“Eduinformatics”: A new education field promotion

原著

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“Eduinformatics”：新教育学分野の提案

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Summary

Kobe Tokiwa University is currently performing university reform. To address many pressing and important problems of university reform, we had, over the past three years, determined research questions about these problems and resolved each of them when a problem presented itself, publishing our findings as reports or presenting in meetings. Before we began this research, we thought that there were no relationships between our studies. In this study, we reflect on our research during the last three years. Looking back, we discovered that we can classify our research into six groups by context analysis: group 1: university reform and collaboration between academic faculty and administrative staff, group 2: proposal of novel knowledge-creation models, group 3: novel visualization methods for education, group 4: information and communication technology for education, group 5: evidence-based education, group 6: first-year experience. More abstractly, our research can provide basis for a novel interdisciplinary concept, which we call “eduinformatics.” Based on this research, we propose changes to higher education that will result in increased quality of learning and teaching.

Key words: eduinformatics, university reform, evidence-based education, higher education research, interdisciplinary

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要旨

神戸常盤大学は大学改革の真っ只中にある。われわれは過去3年間、本学における高等教育上の重要な課題を解決すべく、その都度リサーチクエスチョンを定めたうえでそれを解決し、その内容を論文や学会発表という形で公表してきた。今回、これらの一連の研究成果を俯瞰的に眺め、文脈解析を行った結果、われわれの研究が、①大学改革と教職協働、②新たな知の創造モデルの提案、③教育の新可視化法の開発、④ ICT を用いた教育方法の開発、⑤エビデンス・ベースドな教育の実践、⑥初年次教育、の6つの分野に分類できることを見出した。そしてこの6つの分野が、bioinformatics という既存の概念に倣い、教育研究といういわゆる文系色の濃い分野に、いわゆる理系色を融合させた学際的分野として“eduinformatics”という新たな概念を提唱することで1つに括れることを発見した。この新たな概念を高等教育研究に敷衍することで、わが国の高等教育研究が飛躍的に発展していくことが期待できる。

キーワード：eduinformatics、大学改革、エビデンスベースドな教育、高等教育研究、学際的

Introduction

Universities in Japan have changed significantly in the twenty-first century, because many social revolutions have required changes to higher education. Most universities in Japan are currently undergoing university reform.

The Central Council for Education (CCE) used to be part of the Ministry of Education, Culture, Sports, Science, and Technology (MEXT), to which it proposed educational policy. In its 2015 report, “Guidelines for improvement and enhancement of university management”[1], CCE stated that “the position of academic faculty and administrative staff in the university is equal and collaboration between academic faculty and administrative staff is important.” In addition, in the 2014 report, “Promotion of governance reform of university”[2], CCE wrote, “Society is changing rapidly. To enhance the function of the university, it is important that the university constructs novel governance independently.” The practice of enhancing governance in universities includes collaboration between academic faculty and administrative staff. Moreover, CCE stressed the importance of constructing university-wide learning and teaching management in the 2012 report, “Towards the qualitative transformation of university education in order to build a new future”[3].

Based on these reports, which stress the importance of collaboration between academic faculty and administrative staff, Kobe Tokiwa University tried to address this problem. In addition, in March 2015, we discussed learning and teaching management reform in our university.

The aim of this study is to reflect on our three years of research (2015, 2016, and 2017) of collaboration between academic faculty and administrative staff in Kobe Tokiwa University. Moreover, we propose the novel concept of “eduinformatics.”

Methods

Cosine similarity for a vector space

Cosine similarity can be used to measure the difference between documents. Cosine similarity is defined as follows:

$$\cos(\vec{a},\vec{b}) := \frac{\vec{a}\cdot\vec{b}}{|\vec{a}||\vec{b}|} = \frac{\sum_{i=1}^{|V|} a_i b_i}{\sqrt{\sum_{i=1}^{|V|} a_i^2}\cdot\sqrt{\sum_{i=1}^{|V|} b_i^2}}$$

Cosine similarity is a measure of similarity among vectors. Because in this study a vector means text file of our published stidies or abstracts for conferences. The maximum value of cosine similarity is 1, and the minimum is -1. When two text files are the same, cosine similarity is 1.

