builder”.

The bibliography in English on Tektology, presented by Biggart (1988), is comprehensively covered in Biggart, Dudley, and King (1988). They present a series of texts – that provide an idea of the scope and importance of Tektology – divided into three categories: philosophical foundations (ABALKIN, 1988; ALEKSEEVA, 1988; GLOVELI, 1988; KUZMINYKH, 1988; PLYUTTO, 1988; POUSTYLNİK, 1988; SADOVSKY, 1988; WHITE, 1988), applications in economics (BELYKH, 1988; DZARASOV, 1988; FIGUROVSKAYA, 1988; MAEVSKY, 1988; PARMENOV, 1988), and General Systems Theory (DUDLEY, 1988; GORELIK, 1988; KUZMIN, 1988; MOISEEV, 1988; OGURTSOV, 1988; SHAPIRO, 1988; URMANTSEV, 1988).

For Huestis (2007), Alexander Bogdanov was a polymathic genius, with German biographer Dietrich Grille estimating the Russian's total production of works at around 200 volumes. Of Bogdanov's oeuvre, the most important was his three-volume *Universal Organizational Science (Tektology)*, published between 1913 and 1922. In the field of medicine, Bogdanov is credited as one of the pioneers of the Russian centralized blood transfusion system, having convinced Joseph Stalin to establish the world's first institute of its kind in 1926.

Kats (2004) critiques Tektology, a version of Unified Science that was heavily influenced by Ernst Mach and Herbert Spencer. Nevertheless, he acknowledges that Alexander Bogdanov's ideas have an impressive scope, making them worthy of further exploration. He further states that Bogdanov's theory was in line with the relativism of Einstein, Poincaré, Mach, and the then-developing quantum physics. The core of Bogdanov's theory was his belief that all types of human activity, from the simplest to the most complicated, could be reduced to the concept of organization.

Rovelli (2021), an Italian theoretical physicist who is a founder of loop quantum gravity theory, provides an in-depth analysis of Bogdanov's ideas and theories at the intersection between Tektology and Quantum Physics. He offers readers a comprehensive overview of the subject and is an essential resource for anyone interested in discovering the potential of Tektology and Quantum Physics to shape our understanding of the world.

Gorelik (1975, 1980) presents Tektology as a dynamic science of complex 'wholes', concerned with universal structural regularities, general types of systems, general laws of their transformation, and basic laws of organization of all elements in nature, practice, and cognition. He argues that Tektology is still relevant today due to its similarities with modern generalizing sciences. It can provide a meaningful integration of human systems management and a new point of view on the universe and human experience, that is, the organizational point of view, leading to a rational understanding and dealing with the increasing complexity of existence. In short, Tektology offers a unique and invaluable perspective that can be applied to many aspects of our lives.

Some authors (CAPRA, 1996; DUDLEY, 1996; GARE, 2000; GORELIK, 1975; HUESTIS, 2007) claim that Tektology is a theory which contains numerous basic concepts that anticipate Norbert Wiener's Cybernetics and Ludwig von Bertalanffy's ideas, as well as those from complexity theories such as René Thom and Ilya Prigogine (CAPRA, 1996; GARE, 2000). Gare (2000) further postulates that Bogdanov, in reformulating Marx's social theory to avoid its flaws, did so in a manner that clearly anticipated Habermas. Kats (2004), however, states that these concepts (system, organization, positive and negative feedback, control, dynamic balance) were adopted by Bogdanov, but were introduced by Spencer.

Gorelik (1975) argues that in Bogdanov's world, changes only occur due to differences in energy tensions, and these differences are the primary elements of Tektology. These differences result in three possible outcomes: organized complexes, in which the whole is greater than the sum of its parts; disorganized complexes, in which the whole is smaller than the sum of its parts; and neutral complexes, in which the organization and disorganization activities are the same. Ultimately, the differences in energy tensions are responsible for the various forms of combination of these actions and reactions.

The author further highlights the relativity of these types of complexes, noting that the notions of organized, disorganized, and neutral complexes are not absolute, but rather relative to the context. As Bogdanov notes in his work *Tektologia: Vseobshchaya Organizatsionnaya Nauka (Tektology: The Universal Science of Organization)*, a complex is not organized generically or universally, but rather in relation to specific actions, reactions, and energies. It can be disorganized in some activities and remain neutral in others.

Gare (2000) suggests that complexes can be seen as the combination of distinct elements with a structure that can resist the activities of other complexes in each context. This interplay among complexes ultimately results in each one being organized, disorganized, or neutral relative to the context.

