IIAI Open Conference Publication Series
IIAI Letters on Institutional Research
Vol.004, LIR218
DOI: https://doi.org/10.52731/lir.v004.218

Proposing a New Field: Institutional Research (IR) Philosophy based on Eduinformatics — Bridging the Gap Between Practice and Theory in IR

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Abstract

Amid the transition from Society 4.0 to Society 5.0, the role of Institutional Research (IR) in higher education is evolving. We have proposed an interdisciplinary field named "Eduinformatics," which integrates education and informatics, offering fresh insights into data-driven educational strategies. In this study, we further introduce "IR Philosophy" as a novel approach to bridge the gap between the theoretical and practical aspects of IR. By examining the current state of IR in Japanese universities, we emphasize the significance of technical skills and the importance of understanding the broader educational context, termed "contextual knowledge." Our findings suggest that while technical proficiency is crucial, a profound understanding of the broader educational context, referred to as "issue knowledge," is equally vital. Furthermore, as we move into the era of Society 5.0, our research underscores the need for a more integrated approach to IR, emphasizing its pivotal role in shaping the future of education.

Keywords: Institutional Research (IR), IR Philosophy, Society 5.0, Eduinformatics

1 Introduction

"Institutional Research" (IR) is a rapidly emerging field in Japanese higher education institutions in recent years. The introduction of IR in Japan was triggered by the generalization of university establishment criteria in 1991[1]. While a concrete definition of the term "IR" is yet to be established, several are included in the glossary created by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT).

In 2012, as part of the report titled "Transforming the Quality of University Education for

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Building a New Future ~ Towards Universities that Cultivate Lifelong Learning and Autonomous Thinking"[2] the provisional term "University Portrait" contained a description of IR. This report outlines the process of universities understanding and analyzing their own activities using educational information and connecting this understanding to reforms—an enhancement of the so-called IR function.

Furthermore, the 2018 "Grand Design for Higher Education Towards 2040"[3] Term Explanation defines IR[4] as a function or department that conducts surveys and analyzes information about institutions in higher education. The central collection and analysis of institutional information enable institutions to plan, formulate policies, and make decisions smoothly. It also provides institutional information to internal and external stakeholders as needed.

Similarly, the 2020 "Educational Management Guidelines"[5] of the Central Council of Education University Subcommittee established a definition of institutional research (IR) and teaching IR. Just as with the previous definition, it is implied that the term "Educational IR" is used specifically within these guidelines.

In Japan, IR is generally categorized into three types: education, research, and management [6]. In the 2012 report [2], educational IR is mentioned in the context of university reforms. This is because IR first appeared in relation to evaluations. While the 2018 term explanation [4] only refers to institutions without specifically mentioning types of IR, the 2020 term explanation [5] explicitly addresses educational IR.

As of 2022, while research and management IR exist, teaching IR is likely the most advanced field [7]. Moreover, areas closely related to IR, such as "enrollment management" and "institutional effectiveness" (IE), exist as concepts and activities similar to those of IR. Enrollment management has a close connection with IR, and the first chapter of "The Handbook of Institutional Research" [8] is titled "Enrollment Management and Academic Affairs." IR and enrollment management have an inclusive relationship. "Learning analytics" is another field closely related to IR [9]. Hence, IR spans a wide range of border areas; thus, it is not sufficient to just deal with IR reflecting the current state of affairs.

In America, where IR has been practiced for over 50 years [10], the field has developed through an interaction exchange between practical and academic aspects. Contrarily, in Japan, interests and initiatives in the practical aspects of IR, such as the content of IR work, its organizational positioning, and responses to accreditation evaluations, have been predominant.

In this context, we focused our research on establishing a foundation for IR as an academic field with a particular focus on the following three objectives: Establishing a foundation to organize the theoretical framework of IR as an academic field and improve the skills of IR practitioners, building platforms for sharing datasets used in research, and researching and developing authentication technologies.