Cosine similarity for normalized vectors is defined as follows:

$$\cos(\vec{a},\vec{b}) := \vec{a}\cdot\vec{b} = \sum_{i=1}^{|V|} a_i b_i$$

Network analysis using cosine similarity

We visualized the cosine similarity matrix using network analysis. We obtained the symmetric matrix of cosine similarity described above. This matrix vector is known as an adjacency matrix in network analysis. Next, we transformed the adjacency matrix to an adjacency list using the igraph library[4]. We visualized this data using the open-source software Cytoscape[5].

Multidimensional Scaling (MDS) Methods

We visualized the cosine similarity matrix using MDS methods. We obtained the symmetric matrix of cosine similarity described above. We visualized this data using MDS methods by employing the R package “lsa” (latent semantic analysis) [6], scatter plotting, and R’s “maptools” package[7] using R[8].

Content Analysis

We made a word list from our studies to represent their key concepts. Our research stidies and abstract is shown in Table 1. Using whole words from this list, we discussed and reflected on our research with academic faculty and administrative staff at Kobe Tokiwa University. We determined that six groups encompass our research’s key concepts.

Table 1. Our three years of research and relationship to six groups, numbered

		Title	Journal or Meeting	University reform and collaboration between academic faculty and administrative staff	Proposal of novel knowledge-creation models	Novel visualization methods for education	Information and communication technology, ICT, for education	Evidence-based education	First year experience
2016	3	Knowledge creation through collaboration between academic and administrative faculty: Strategies of raise chance of the serendipity.	Bulletin of Kobe Tokiwa University	○					
	4	Three-step knowledge network model	Bulletin of Kobe Tokiwa University		○				
	1	Knowledge creation through collaboration between academic and administrative faculty: Strategies of raise chance of the serendipity.	2016 Higher Educational Reform Forum in Tokai Region of Honshu	○					
	2	Significance of collaboration between academic and administrative faculty: in the view of knowledge	Proceedings of Kyoto university conference on higher education	○					
	5	SWOT analysis and Complex Network analysis to enhance governance in universities by collaboration between academic and administrative faculty	Advanced Applied Informatics (IIAI-AAI), 2016 5th IIAI International Congress on IEEE	○					
	6	On statistics education for Kobe Tokiwa University Department of Medical Technology	The11th Annual Meeting of Japanese Association of Medical Technology Education					○	
2017	10	Innovate the management of teaching and learning at our own university through collaboration between academic faculty and administrative staff	Bulletin of Kobe Tokiwa University	○					
	11	Tag-based knowledge network models	Bulletin of Kobe Tokiwa University		○				
	13	On statistics education for Kobe Tokiwa University Division of Health Sciences students	Bulletin of Kobe Tokiwa University						
	12	Novel Visualization for Curriculum in Silico using Syllabus by a Combination of Cosine Similarity, Multidimensional Scaling Methods, and Scatter Plot: Dynamic Curriculum Mapping (DCM) for Syllabus	Bulletin of Kobe Tokiwa University			○			
	14	A New Way of Visualizing Curricula using Competencies: Cosine Similarity, Multidimensional Scaling Methods, and Scatter Plotting	Advanced Applied Informatics (IIAI-AAI), 2017 6th IIAI International Congress on. IEEE			○			
	16	Possibility of withdrawal in EMIR	Journal of Meeting on Japanese Institutional Research					○	
	18	Web-based Support System for Students to Select Courses using Tokiwa Competencies	2017 International Conference on Education, Psychology, and Learning (ICEPL)				○		
	20	Information and Communication Technology (ICT) Support System for Students Selecting a Seminar	2017 International Conference on Education, Psychology, and Learning (ICEPL)				○		
	30	Development of Measurement of Basic Abilities Focusing on Statistic, MBAFS, and consideration of statistical education in specified educational university for medical technologist	Japanese Journal of Medical Technology Education					○	