Dudley and Pustylnik (1995) emphasize the critical role of the observer in research, arguing that complexes existing as the result of real (i.e., observable) interactions are essentially indefinable without an observer. Therefore, the boundary conditions of a given system are subjected to the effects of the ongoing investigation, and the observed systems become a function of the observer. According to Bogdanov, it is the observed interactions and interdependencies that constitute the facts of existence; any classification applied to differentiate complexes is arbitrary. Therefore, Tektology is empirical as it attempts to provide a means of studying a directly observable reality.

The concept of complex does not necessarily have a direct relationship with the term “complexity”, and can represent a nerve synapse, the genetic structure of a species, the atomic organization of an element or a planetary system, an

ecosystem, or even the relationships among individuals or groups.

According to Gare (2000), there are various regulatory mechanisms in Tektology that enable the formation and dissolution of complexes. The author further explains that the cybernetic concept of feedback can be observed in Tektology, allowing for a continuous process of regulation that makes complexes increasingly stable or unstable based on their assimilation or release of elements from their environment. When a complex reaches an extreme level of instability, it is referred to as a crisis. The author makes a distinction between two distinct types of crises: conjunctive crisis (crisis C), which occurs when various complexes come together, and disjunctive crisis (crisis D), which involves the breakdown of complexes.

Given the depth and breadth of Bogdanov's work, it was not intended to provide a comprehensive overview of all the characteristics and concepts of Tektology in this article. This challenge calls for further exploration and would best be suited to a more specific work.

6. TELDICT: BUILDING A COMMON LANGUAGE

For this initial version of TELdict, we are introducing the concept of an Informational Complex (IC): a living or non-living entity that, to some extent, can collect, store, process, and/or disseminate information. It offers a powerful way to obtain, manage, and share knowledge. Each IC has its own internal structure (the inner environment from DSR), which is both influenced by and influences its external/outer environment.

ICs can be divided into three main categories: natural (e.g., a human being, a neuron, or a stone), artificial (e.g., a computer, cellphone, or any other artifact), and hybrid (e.g., a person with a cellphone). Natural and artificial came from the viewpoint of DS. The type of IC ultimately depends on the specific context being analyzed – for instance, a brain-machine interface (MUSK; NEURALINK, 2019) can be classified as a single hybrid IC, or as two ICs: a natural (brain) and an artificial (the interface) one.

Table 1 synthesizes TELsteps, and **Table 2** presents the first version of TELdict.

Table 1 - TELsteps

| Step | Description |
|-------------------------------------|---|
| Defining the goal | It is essential to be aware of the context of the problem to ensure successful outcomes. By outlining the purpose of the project, all stakeholders can gain a shared understanding of the objectives and expected results. This will ensure that everyone is aligned and that resources are used effectively to reach the desired goal. At this point, it must be evident that the project has practical relevance. It is also important to define the requirements and limitations of the artifact – the feasible expected solution |
| Developing the artifact | Create the artifact that is required to achieve the desired outcomes with scientific rigor and accuracy. Develop a well-defined and rigorous methodological procedure, considering all the identified requirements and limitations from the previous step |
| Validating its efficacy | Test the effectiveness of the artifact to ensure it meets the goal. To do this, create a plan for validating the artifact, which should include steps such as collecting and analyzing data, setting up test scenarios, conducting user tests, and running simulations. Additionally, monitor the results of the validation process to identify any areas that need improvement, and use the findings to refine and improve the artifact. Improve the methodological procedure with detailed information from this step |
| Disseminating the knowledge created | The concept of scientific dissemination is closely linked with the idea of knowledge sharing, which is present in both Tektology and DSR. Knowledge sharing involves the process of making knowledge created by experts accessible and usable by other people, including those who may not be experts themselves. This could include publishing papers in scientific journals, delivering public lectures, and taking part in media interviews. The primary goal of knowledge sharing is to increase public understanding of scientific topics and to inform decision-making on matters of science and technology |

(Source: Developed by the authors)