I. Establishing an ontology for systematizing IR academically
II. Implementing a skillset and development program necessary for practicing IR
III. Establishing information technology such as information infrastructure and authentication infrastructure to effectively function IR

Implementing a skillset and development program necessary for practicing IR We initially conducted surveys as practical investigations of talent and skillset development. The first survey investigated the frequency of IR training opportunities using archived data from the asagao-Mailing List (ML). Based on the information disseminated through ML, we identified IR-related training events and examined their annual frequency [11]. From 2010 to 2015, an increasing trend was observed, and from 2016 to 2021, the number of events remained high, exceeding 40 during the peak years. Regarding the hosting entities, in 44.9% of the cases, the events were organized by individual universities.

To investigate objectives I and II, we conducted a survey across whole 806 Japanese universities (86 national, 94 public, and 626 private institutions)[12]. In this research, we found that many of them said that knowledge and skills corresponding to "contextual intelligence" and "issues intelligence" were necessary, and among those corresponding to "technical/analytical intelligence," were differently perceived in terms of their necessity. In addition, when asked to self-evaluate their knowledge and skills, some respondents gave lower self-evaluations than they did for the perceived needs for these knowledge and skills.

However, one research question remains. Is it sufficient to have the technical skills to implement practical IR? The survey response reveals that "contextual intelligence" and "issues intelligence" are important in IR practice. Therefore, we set our research questions as follows: RQ: What is the connection between the practice and theory of IR?

2 Similarities in the Transition from Society 2.0 to Society 3.0 and from Society 4.0 (Current) to Society 5.0

Society 5.0 is the concept of the future society [13]. The Japanese Cabinet Office provides one definition of Society 5.0. Society 1.0 is a hunting society. Society 2.0 was an agricultural society. Society 3.0 was an industrial society. Society 4.0 is an information-based society. Society 5.0 is the one after Society 4.0. [13] (Figure 1). In countries other than Japan, Society 5.0 is referred to as Industry 5.0. Therefore, Industry 5.0 mentioned in this paper is to be interpreted as synonymous with Society 5.0.

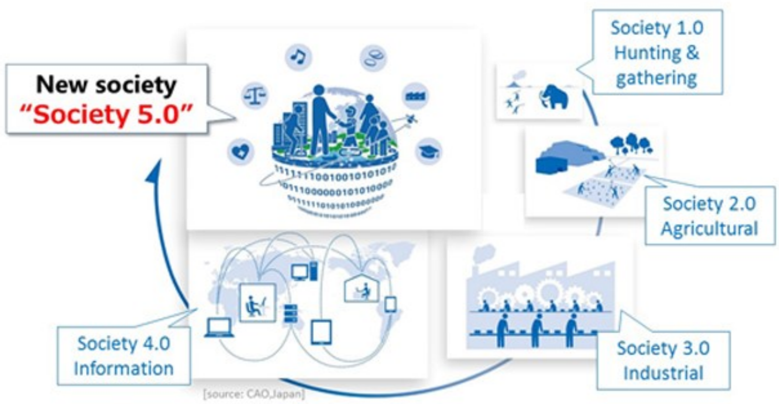

Figure 1: Society 5.0 (from [13]).

Science, technology, engineering, and mathematics (STEM) are some of the most important education in the 21st century [14]. In 2010, Rodger W. Bybee introduced the importance of STEM education in the journal "Science" [15]. The title was "What Is STEM Education?". In this article, he stated that it is important that STEM education deals with not only science and mathematics but also technology and engineering for 21^{st} century citizens. STEM education is important because of the scientific literacy of younger generations.

Moreover, both art and STEM create new variant disciplines such as science, technology, engineering, arts, and mathematics (STEAM) [16]. Especially ability of Creativity is particularly important for the younger generations. Therefore, STEAM education is currently one of the most important disciplines in STEM education. To establish the next century (21^{st} century), STEAM education is important for the younger generation. STEAM education is important not only for higher education but also for pre-primary, primary, and secondary education as students can easily obtain creativity. Research on early childhood education in STEAM has been published and reviewed [17][18].