	7	Teaching management reform based on student support policy	Proceedings of Kyoto university conference on higher education	○					
	8	Dynamic Curriculum Mapping (DCM) for Syllabus	Proceedings of Kyoto university conference on higher education			○			
	9	New organizational structure for collaboration between academic faculty and administrative staff	Proceedings of Kyoto university conference on higher education	○					
	15	A New Way of Visualizing Curricula using Competencies: Cosine Similarity, Multidimensional Scaling Methods, and Scatter Plotting	6th International Conference on Data Science and Institutional Research			○			
	17	Possibility of withdrawal in EMIR	Proceedings of the 6th Meeting on Japanese Institutional Research					○	
	19	Web-based Support System for Students to Select Courses using Tokiwa Competencies	International Conference on Education, Psychology, and Learning (ICEPL)				○		
	21	Information and Communication Technology (ICT) Support System for Students Selecting a Seminar	International Conference on Education, Psychology, and Learning (ICEPL)				○		
	22	Collaboration between Academic Faculty and Administrative Staff for Quality Assurance of Higher Education	Proceeding of 7th Japan Association for Quality Assurance in Higher Education	○					
	23	Construction of a Prototype of a Method for Advising Students Regarding Courses Using Competencies	Proceeding of 7th Japan Association for Quality Assurance in Higher Education						○
	24	Practice Report about Department of cross-type First Year Course "Manaburu I	Proceeding of 7th Japan Association for Quality Assurance in Higher Education						○
	25	University reform: Constriction of five policy for Quality Assurance of Higher Education	Proceeding of 7th Japan Association for Quality Assurance in Higher Education	○					
	26	A Report on the Use of an ICT Support System in a First-Year Course at Kobe Tokiwa University	23rd International Conference on Teaching, Education & Learning (ICTEL)				○		○
	27	Construction of a Prototype of a Method for Advising Students Regarding Courses Using Competencies	23rd International Conference on Teaching, Education & Learning (ICTEL)				○		
	28	Competency-Based Learning/Education in Japan for a Globalized and Knowledge-Based Society	Proceeding of 14th International Workshop on Higher Education Reform (HER)				○		
	29	Importance of Collaboration between Academic Faculty and Administrative Staff in University Reform in Japan	Proceeding of 14th International Workshop on Higher Education Reform (HER)	○					

Results

To reflect on our three years of research (2015, 2016, and 2017) (Table 1), we first performed cosine similarity and network analysis of text files of reports and abstracts for meetings or conferences (Figure 1). Each node (circle) shows each report or abstract, and each edge (line) shows a relationship between two text files. As you can see, we cannot understand a relationship between each of our published reports or abstract. Because the network has many edges it is too complex for us to understand. This means that cosine similarity and network analysis is not suited to reflecting on our three years of research.

Next, we tried to visualize relationships between each of our published reports or abstracts by cosine similarity, multidimensional scaling methods, and scatter plotting (Figure 2). The x and y axes were defined by MDS. The x and y axes of MDS are similar to the first and second principal components of principal component analysis, respectively.

In Figure 2, we can observe some associations. However, when we investigated in detail, we found that this figure could not distinguish between our published reports or abstracts, because our publications include both Japanese and English texts.

So, in addition to these two analyses, we performed content analysis to classify our recent research. Content analysis is a well-known method for developing research questions in social sciences. Berelson[9] and Krippendorff[10] are noted content-analysis researchers who together defined content analysis as a quantitative approach to research questions. This means that content analysis quantitatively addresses quantitative research questions. The KJ method developed by Jiro Kawakita is another well-known quantitative approach to quantitative research questions[10].

