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A Novel Balanced Reporting Innovation with Data Governance Evolution (BRIDGE) Method: An Eduinformatics Integration of Creativity, Abduction and Organizational Knowledge Acceptance

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Abstract

The era of Society 5.0 demands both creativity and systematic knowledge implementation in organizational settings. However, there exists a significant gap between understanding new knowledge and its practical application. This paper proposes the Balanced Reporting Innovation with Data Governance Evolution (BRIDGE) method as a novel approach to facilitate the transi-tion from intellectual understanding to unconscious competence in implementing new knowledge. Through the lens of Eduinformatics, we demonstrate how the BRIDGE method effectively integrates abductive reasoning for innovation while ensuring organizational ac-ceptance. Using a case study from institutional research practices, we show how the method provides a structured transition period where traditional and innovative approaches coexist, en-abling organizations to maintain operational continuity while implementing new methodologies. The BRIDGE method addresses the fundamental challenge of knowledge acceptance by ac-knowledging that while creativity and abduction are essential for generating new knowledge, successful implementation requires careful consideration of organizational dynamics. Our findings suggest that this method can be adapted for various organizational contexts where new knowledge needs to be effectively implemented and accepted, providing a practical framework for bridging the gap between innovation and adoption.

Keywords: Creativity, Eduinformatics, Abduction, Knowledge

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1 Introduction

1.1 Society 5.0 and STEM / STEAM Education

The advent of Industry 5.0 [1] and Society 5.0, proposed by the Japanese Cabinet Office [2][3], marks a significant transformation in how we approach technological advancement and social development. This transformation necessitates a fundamental shift in educational paradigms, particularly in the context of information and communication technology (ICT) for future generations [4]. The evolution of human society, as conceptualized in the Society 5.0 framework, represents a progression through distinct phases: from hunting (Society 1.0) and agriculture (Society 2.0) to industrialization (Society 3.0) and information (Society 4.0), culminating in the current emerging phase (Fig. 1)

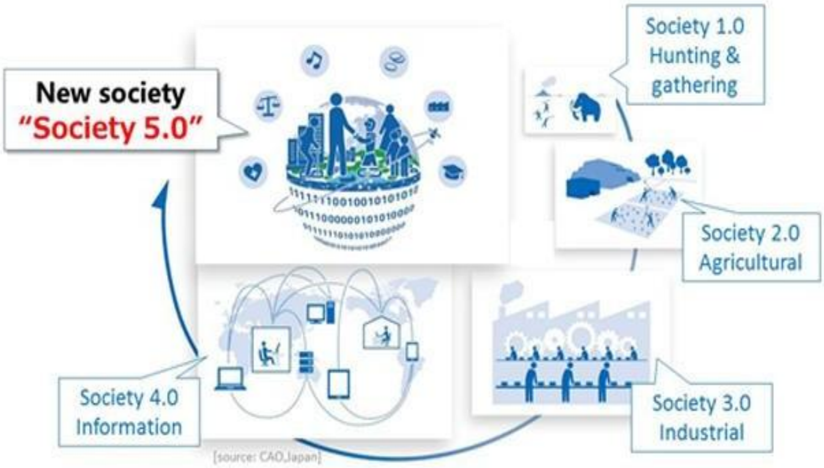

Figure 1: Society 5.0 ([5])

Educational frameworks for this new era have evolved to encompass comprehensive approaches to learning. Contemporary education emphasizes the integration of multiple disciplines, as exemplified by Science, Technology, Engineering, and Mathematics (STEM) education [6], [7]. This framework has further evolved into Science, Technology, Engineering, the Arts, and Mathematics (STEAM), acknowledging the crucial role of artistic and creative thinking in technological innovation [8]. The incorporation of arts into the traditional STEM framework reflects a growing recognition that technological advancement must be complemented by creative problem-solving capabilities.

Contemporary educational requirements, as outlined by the Organization for Economic Co-operation and Development (OECD), extend beyond traditional knowledge acquisition [9]. The OECD framework emphasizes three essential clusters of competencies: delivery-related, interpersonal, and strategic [9]. This comprehensive approach reflects the understanding that education in the Society 5.0 era must cultivate both technical expertise and creative capabilities. Such an integrated approach ensures that learners develop the diverse skills necessary for navigating and contributing to an increasingly complex technological landscape while maintaining the human creativity essential for innovation.