Creativity for the younger generation and securing a good quality of life (QOL) in the future are major reasons to consider STEAM education for younger generations. Information and communication technology (ICT) is evolving rapidly. In the future, the younger generations will have to use more ICT in their lives. In fact, a paradigm shift has promoted a new era of industrial-level Industry 5.0 [19] and Society 5.0 [20][21].

In the era of Society 5.0, education is not the same as those of earlier societies. For example, the Organization for Economic Cooperation and Development (OECD) proposes competency-based education [22]. The OECD distinguishes between technical competencies and core competencies [22] by describing that "Technical competency requirements to successfully perform a given job are defined in job vacancy announcements" and core competencies are categorized into the following three clusters: delivery-related, interpersonal, and strategic cluster[22]. This shows that in the 21^{st} Century, education not only includes simple knowledge but also the ways to use it and create new knowledge.

Education is changing along with these rapidly changing situations, from Society 4.0 to Society 5.0. The government has defined "recurrent education" and "reskilling" as key components for career advancement and productivity growth [23]. In the fiscal year 2016, the MEXT organized a discussion group called the "Discussion on the Enhancement of Mathematical and Data Science Education," consisting of knowledgeable experts and scholars. This group compiled measures to strengthen mathematical and data science education in universities [24]. Then, in the "AI Strategy 2019," which was decided by the Integrated Innovation Strategy Promotion Council in 2019 (June of the first year of Reiwa)[25], it was set forth that by the target year of 2025, "all university and technical college students, regardless of their field of study (approximately 500,000 graduates/year), should acquire basic knowledge in mathematics, data science, and AI."

Furthermore, the Committee for the Promotion of Measures to Strengthen Mathematical and Data Science Education in Universities stated that "regardless of their field of study, a certain number of university and technical college students (approximately 250,000 graduates/year) should acquire foundational skills in applying mathematics, data science, and AI to their specialized fields"[24]. The immediate goal of higher education is "to establish an educational environment where all university students, regardless of their major, systematically acquire mathematical thinking and data analysis/utilization skills"[26].

If we aim to understand the future of education during the shift from "Society 4.0 to 5.0," a historical perspective can provide valuable insights for understanding. This is not the first-time education has been scrutinized during societal transformation driven by technological advancements. In particular, recent discussions on the Institutional Research share common ground with debates on pedagogy during a period when pedagogy was striving to establish itself as a distinct modern science during the transition from "Society 2.0 to 3.0." The following sections explore the technological innovations and the corresponding societal changes that unfolded in the 18th and 19th centuries. We delve into the efforts to establish pedagogy as an independent science during this period. We aim to draw lessons from this historical context to inform future discussions on the Institutional Research.

In the 18th century, profound societal transformations were instigated by a series of technological breakthroughs, most notably, the invention and refinement of the steam engine, along with its widespread adoption for commercial purposes. These advancements heralded the advent of the capitalist mode of production and a significant shift in the industrial landscape from agriculture to industry. This period is often characterized as the onset of the modern era, often referred to as the "transition from Society 2.0 to Society 3.0." Concurrently, these societal changes triggered intense global competition for colonial territories, ultimately paving the way for the emergence of imperialism in the 19th century.

Consequently, during the 18th and 19th centuries, societal expectations regarding education rose significantly. The reshaping of the industrial landscape and the heightened global competition not only gave rise to a novel concept of human resources, particularly industrial workers and citizens, deemed appropriate for the evolving society but also prompted inquiries into how to efficiently cultivate them. Relying on education to tackle such challenges is a familiar scenario. Education has often been used to meet the demands of societal transformations brought about by the emergence and widespread adoption of new technologies.

However, pedagogy in the 18th and 19th centuries did not immediately meet such social expectations; on the one hand, there was the traditional view of pedagogy as a technical theory of guiding children and, on the other hand, there were attempts to establish a new pedagogy as a scientific theory in the wake of the scientific revolution. The question of how to relate these two forms of pedagogy was explored [27].