First, we determined central concepts based on word frequencies across our research. Next, we discussed and classified these words and determined the six common groups using content analysis: group 1: University reform and collaboration between academic faculty and administrative staff, group 2: Proposal of novel knowledge-creation models, group 3: Novel visualization methods for education,

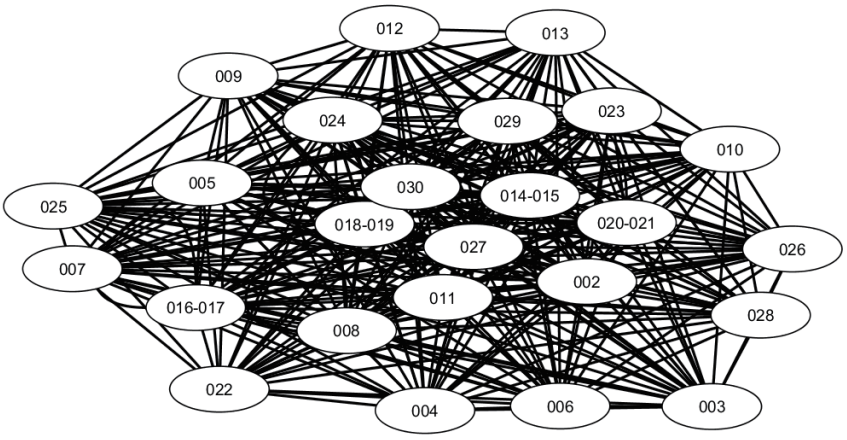

Figure 1 Visualizing relationship between our three years of research by cosine similarity and network analysis; numbers in nodes (circles) show our study or abstract (See Table 1). Edges (lines) show relationship between two stidies or abstract.