Table 2 - TELdict

| Term | Concept |
|--------------------------|---|
| Abstraction | the process of hiding the details of a process or object and only revealing the essential information. It allows us to focus on the essentials of a process without being overwhelmed by the complexity of its details or implementation. It creates simplified models, making them easier to understand, use, and manage |
| Analogy | a comparison between two things that are similar in some way but different in others, used to explain or clarify a concept or idea |
| Artifact | an object made or modified by humans that has a specific purpose or goal. It can be, for instance, anything from a simple tool to a complex machine, a concept, a theory, a system, a maquette, a prototype, a piece of equipment, or a building. Artifacts have their own structure and are designed to interact with an outer environment to achieve their purpose |
| Diagram | a graphic representation of information flow. It is used to visually represent a concept, idea, process, or relationship. A diagram can be used to explain complex information in a simple and organized way |
| Generalization | the process of forming general concepts by abstracting common properties of instances. It is the process of taking specific observations and extending them to a more general conclusion |
| Informational Complex | a living or non-living entity that, to some extent, can collect, store, process, and/or disseminate information. It offers a powerful way to obtain, manage, and share knowledge. Each IC has its own internal structure, which is both influenced by and influences its external environment. An Informational Complex can be natural, artificial, or hybrid. Artificial ICs can be considered an artifact |
| Inner Environment | the substance and organization of the artifact itself; the structure of an Informational Complex |
| Methodological Procedure | a systematic set of steps that must be followed to create and validate an artifact. It provides clarity and transparency to the process, enabling others to understand and replicate it |
| Outer Environment | the surroundings in which an artifact or Informational Complex operates |
| Research Methodology | refers to the methodology used throughout the steps of TELsteps |

(Source: Developed by the authors)

As we can think about the relations among ICs, the process of abstraction in Codd's Entity-Relationship Model (CODD, 1982) could be used to help us better visualize these connections. Representing the ICs as entities, the relations among them can be shown in a diagram. Although this is merely a first step in the definition of TELdict, visual representation of the ICs and their relations can be used to effectively illustrate these connections.

Future research could consider rules for diagrams design (e.g., for the types of crises among ICs) to enhance comprehension and effectiveness, but at this point we suggest utilizing simple diagrams – such as one-page charts – to clearly visualize the TELsteps. This will help to ensure a greater understanding of the process.

Over the last decade, we have successfully adapted and implemented a simpler DSR approach for undergraduate and graduate courses in Administration, Information Science, and Architecture. We have further supervised numerous thesis and dissertations that applied DSR, giving us the chance to engage students from different fields in a more in-depth discussion of the adoption of TELsteps – although until now we have never

used this name. The most recent experiences occurred in 2022.

The first experience occurred in the second semester at the Federal University of Minas Gerais (UFMG), when we introduced the discipline of Design Science Research for graduate students from diverse backgrounds. After introducing the foundational concepts, the students created two artifacts, employing the TELsteps method: (1) a digital repository to store the output of the Graduate Program on Built Environments and Sustainable Heritage (ACPS) at UFMG, and (2) an event to facilitate the exchange of knowledge regarding ongoing research at the same Program. Both artifacts were created using TELsteps methodology, with a consistent Systematic Literature Review for justifying the creation of each one. **Figures 4 to 6** show the diagrams created by the students for this project.

Reinforcing the importance of research, extension, and teaching, the interdisciplinary ACPS Program in Applied Social Sciences provides an opportunity to share the outcomes of research projects and improve their quality. This is the goal – step 1 in TELsteps – shown in **Figure 4**: to increase the visibility of scientific output.