1.2 Eduinformatics

The emergence of new educational paradigms necessitates innovative methodological frameworks for addressing contemporary challenges. In this context, Eduinformatics represents a novel interdisciplinary field that integrates educational principles with informatics methodologies [10]. This integration extends beyond the conventional application of informatics in education, encompassing the development and proposal of new analytical approaches for addressing educational challenges [11].

The foundation of Eduinformatics lies in its dual focus: utilizing informatics to enhance problem-solving capabilities in education while simultaneously developing new methodological approaches. This framework has demonstrated particular efficacy in various educational contexts, especially in the analysis and visualization of complex educational data [11]. The systematic approach of Eduinformatics enables researchers to develop more effective methodologies for addressing contemporary educational challenges.

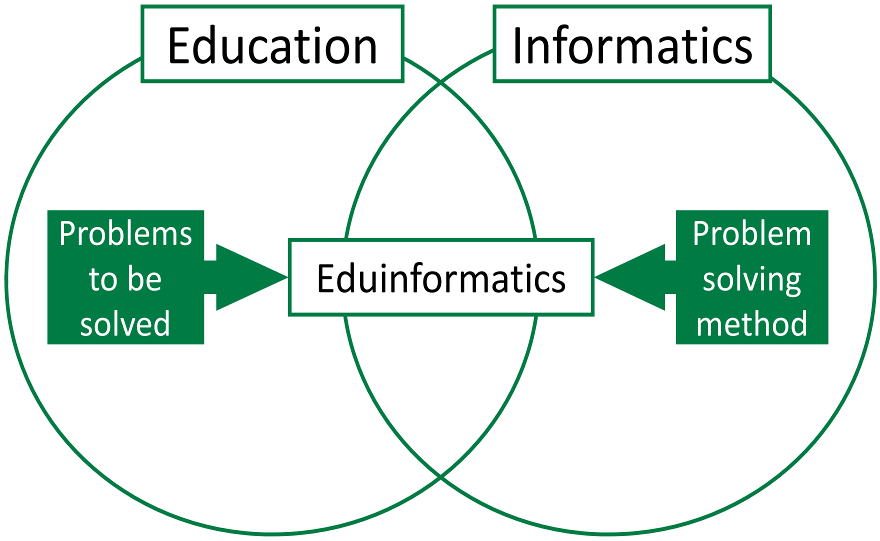

Figure 2: Concept of Eduinformatics ([10])

Recent applications of Eduinformatics have expanded to include theoretical research based on data-driven approaches [11]. This evolution reflects the field's adaptability to emerging educational needs, particularly in the context of higher education reform and institutional research activities. The integration of Eduinformatics principles facilitates the development of systematic approaches to educational analysis, enabling more effective responses to evolving educational challenges in the digital age [10]. This methodological framework provides a structured foundation for analyzing educational phenomena while maintaining the flexibility necessary for addressing diverse educational contexts and supporting evidence-based decision-making in educational settings.

1.3 Knowledge Network and Knowledge Network Tag Models

The conceptualization of knowledge as interconnected networks, rather than isolated units, has become increasingly significant in modern educational frameworks. Our research has developed two fundamental models to understand this interconnected nature of knowledge creation and dissemination: the Knowledge Network Model and its evolution, the Knowledge Network Tag Model [12], [13].

The Knowledge Network Model initially conceptualized the process of knowledge creation through three distinct stages: the proliferation stage, where individual pieces of knowledge are acquired; the mixing stage, where these pieces begin to interact; and the creation stage, where new knowledge emerges from these interactions [12]. This model provided a foundation for understanding how discrete units of information transform into networked knowledge within human cognition.

Building upon this framework, we introduced the Knowledge Network Tag Model, which incorporates the concept of "tags" as catalysts for knowledge connection (Fig. 3). Tags serve as intermediate elements that facilitate the linking of seemingly unrelated pieces of knowledge, enabling more dynamic and flexible knowledge creation processes [13]. This innovation in our theoretical framework better reflects the complex nature of human cognitive processes, where associations between different knowledge elements often occur through shared characteristics or contextual similarities.

The significance of these models lies in their ability to explain how individuals develop comprehensive understanding through the construction of knowledge networks. In the context of modern education, where information is abundant and increasingly interconnected, these models provide valuable insights into how learners can effectively organize and synthesize information. The tag-based approach particularly resonates with contemporary learning environments, where information is often categorized and accessed through multiple interconnected reference points.