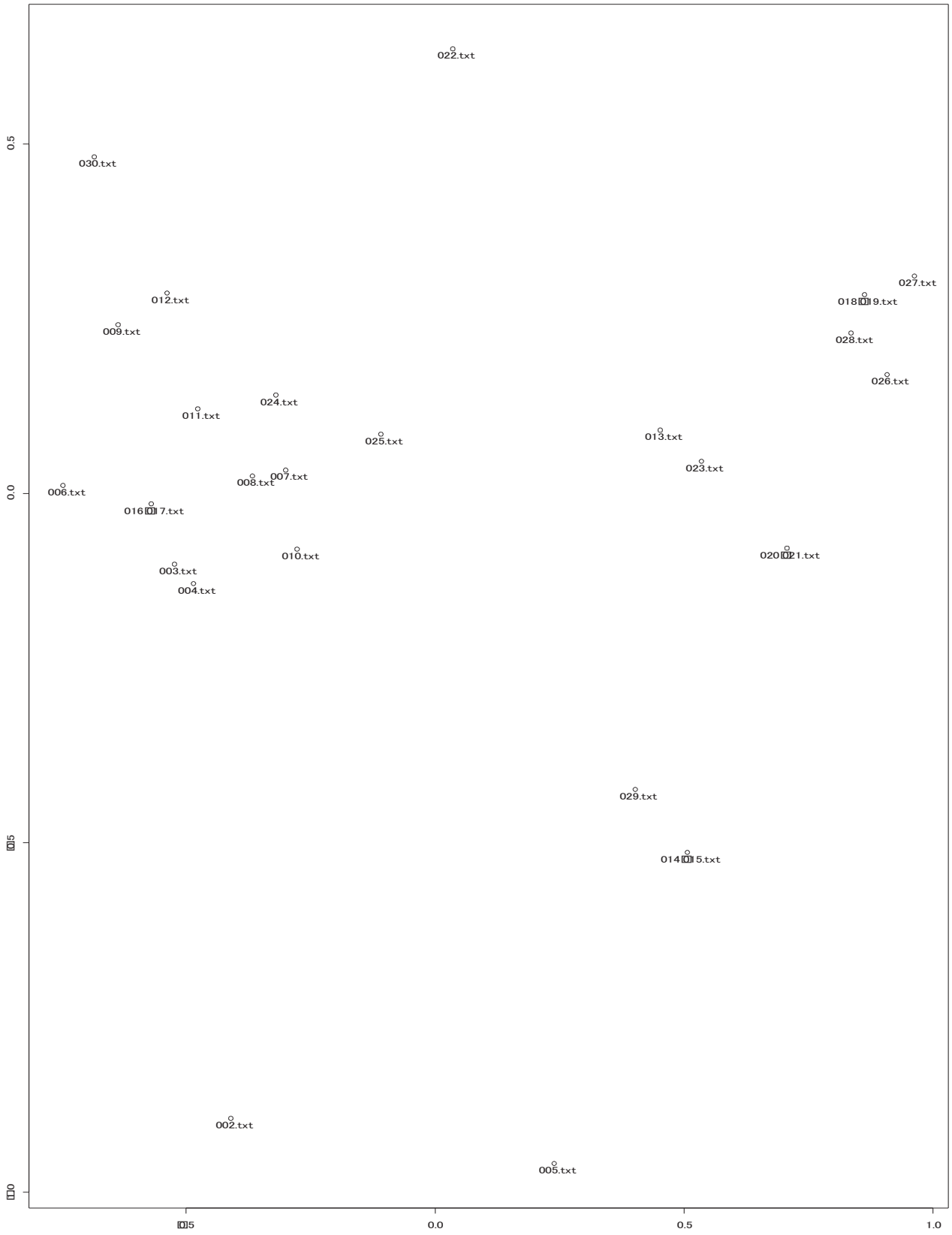

Figure 2 Visualizing relationship between our three years of research by cosine similarity and MDS; using 30 test files for stidies or abstracts (Table 1), we visualized MDS via scatter plotting.

group 4: Information and communication technology (ICT) for education, group 5: Evidence-based education, group 6: First year experience. The relationship between each study and the six groups is shown in Table I. In the next section, we describe our research categories in detail using these six.

Group 1: University reform and collaboration between academic faculty and administrative staff

Before an effective university reform can take place, it is important that the university first determine its problems and construct its future vision based on solving these problems. To do this, we first led a workshop intended to provide better understanding of management at Kobe Tokiwa University. In the workshop, five academic faculty members and two administrative staff members discussed strengths, weakness, opportunities, and threats to our university using SWOT analysis[11], which is a tool used to not only evaluate the strengths, weaknesses, opportunities, and threats of a company, but also part of a strategic planning process. SWOT analysis was developed as part of the Harvard Business Policy in the 1960s[12].

SWOT analysis is well known as a useful tool to construct strategy but, sometimes, the analysis changes the goals so much that the group cannot reach the step of constructing a strategy. Based on our SWOT analysis, we drew up a work system[11], using steps proposed by Porter[13]. Next, we analyzed these results based on the concept of "knowledge" and published a peer-reviewed, Japanese-language report[11)14]. Because universities mainly develop or create "knowledge," we tried to think about how humans create knowledge. The main result was as follows: the mutual exchange of knowledge between academic faculty and administrative staff is hindered by a fixation on boundaries between specialists and nonspecialists, ensuring that knowledge only flows in one direction. It is possible to nurture an environment that is conducive to knowledge exchange, where, for example, a facilitator exists to bridge the boundaries between specialists and nonspecialists. Collaboration in such an environment allows for the unobstructed flow of knowledge and the creation of new knowledge.

We further visualized the results of the SWOT analysis using complex network analysis, which is standardly used to analyze features of huge and complex networks. In 1998, Watts et al. revealed the existence of "small-world" networks[15]. Our findings suggested that to improve the university, it is critical that all academic faculty and administrative staff are aware of the need for improvement[16].