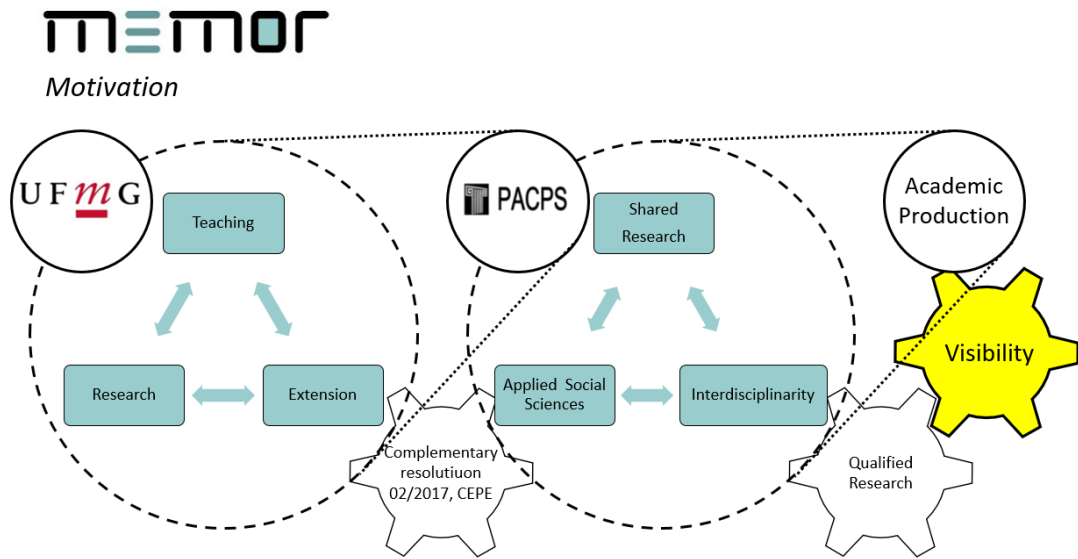


Figure 4 - Diagram of the goal: visibility of the scientific production (Source: Adapted from Vidigal et al. (2022))

Figure 5 illustrates the connection between the problem at hand and the proposed artifact, which has been justified through a Systematic Literature Review. This provides a clear

understanding of how the artifact is designed to address the problem and what requirements it must fit.

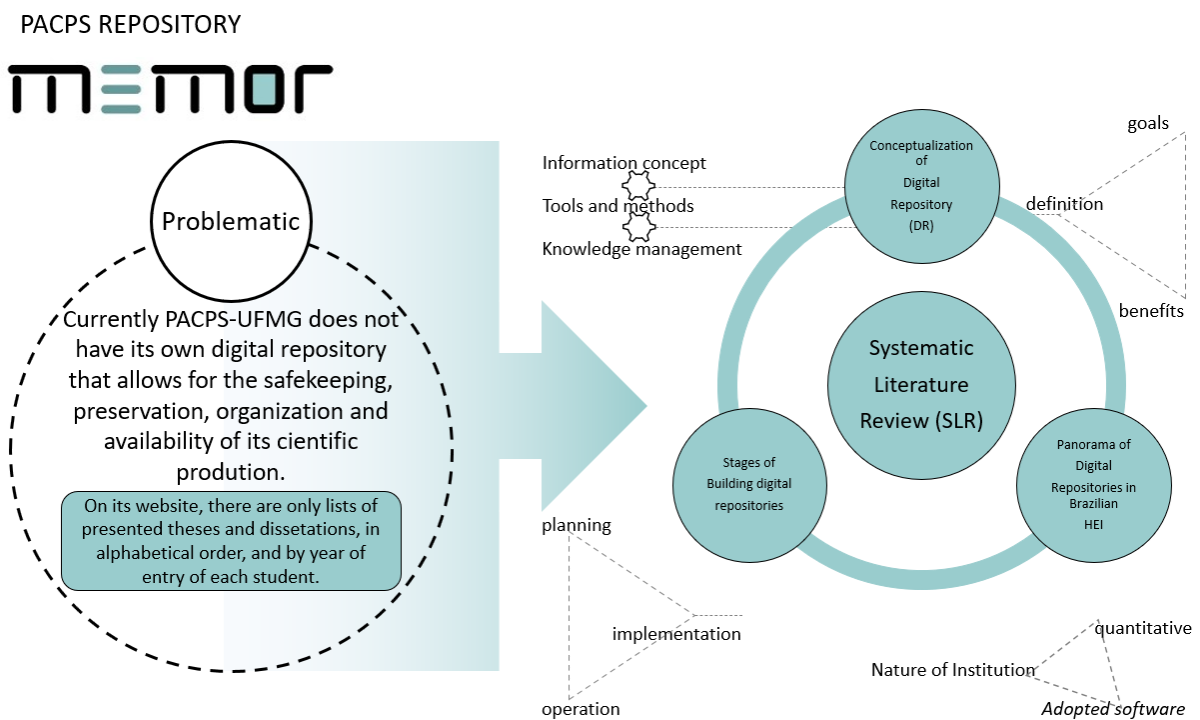


Figure 5 – Developing the artifact (Source: Adapted from Vidigal et al. (2022))

For the final step of TELsteps, the report (VIDIGAL et al., 2022) was presented in December 2022, and the created artifact will be linked to the ACPS' Portal on the web (Figure 6).

This artifact will provide an overview of the ACPS' projects progress, findings, and results.