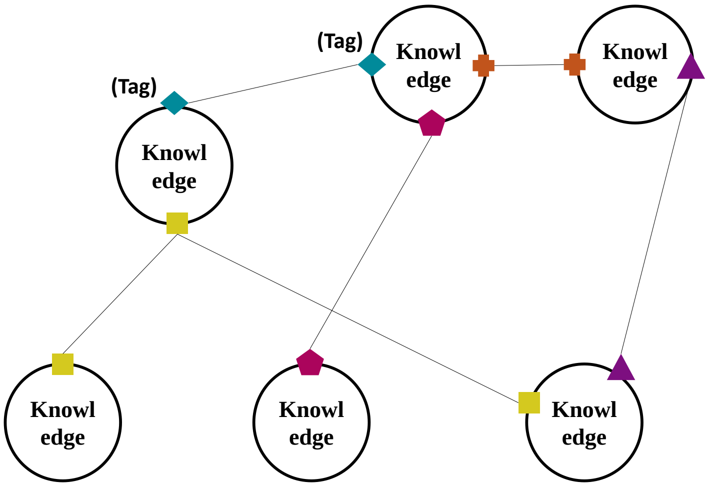

Figure 3: Concept of knowledge network growth model from modification of [13]

These theoretical frameworks have demonstrated particular utility in analyzing complex educational relationships and understanding how different pieces of knowledge become interconnected in meaningful ways. Through these models, we can better understand and facilitate the development of systemic thinking capabilities, which are crucial for navigating the complexities of modern information landscapes [12], [13].

1.4 Abduction in Educational Context

Abduction, first proposed by Charles Sanders Peirce as the third form of inference alongside deduction and induction, has gained significant attention in artificial intelligence and computer science research [14]. Unlike deductive reasoning, which proceeds from general principles to specific conclusions, or inductive reasoning, which moves from specific observations to general principles, abduction represents a distinct form of logical inference that generates explanatory hypotheses from observed phenomena.

In the context of educational research and institutional research (IR), the challenge of hypothesis generation through abduction has become increasingly significant, particularly as we move towards data-driven approaches in education. Traditional data analysis methods often struggle with the complexity of generating meaningful hypotheses from extensive educational datasets. To address this challenge, we have developed the Abduction, Abstract Degree and Urgency Matrix (ABDU-M) as a systematic framework for hypothesis generation and evaluation in educational contexts (Fig. 4)[15].

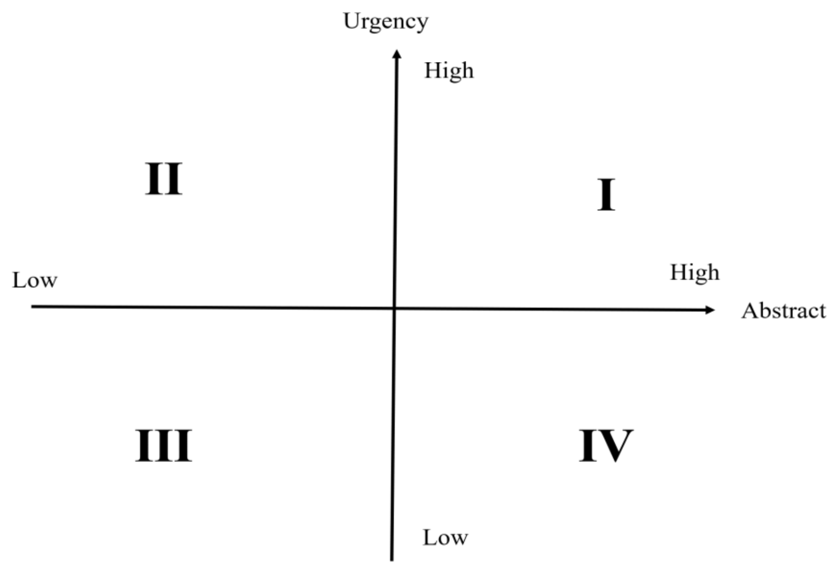

Figure 4: Abduction, Abstract Degree and Urgency Matrix (ABDU-M) ([15])

The ABDU-M framework operates along two primary dimensions: urgency and abstractness. Within this matrix, tasks requiring immediate attention while dealing with abstract, conceptual challenges occupy the high urgency and high abstractness quadrant, while immediate practical tasks requiring concrete action fall into the high urgency and low abstractness quadrant. The framework also accommodates strategic planning and theoretical development in the high abstractness and low urgency sector, while routine operational tasks are positioned in the low abstractness and low urgency area.