Our results led us to build a team, which we are a part of, for university reform under the president in December 2015; the idea for this team was to develop learning and teaching management reform based on collaboration between academic faculty and administrative staff[17]. In the 2008 CCE report, the group proposed integrating the admissions policy (AP), curriculum policy (CP), and diploma policy (DP) in Japanese universities[18]. Our first step was to define the educational goals of Kobe Tokiwa University. Because our university had no unified policies, and based on the CCE report, we proposed integrating AP, CP, and DP using defined educational goals. Creating these goals led us to conclude that in order to enhance learning and teaching management, we would need to adjust more than just these three policies.

Next, because AP, CP, and DP only deal with regular curricula, we proposed a new policy, the student

support policy (SSP), to the president. We think it is important for students to be exposed not only to regular curricula, but also to quasi-regular (used in remedial education) and extra curricula (volunteer and club activities).

To continue the plan-do-check-act or plan-do-check-adjust (PDCA) cycle for verifying the quality of learning and teaching at the university, we considered three policies, along with an assessment policy (ASP). Recently, some reports released by the CCE have stressed the importance of connecting an ASP with AP, CP, and DP[19].

To evaluate and connect the aforementioned policies (AP, CP, DP, ASP, and SSP), we needed to create a common evaluation indicator. We developed a list of the 19 Tokiwa competencies that students acquire through regular, quasi-regular, and extra curricula[17]. Tokiwa defines 19 types of competencies: Culture, Common Sense, Professional/Expertise, Media Literacy, Logical Thinking, Critical Thinking, Intellectual Curiosity, Exploration, Continuity, Self-Management, Reflection, Design Thinking, Presentation, Judgment, Implementation, Responsibility, Contribution, Communication, and Cooperation and Collaboration[20)21)22)]. We also showed that collaboration between academic faculty and administrative staff has a key role in this reform[23)24)].

Group 2: Proposal of novel knowledge-creation models

As described above, a collaborative team between academic faculty and administrative staff is very important. However, in most universities, collaborating on scientific research is very difficult[25]. We found that in Kobe Tokiwa University, however, a collaboration team can work well, in part based on the history of the university.

The aim of the collaboration team that connected academic faculty and administrative staff was university reform. In actuality, that means improvement of higher education for students at the university. We discussed how to improve student learning, or how to deepen and create knowledge, which was a primary interest[11].

In 2016, we proposed a new model for creating knowledge[26] using principles from mathematics and life sciences. This model was developed using graph theory and protein-protein interaction (PPI). Graph theory is a field of mathematics that deals with graphs that consist of both nodes (points) and edges (lines), and PPI is a field of biology. The proposed knowledge creation model consists of the propagation step, the mixing step, and the creation step, and we use higher education as an example of knowledge creation that this model can describe. When we use this model *in silico*, we can calculate and evaluate the efficiency of learning.

In 2017, by applying the notion of "tags" to existing knowledge-creation models, and inspired by PPI networks and graph theory, we published and proposed another novel knowledge-creation model[27]. The concept of "tags" was proposed by Murata[25] in 2015. He suggested that many tags in the human brain react to outside information. The links between tags help generate solutions to problems. We applied this "tag" concept to our model. As described above, when we use this model *in silico*, we can calculate

and evaluate the efficiency of learning.

Group 3: Novel visualization methods for education

Our previous studies described above[16)26)27)] make us understand that the network, or graph, is a very important concept in education. We tried to apply the network system to deal with additional education problems.

MEXT requires Japanese universities to build curriculum maps[28)], which are similar to networks or graphs. Curriculum maps are important tools used for students to learn and for academic faculty to teach in a university. However, because it is an ongoing process that requires input from many semesters, many universities do not construct a new curriculum map every year. We tried to construct a curriculum map *in silico* [29)30)]. Unfortunately, we were unable to get good results using visualization as a network or a graph. Because the number of relationships, that is edges or lines, was too high, we could not get the figures we expected as a curriculum map.