Symbolized by the question, "How do we teach and guide children?" pedagogy was born as a practical science targeting various individual educational practices and questioning its contribution to those practices. At the time, incorporating modern scientific standards into traditional pedagogy seemed difficult because the modern scientific perspective, which reduces human phenomena to their elements and analyzes their universality, was thought to exclude the unique perspective of pedagogy, which focuses on the diversity of individual educational practices [28].

As a result, pedagogy was divided into two camps: one is concerned with the facts of practical experience, paying little attention to philosophical and theoretical developments; and the other is concerned with philosophy and theory and less concerned with the facts of practical experience. Pedagogy as an academic discipline could not adequately deal with the issue of developing new human resources suitable for the new society.

Johann Friedrich Herbart (1776-1841) was pivotal in systematically establishing pedagogy as a science within this context. His pursuits were twofold: a theoretical interest in formulating a philosophical framework to underpin the potential for human development and a practical interest in developing a structured system of representation to observe and document the progression of human growth, thus enhancing his intellectual exploration [29]. Consequently, he structured pedagogy as a science by integrating practical philosophy (ethics) and psychology as foundational disciplines. He articulated that "Pedagogy, as a science, draws on practical philosophy and psychology; the former defines the objectives of cultivation, while the latter delineates the methods, means, and challenges involved [30]."

Although Herbart's systematized pedagogy was later disentangled into speculative ethics (philosophy of education) and empirical psychology (psychology of education), it was methodically refined as a practical theory by the Herbart School. Its influence extended beyond Germany, gaining global recognition. Undoubtedly, one of the driving factors behind this expansion was the anticipation that the pedagogical framework formulated by the Herbart School would provide solutions to the challenge of nurturing new human resources suited for the evolving society. Consequently, during the 20th century, pedagogy underwent a bifurcation and further development, branching into two distinct areas: philosophy of education and psychology of education.

There are some similarities between the changing situations from Society 4.0 to 5.0 with those from Society 2.0 to 3.0, during the 18th century industrialization. While the current focus on IR is solely on practice, both practice and theory are essential in reality. Therefore, bridging this gap is necessary in the context of time. This is precisely how, during the Society 2.0 to 3.0 transition, education branched into educational philosophy and educational psychology.

In the current era of transitioning from Society 4.0 to 5.0, the need for a philosophy of IR is implicated. Therefore, we propose a new IR field called the "IR Philosophy." IR philosophy perceives IR as an academic discipline, which scientifically derives theory from practice and constantly questions what good IR might be. It is likely to become an important field of higher education in the future.

3 Discussion

As previously described, most Japanese universities have IR sections. From our survey, the faculty and staff of IR sections wanted to obtain many abilities, not only in statistics, but also in the knowledge of higher education. To solve these problems, we proposed Eduinformatics.

Eduinformatics is a new interdisciplinary field that includes informatics and education [31], which is a combination of the words "education" and "informatics." It is an interdisciplinary field involving both education and informatics. It analyzes student data and develops novel analytical methods [32] (Figure 2).

To address the sustainability of IR sections, we propose Feasibility-Sustainability Analytics (FS Analytics) [33][34] (Figure 3). This FS analysis, with the vertical axis representing feasibility and the horizontal axis representing sustainability, makes it possible to analyze the handover tasks.

Upon reflection, we realized that we had been proposing a concept that elevated the abstraction level of IR activities that we had been conducting as our tasks. Therefore, we proposed the Abduction, Abstract Degree and Urgency Matrix (ABDU-M), with the vertical axis representing "urgency" and the horizontal axis representing "abstractness" [35] (Figure 4).

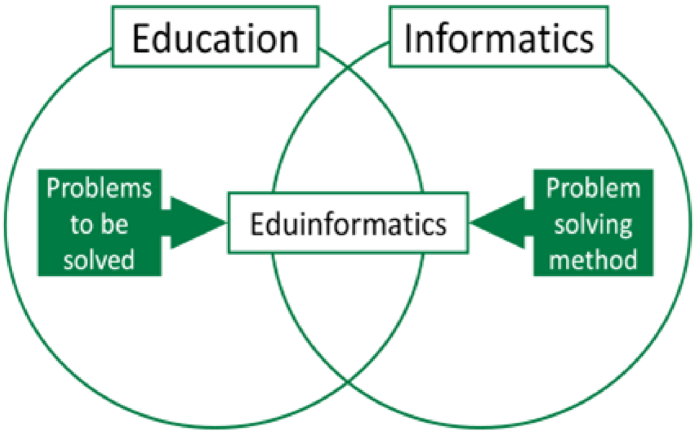

Figure 2: The concept of Eduinformatics from [35].