From an Eduinformatics perspective, ABDU-M provides a structured approach to balancing the immediate needs of educational institutions with longer-term strategic objectives. This framework particularly excels in supporting the abductive process by helping educators and researchers identify patterns and generate hypotheses from complex educational data. The matrix's flexibility allows for both agile responses to urgent educational challenges and thoughtful consideration of more abstract, systemic issues, while facilitating the crucial transition from data observation to hypothesis generation in educational research and institutional improvement.

1.5 Kirkpatrick's Four-Level Model

The gap between understanding and unconscious competence is a critical consideration in knowledge adoption and skill development. Kirkpatrick's Four-Level Model, widely accepted in training evaluation, provides a framework for understanding this distinction (Figure 5) [16] [17]. The model consists of four sequential levels: Reaction, Learning, Behavior, and Results.

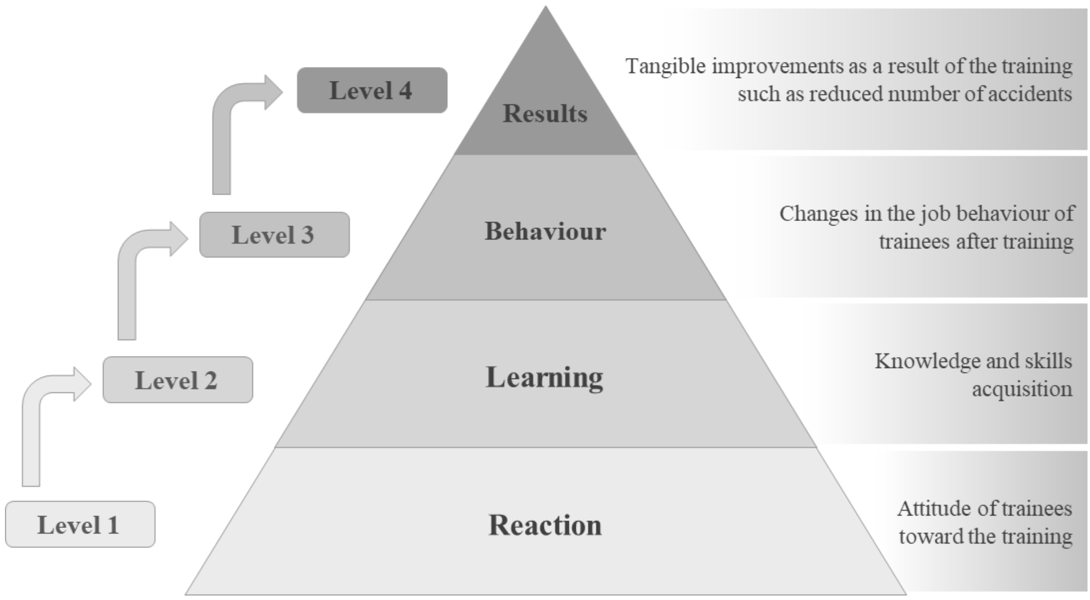

Figure 5: Kirkpatrick's four-level model of training evaluation [17]

Level 1 (Reaction) measures how participants feel about the training, including their emotional response and perceived value. Level 2 (Learning) evaluates the increase in knowledge, skills, or awareness - essentially what participants "know" after training. Level 3 (Behavior) assesses whether participants apply their learning in practice, while Level 4 (Results) measures the final organizational outcomes.

The critical gap often lies between Level 2 (Learning) and Level 3 (Behavior). While individuals may understand a new concept or approach intellectually (Level 2), this does not automatically translate into changed behavior or unconscious competence (Level 3). This distinction is particularly relevant when introducing innovative methods or knowledge in professional settings. For example, in institutional research, practitioners may intellectually grasp the value of new analytical approaches but struggle to implement them effectively in their daily work.

2 Research Question

The preceding sections have demonstrated that in the era of Society 5.0 and Industry 5.0, the creation of new knowledge through creativity and abduction is essential for innovation. However, there exists a fundamental challenge: the gap between understanding new knowledge (Level 2 in Kirkpatrick's model) and unconsciously implementing it (Level 3). This challenge is particularly evident in institutional research (IR), where our experience has shown that even when innovative methods for data visualization and analysis are developed, their adoption often faces significant resistance.

Based on these observations in IR, we can extrapolate a broader question applicable to knowledge adoption across various fields. Therefore, our research question is:

"How can we facilitate the transition from intellectual understanding to unconscious competence when implementing new knowledge?"