Using DCM methods, instead of networks or graphs, to visualize the relationship between curricula, we can get reliable results. However, the latest figure created on the computer differs from the usual curriculum mapping created by humans. To address this problem in the next step, we used competencies instead of syllabi to visualize curricula (Figure 3)[31)]. Each circle shows a common liberal and general education course at Kobe Tokiwa University. The x and y axes of MDS are similar to the first and second principal components of principal component analysis, respectively.

As described above, to evaluate and connect the aforementioned policies (AP, CP, DP, ASP, and SSP), Kobe Tokiwa University defined 19 Tokiwa competencies as common evaluation indicators (Table 2). Starting this year, Kobe Tokiwa University started offering 39 common liberal and general education

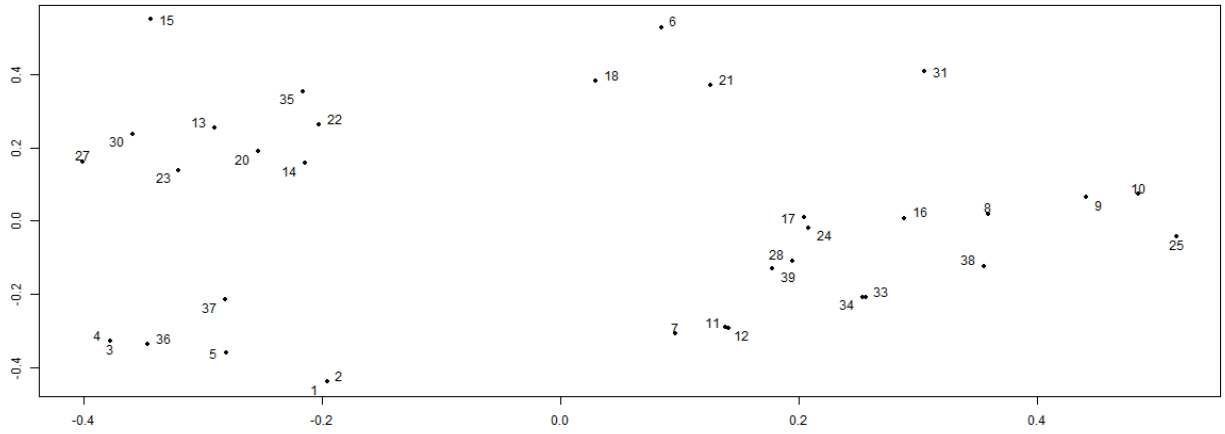

Figure 3 Visualizing curricula using syllabi; using 19 competencies (Table 2) for 39 courses (Table 3), we visualized MDS via scatter plotting (From Takamatsu et al., "A New Way of Visualizing Curricula Using Competencies: Cosine Similarity, Multidimensional Scaling Methods, and Scatter Plotting," 2017)

Table 2. Tokiwa competencies

Abbreviated name of competency	*Competency*
1. Culture	Establishing the liberal arts as the foundation of human nature, which can involve a variety of people
2. Common Sense	Establishing that members of society should acquire knowledge and behave in certain ways
3. Professionalism/Expertise	Having the necessary knowledge and skills to perform the duties of each profession
4. Media Literacy	Collect, organize, and analyze the necessary information for proper thinking and judgment
5. Logical Thinking	Based on evidence, a situation can be considered logically
6. Critical Thinking	A multilateral, critical perspective captures ideas and can be considered
7. Intellectual Curiosity	To know something, to learn, and remember it with fun and joy
8. Exploration	By thinking deeply about things and methods, it is possible to be like Mikiwameyo in terms of essence
9. Continuity	By learning and thinking, it is possible to maintain one's stance and make efforts to act
10. Self-Management	It is possible to handle one's physical and mental health appropriately
11. Reflection	By reflecting on one's thinking and behavior, it is possible to always seek ways to improve
12. Design Thinking	It is possible to design a solution and develop a comprehensive variety of thoughts and knowledge
13. Presentation	It is possible to convey one's feelings and thoughts to others
14. Judgment	Based on information and thinking, it is possible to make an appropriate decision given the circumstances
15. Implementation	Without fearing failure, it is possible to take a specific action based on one's feelings and thoughts
16. Responsibility	It is possible to face things and have responsibility as a member of society
17. Contribution	I feel joy for someone when something is useful for them, and it is possible to take a specific action
18. Communication	Listen to others' opinions, which can result in creative dialogue
19. Cooperation & Collaboration	Looking beyond one's own interests and those of others, it is possible to work together