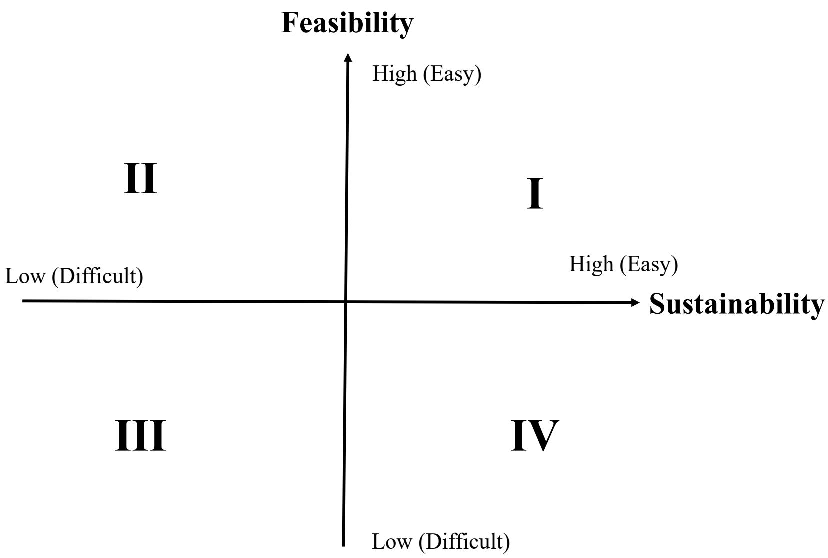

Figure 3: The matrix of feasibility and sustainability [33][34].

Abduction, Abstract Degree and Urgency Matrix (ABDU-M), with the vertical axis representing "urgency" and the horizontal axis representing "abstractness" [35] (Figure 4).

Based on these two concepts, we can connect the practice and theory in IR. Our survey showed that the aim of IR at each university in Japan differs and depends on the university.

Therefore, it is important to connect the practices of each university to IR theory. IR philosophy plays an important role in adapting theory from practice. Moreover, to adapt theory from the practice of IR, we must understand Japan's social and educational history. In IR philosophy, it is important to learn about the history of education in the old Edo era, which formed the background of Japanese education between 1603 and 1867.

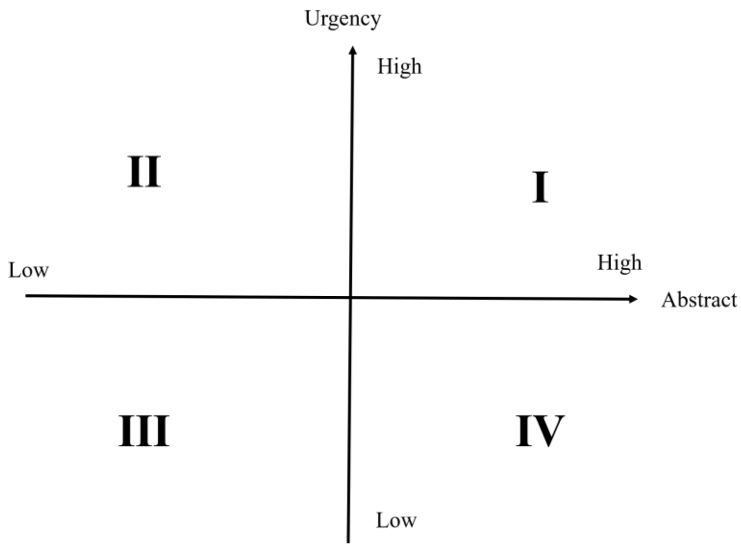

Figure 4: Abduction, Abstract Degree and Urgency Matrix (ABDU-M) [35]

Finally, we describe the data- and hypothesis-driven research approaches. Figures 5 and 6 show the relationship between hypothesis- and data-driven research approaches [36]. We propose that these two approaches are dependent on each other (Figure 6). When constructing hypotheses from data, abduction is usually used. Abduction, similar to induction or deduction, is a theoretical thinking method proposed by Charles Sanders Peirce[37]. Though we cannot understand abduction well now, IR philosophy may be related to it.