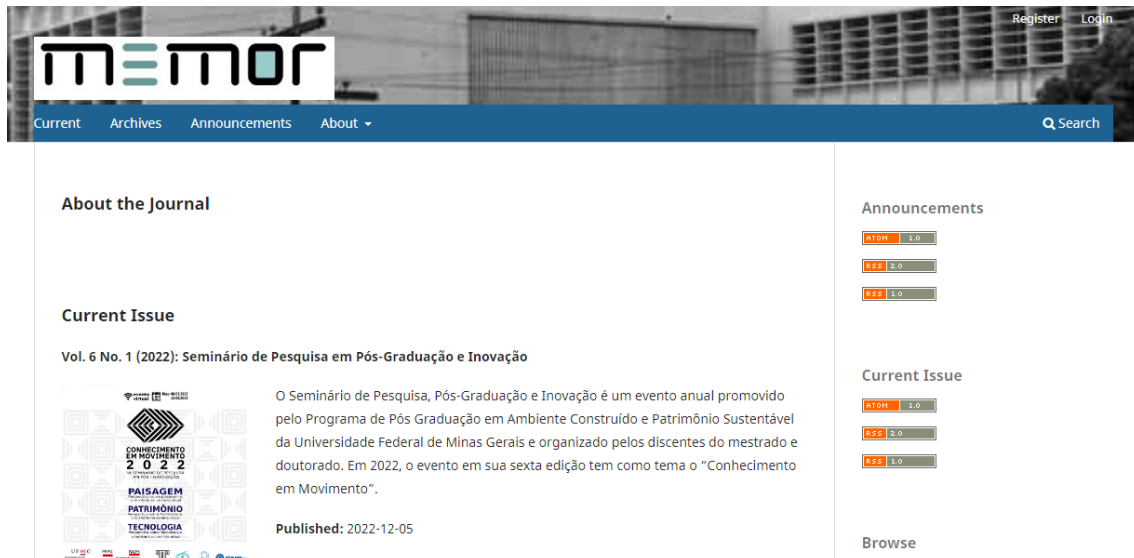


Figure 6 – Final artifact MEMOR (Source: Adapted from Vidigal et al. (2022))

Another experience was about engaging undergraduate Business Administration students, in their first year of the course, using DSR to develop their first paper. Eight of these papers were then presented in a Congress. The same students used DSR to create a second paper, integrating three disciplines of the same course: Academic Research and Writing, Microeconomics, and Statistics.

At least three theses that utilized the DSR approach were supervised, providing valuable insights about the structure and steps of the research process. It was demonstrated that TELsteps can be a useful research methodology for all stages of the research process, not just the construction of the manuscript. This was an important contribution, as it highlighted the potential of TELsteps to help with the research methodology rather than just the methodological procedure for creating the artifact.

The most recent experience with TELsteps, used by the first author but not explicitly discussed with the team, has been the creation, since 2022, of a shared database for three non-profit organizations working together to address the devastating ecological disaster in Brumadinho, Brazil. The basic idea was not to interfere in each organization's systems, but to create an artifact – a common database – with the same structure for all the three organizations, providing integrated information to help the organizations coordinate their efforts and to support other stakeholder's decisions.

7. CONCLUSION

This work, related to an Integrative Learning approach, is part of an ongoing research project named "Transdisciplinary Environments of Learning" (TEL) that uses a standard methodology (TELsteps) – adapted from Design Science Research (DSR) – across different fields, also proposing a common language (TELdict).

TELsteps is composed by four steps: defining the goal, developing the artifact, validating its efficacy, and disseminating the knowledge created. These steps do not necessarily need to be followed in a linear sequence; at any point one can review the previous step in relation to any of the four steps.

TELdict proposes terms such as "abstraction", "analogy", and "generalization" to facilitate understanding of convergent aspects; "artifacts" and "informational complexes" to represent elements of each project in a generic way; and "inner" and "outer environments" as important contexts for the artifact's performance.

An important distinction proposed in TELdict is the difference between "methodological procedure" and "research methodology". The first refers to the specific steps and techniques used in the creation and validation of the artifact. In contrast, the second one is a broader framework that guide all the research process represented in TELsteps.

For TEL, it is not required for the domains to change their methodology, but rather to analyze their results using a common methodology/language. By using the same methodology, different fields can interpret the results and reuse knowledge more easily.

Tektology provided the basic structure for the construction of Informational Complex concept. Given the depth and breadth of Bogdanov's work, it was not intended to provide a comprehensive overview of all the characteristics and concepts of Tektology in this article. This challenge calls for further exploration and would best be suited to a more specific work.

The ongoing research at LATACI[®] Research Institute is developing the Relational Model of Informational Complexes (RMIC), exploring rules for diagram design (e.g., for the types of crises) to enhance comprehension and effectiveness, and we hope it will be shared in a near future paper. Additionally, it will provide practical guidance on how to use the concepts to develop effective solutions to real-world problems.

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