This question is particularly relevant in contemporary professional environments where continuous innovation and adaptation are essential. While we draw primarily from our experiences in IR, the implications of this research question extend beyond this specific domain. The answer to this question could provide valuable insights for any field where new knowledge needs to be not just understood, but internalized and implemented effectively.

To address this question, we propose the BRIDGE (Balanced Reporting Innovation with Data Governance Evolution) method. This paper will examine how this method can serve as a systematic approach to bridge the gap between innovation and practical adoption, using IR as a case study while maintaining broader applicability to knowledge adoption in general.

3 Practice Examples

3.1 IR Activities at Tokyo Institute of Technology

The Information and IR Office at Institute of Science Tokyo (IST, established in October 2024 through the merger of Tokyo Institute of Technology and Tokyo Medical and Dental University) has its roots in the IR office established at the former Tokyo Institute of Technology in 2015. This office has been conducting various institutional research and analysis activities, with student surveys playing a particularly significant role [18].

Through these student surveys, the Information and IR Office systematically captures and visualizes information about learning outcomes and educational effectiveness, using this data to drive educational improvements. Specifically, the office conducts the following activities [18]:

1. Monitoring and coordinating various student surveys previously conducted independently by different departments

2. Supporting survey implementation and analysis in collaboration with respective departments
3. Designing surveys to ensure systematic information collection from an IR perspec-tive, even for independently conducted surveys
4. Analyzing student surveys using the I-E-O-L model [19]:
    I. Input (pre-enrollment information)
    II. Environment/Engagement (learning environment and student engagement during enrollment)
    III. Output/Outcome (learning outcomes until graduation)
    IV. Life career (post-graduation professional experience and general life information)
5. Visualizing survey implementation status, content, and survey elements
6. Analyzing issues and proposing improvements for both overall and individual surveys

The insights gained from these initiatives are also utilized in IR consultation services provided to other universities [18]. Through supporting survey operations, the IR office has encountered various challenges while collaborating with survey administrators. These challenges are analyzed from a social psychology perspective to develop more effective support methods [20].

In the process of analyzing surveys and preparing reports for departments, the office has developed a survey analysis system combining Python and Quarto for both analysis and report generation [21]. This system has proven particularly effective in meeting the specific needs of higher education IR, where paper-based reports are often required by universities, making it impractical to implement all analysis results through BI (Business Intelligence) tools alone.

3.2 Traditional Report Creation Methods and Their Challenges

Prior to this study, both our target department and the IR Office had been creating reports using a traditional method where figures were created in Excel and then pasted into Word documents. However, this conventional approach presented several significant challenges.

The most prominent issue was the significant decrease in work efficiency. The process of copying figures from Excel and pasting them into Word documents was cumbersome, requiring substantial time for report creation. Furthermore, the multi-step nature of this process increased the risk of human error, such as data transcription mistakes and figure placement errors. These potential human errors necessitated additional verification procedures, further increasing the overall analysis time.

Moreover, when modifications were needed in an already completed report, the entire process - from data modification in Excel to re-pasting into Word documents - had to be repeated, proving highly inefficient. The management of data across multiple documents and files also made it challenging to maintain data consistency. These issues not only reduced the efficiency of report creation but also potentially impacted the quality of data analysis.

This traditional method's limitations became particularly apparent when dealing with comprehensive survey analyses, where multiple iterations of modifications were often required. The manual nature of the process made it susceptible to errors and inconsistencies, especially when handling large datasets or complex analyses that required multiple revisions based on departmental feedback.

3.3 Introduction of a New Report Creation Method

To address these challenges, we implemented a new analysis and report creation method using Python and Quarto in parallel with the traditional approach this academic year. The new method automates the process from data preprocessing to statistical analysis and figure creation by consistently using Python. Furthermore, by utilizing Quarto, analysis results are automatically converted into report format, eliminating the need for manual figure pasting.

This new approach fundamentally transforms the reporting process through comprehensive automation of all steps from initial analysis to final report creation. By encoding the entire analysis process, the method ensures high reproducibility of results while enabling unified data management across all stages. The automated nature of the system significantly reduces the time and effort required for modifications, as changes can be propagated through the entire report automatically. Additionally, the integrated approach maintains data consistency throughout the process, eliminating discrepancies that often arise in manual handling.

Quarto was specifically chosen as our reporting tool for its ability to convert outputs to Microsoft (MS) Word format. This feature is particularly valuable in our context because it allows department staff to easily add their interpretations and considerations to the analysis results. The MS Word format enables faculty and staff to incorporate their insights seamlessly into the final report.