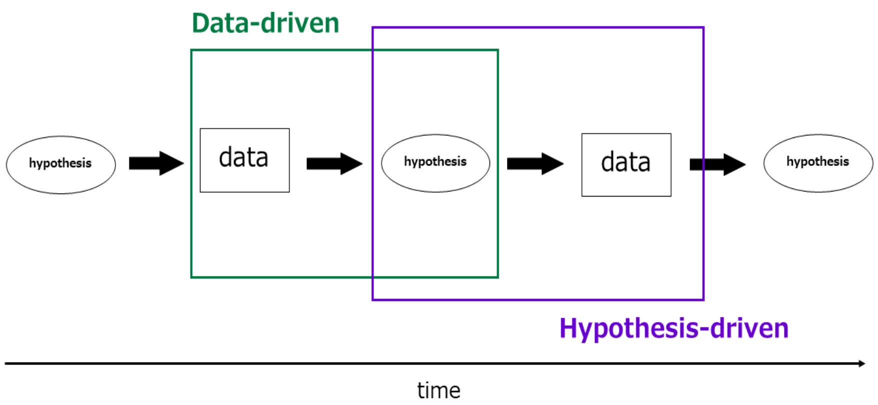

Figure 5: Data-driven approach and hypothesis-driven approach from [36]

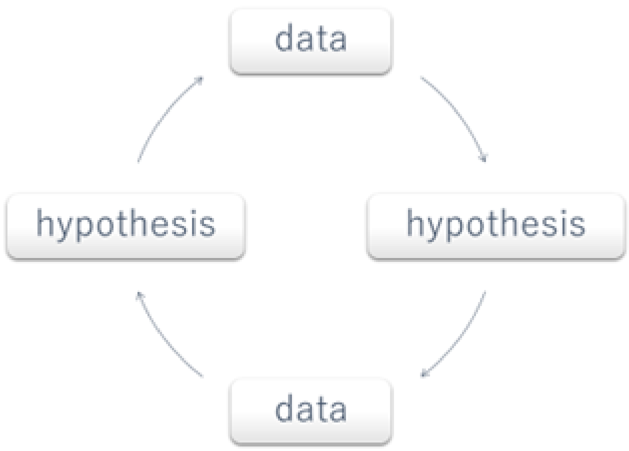

Figure 6: Cycle of hypotheses and data from [36]

Acknowledgement

This study was supported by JSPS KAKENHI (Grant Numbers: 22H00077 and 20K10653).

References

[1] M. Fujiwara, S. Chikamori, A. Asano, and N. Soshii, "Development of institutional research (IR) to support policy formulation in the educational field: Definition, organizational structure, and processes of institutional research in the educational field at Ritsumeikan University (Japanese)," *Univ. Adm. Stud.*, vol. 4, pp. 17–31, 2009.

[2] MEXT, "Transforming the Quality of University Education for Building a New Future :

Towards Universities that Cultivate Lifelong Learning and Autonomous Thinking (Japanese)," 2012. [Online]. Available: https://www.mext.go.jp/b_menu/shingi/chukyo/chukyo0/toushin/1325047.htm (accessed Jul. 01, 2022). [Accessed: 01-Jun-2023].

[3] MEXT, "Grand Design for Higher Education Towards 2040 (Japanese)," 2018. [Online]. Available: https://www.mext.go.jp/b_menu/shingi/chukyo/chukyo0/toushin/1411360.htm. [Accessed: 01-Jun-2023].

[4] MEXT, "Term Explanation: 'Educational Management Guidelines' (Japanese)," 2022. [Online]. Available: https://www.mext.go.jp/content/20200206-mxt_daigakuc03-000004749_005.pdf. [Accessed: 01-Jun-2023].

[5] MEXT, "Eucational Management Guidelines (Japanese)," 2020. [Online]. Available: https://www.mext.go.jp/b_menu/shingi/chukyo/chukyo0/toushin/1411360_00001.html. [Accessed: 01-Jun-2023].

[6] R. Yamada, "Trend of IR in Japan: Emergence of IR Including Management, Teaching and Learning and Research," *Proc. Inst. Stat. Math.*, vol. 68, no. 2, pp. 197–208, 2020.

[7] Y. Aioi, S. Iseri, S. Imai, T. Oishi, S. Okada, N. Kondo, R. Sugihara, S. Tajiri, M. Tsubakimoto, K. Nishiyama, T. Matsuda, and M. Mori, *Standard Guide book of Institutional Research in Universities*. impress R&D, 2022.

[8] R. D. Howard, G. W. McLaughlin, and W. E. Knight, *The Handbook of Institutional Research*, 1st ed. Jossey-Bass, 2012.

[9] T. Matsuda and Y. Watanabe, "Educational IR, Learning Analytics, and Educational Technology," *Inf. Technol. Educ. Learn.*, vol. 41, no. 3, pp. 199–208, 2017.

[10] J. L. Saupe, "The functions of institutional research. 2nd Edition.," 1990.

[11] S. Iseri, T. Oishi, N. Kondo, and K. Takamatsu, "Actual Conditions of Training Opportunities on IR in Japan — From the Archived Data of Asagao ML —," in *11th Meeting Japanese Institutional Research*, 2022, pp. 164–169.

[12] S. Iseri, T. Oishi, N. Kondo, and K. Takamatsu, "Training Opportunities and Required Skills for Institutional Research Programs in Japan," in *Proceeding of the 23rd annual conference of South East Asian Association for Institutional Research (SEAAIR2023)*, 2023, p. in press.

[13] Cabinet Office in Japan, "Society 5.0," 2016. [Online]. Available: https://www8.cao.go.jp/cstp/english/society5_0/index.html. [Accessed: 01-Oct-2023].

[14] X. Ge, D. Ifenthaler, and J. M. Spector, *Emerging technologies for STEAM education: Full STEAM ahead*. Springer, 2015.

[15] R. W. Bybee, "What is STEM education?," *Science*, vol. 329, no. 5995. American Association for the Advancement of Science, p. 996, 2010.

[16] D. Aguilera and J. Ortiz-Revilla, "STEM vs. STEAM education and student creativity: A systematic literature review," *Educ. Sci.*, vol. 11, no. 7, p. 331, 2021.

[17] S. Wahyuningsih, N. E. Nurjanah, U. E. E. Rasmani, R. Hafidah, A. R. Pudyaningtyas, and M. M. Syamsuddin, "STEAM learning in early childhood education: A literature review," *Int. J. Pedagog. Teach. Educ.*, vol. 4, no. 1, pp. 33–44, 2020.

[18] A. A. Akturk and H. O. Demircan, "A review of studies on STEM and STEAM education in early childhood," *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Derg.*, vol. 18, no. 2, pp. 757–776, 2017.

[19] E. Carayannis and J. Alexander, *Global and local knowledge: Glocal transatlantic public-private partnerships for research and technological development*. Springer, 2006.

[20]O. Onday, "Japan's society 5.0: going beyond industry 4.0," *Bus. Econ. J.*, vol. 10, no. 2, pp. 1–6, 2019.

[21] M. Fukuyama, "Society 5.0: Aiming for a new human-centered society," *Japan Spotlight*, vol. 27, no. 5, pp. 47–50, 2018.

[22] "competency framework," *OECD*. [Online]. Available: http://www.oecd.org/careers/competency_framework_en.pdf. [Accessed: 15-Sep-2018].