At Tokyo Tech's Information and IR Office, Python has been standardized as the programming language for analysis to ensure reproducibility and sustainability of operations. The integration of Python with Quarto provides a robust foundation for consistent, efficient, and maintainable report generation.

This new method represents a significant shift from traditional manual processes to a more automated, systematic approach. The combination of Python for analysis and Quarto for report generation creates a streamlined workflow that addresses many of the limitations inherent in the traditional method while maintaining the flexibility needed in academic reporting.

3.4 Comparison of Methods and Departmental Feedback

When we submitted reports created using both old and new methods to the requesting department, we encountered resistance to the adoption of the new analysis method. The primary concern expressed by the department was related to data continuity. The department had been publishing report data in the traditional format on their website for several years, and they raised concerns that transitioning to the new method might make it difficult to compare with these historical data sets.

3.5 Development of the BRIDGE Method as a Solution

To address these concerns, we proposed a compromise solution incorporating a transition period. Specifically, we designated the 2024 academic year as a transition period during which reports would be created using both the traditional and new methods, with both versions being published on the website. This approach ensures access to traditionally formatted reports for pre-2024 data while providing both formats for 2024 data, facilitating a smooth transition to the new method.

We named this parallel implementation approach the BRIDGE (Balanced Reporting Innovation with Data Governance Evolution) method. This proposal was accepted by the requesting department, with an agreement to fully transition to the new method from the 2025 academic year onward.

Figure 1 visually represents this transition plan. Prior to 2023, only the traditional method was used; during 2024, both methods will be implemented in parallel; and from 2025 onward, the new method will be fully adopted. This approach enables data comparison across the transition period while ensuring both continuity of historical data and smooth implementation of the new methodology.

This decision not only promises improved efficiency and quality in report creation but also ensures data continuity and comparability. This case study demonstrates the importance of adopting a gradual and flexible transition strategy.

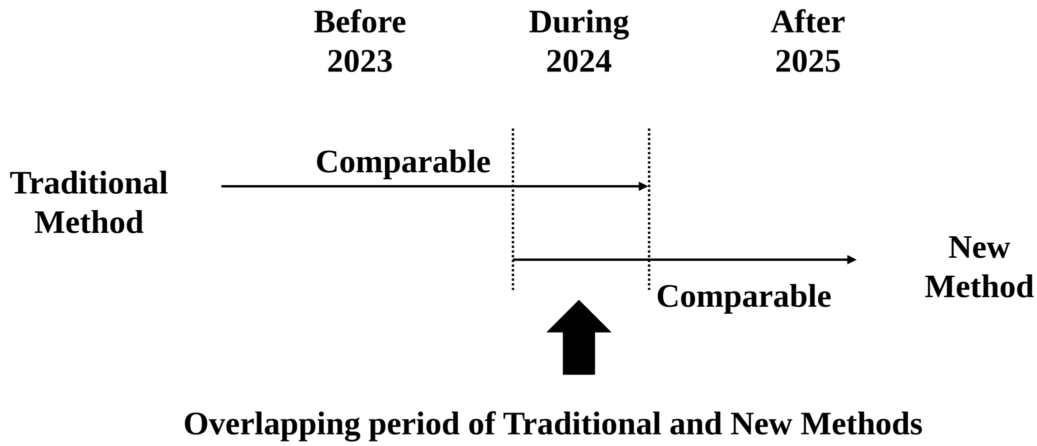

Figure 6: Survey report creation considering continuity (Modified from [22])

4 Conclusion

This paper addressed the research question: "How can we facilitate the transition from intellectual understanding to unconscious competence when implementing new knowledge?" Through our case study of institutional research practices, we have demonstrated that the BRIDGE method provides an effective solution to this challenge.

The BRIDGE method bridges the gap between understanding new knowledge and its practical implementation by providing a structured transition period where traditional and innovative methods coexist. This approach acknowledges that while creativity and abduction are essential for generating new knowledge, the acceptance and implementation of such innovations require careful consideration of organizational dynamics.

Through the lens of Eduinformatics, our study demonstrates how the BRIDGE method successfully integrates three key elements: creative innovation through abductive reasoning, systematic knowledge integration, and organizational acceptance. The method's success in our IR case study suggests its potential applicability in broader contexts where organizations need to implement innovative practices while maintaining operational stability.

This research shows that successful knowledge implementation requires not only creative innovation through abduction but also careful consideration of existing practices, providing a framework that could be adapted for various organizational contexts.

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