[23] MHLW, "Human Resource Development Revolution Basic Concept (Japanese)," 2018. [Online]. Available: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000207430.html. [Accessed: 15-Apr-2022].

[24] D. on the E. of M. and D. S. Education, "Measures to Strengthen Mathematical and Data Science Education in Universities (Japanese)," *MEXT*, 2020.

[25] I. I. S. P. Council, "AI Strategy 2019," 2019.

[26] Benesse Holdings, "Towards establishing an environment where all university students can receive data science education," 2019.

[27] M. Ogasawara, "Education," in *History of Educational Thought Society*, Revised an., History of Educational Thought Society, Ed. Keisoshobo, 2017, p. 145.

[28] S. Suzuki, "Herbart," in *History of Educational Thought Society*, Revised an., History of Educational Thought Society, Ed. Keisoshobo, 2017, p. 706.

[29] S. Suzuki, "Herbart," in *History of Educational Thought Society*, Revised an., History of Educational Thought Society, Ed. Keisoshobo, 2017, p. 707.

[30] J. F. Herbart, *Umriss pädagogischer Vorlesungen*. Kyodoshuppan, 1974.

[31] K. Takamatsu, K. Murakami, T. Kirimura, K. Bannaka, I. Noda, L. R.-J. Wei, K. Mitsunari, M. Seki, E. Matsumoto, M. Bohgaki, A. Imanishi, M. Omori, R. Adachi, M. Yamasaki, H. Sakamoto, K. Takao, J. Asahi, T. Nakamura, *et al.*, "'Eduinformatics': A new education field promotion," *Bull. kobe Tokiwa Univ.*, vol. 11, pp. 27–44, 2018.

[32] K. Takamatsu, Y. Kozaki, K. Murakami, A. Sugiura, K. Bannaka, K. Mitsunari, M. Omori, and Y. Nakata, "Review of Recent Eduinformatics Research," in *IEEE/IIAI International Congress on Applied Information Technology 2019*, 2019, pp. 27–32.

[33]K. Takamatsu, I. Noda, K. Bannaka, K. Murakami, Y. Kozaki, A. Kishida, H. Kabutoya, K. Mitsunari, R. Adachi, M. Omori, and Y. Nakata, "Sustainability of Digital transformation (DX), Institutional Research (IR), and Information and Communication Technology (ICT) in Higher Education based on Eduinformatics," in *Intelligent Sustainable Systems Selected Papers of WorldS4 2022, Volume 1*, 2023, pp. 565–572.

[34] K. Takamatsu, T. Oishi, S. Matsumoto, K. Nishiyama, I. Noda, S. Imai, K. Bannaka, K. Murakami, A. Kishida, Y. Nakata, and M. Mori, "Practice report of

Feasibility-Sustainability Analytics (FS Analytics) in Institutional Research (IR) based on Eduinformatics and new proposal to improve Sustainability in IR (Japanese)," in *11th Meeting Japanese Institutional Research*, 2022, pp. 12–17.

[35]K. Takamatsu, I. Noda, K. Bannaka, K. Murakami, T. Kirimura, T. Kunisaki, R. Kozaki, S. Matsumoto, A. Kishida, H. Ito, A. Ito, S. Imai, K. Mitsunari, M. Omori, M. Mori, and Y. Nakata, "Abduction, Abstract Degree and Urgency Matrix (ABDU-M) for Flexible/Agile Higher Education Reform based on Eduinformatics," in *Intelligent Sustainable Systems Selected Papers of WorldS4 2023*, 2024, p. in press.

[36] Y. Nakata, K. Bannaka, and K. Takamatsu, "Minimum essentials for mathematical and data science education in basic nursing education: Based on model curriculum（literacy level） which cultivate mathematical, data science, and artificial intelligence （AI）," *Bull. Kobe Tokiwa Univ.*, vol. 14, pp. 38–46, 2021.

[37] C. S. Peirce, *Collected Papers of Charles Sanders Peirce, vol.2*, 2nd ed. Harvard Univ. Press, 1932.