(From Takamatsu et al., "A New Way of Visualizing Curricula using Competencies:

Cosine Similarity, Multidimensional Scaling Methods, and Scatter Plotting," 2017)

Table 3. Thirty-nine courses, 19 competencies, and a group of MDS

competency / course nam	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	total	MDS group
01. Academic Skills and Deep Learning I	0	0	0	0	0	0	0	20	0	10	25	10	15	0	0	0	0	0	20	100	5
02. Academic Skills and Deep Learning II	0	0	0	0	0	0	0	20	0	10	25	10	15	0	0	0	0	0	20	100	5
03. Freshman Seminar I	0	0	0	0	0	0	25	35	0	0	20	0	0	0	0	0	0	20	0	100	3
04. Freshman Seminar II	0	0	0	0	0	0	25	35	0	0	20	0	0	0	0	0	0	20	0	100	3
05. Leadership and Facilitation	0	0	0	0	0	0	0	0	0	0	40	15	0	0	0	10	10	5	20	100	3
06. Information Technology Basics	35	0	0	35	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	4
07. Health and Sports Science II	0	0	0	0	0	0	0	0	0	30	0	0	30	0	0	20	0	0	20	100	1
08. Academic Writing	0	0	0	15	25	15	25	0	0	0	0	0	15	5	0	0	0	0	0	100	1
09. English Communication I	0	0	0	19	30	23	15	0	0	0	0	0	13	0	0	0	0	0	0	100	1
10. English Communication II	0	0	0	10	35	35	10	0	0	0	0	0	10	0	0	0	0	0	0	100	1
11. Basic Communicative English	0	0	0	0	0	0	20	0	0	0	0	0	60	0	0	0	0	20	0	100	1
12. Intermediate Communicative English	0	0	0	0	0	0	25	0	0	0	0	0	60	0	0	0	0	15	0	100	1
13. Sign Language	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	10	100	2
14. Life and Symbiosis	20	0	5	25	0	10	0	40	0	0	0	0	0	0	0	0	0	0	0	100	2
15. Global Environment	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	100	6
16. Mathematics	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	50	100	1
17. Statistics	0	0	0	25	25	0	0	0	0	0	0	0	0	0	0	0	0	0	50	100	1
18. Physics	35	0	0	0	35	0	0	0	0	0	0	0	0	0	0	0	0	0	30	100	4
19. Chemistry	29	0	0	0	21	0	29	8	0	0	0	0	8	0	3	0	3	0	0	100	4
20. Basic Anatomy and Physiology	30	0	0	10	0	0	20	0	0	10	10	0	10	0	0	0	0	10	0	100	2
21. Life Sciences	40	0	0	0	20	15	0	0	0	0	0	0	20	0	0	0	5	0	0	100	4
22. Safety Science	20	20	0	20	0	0	0	0	0	0	0	0	0	0	0	20	0	0	20	100	2
23. Agriculture	20	25	0	0	0	5	10	18	0	0	0	0	5	0	0	13	5	0	0	100	2
24. Introduction to Programming	0	0	0	0	30	0	0	0	0	0	0	45	0	0	0	0	25	0	0	100	1
25. Life and Ethics	0	0	0	0	25	50	0	0	0	0	0	0	25	0	0	0	0	0	0	100	1
26. Literature	35	0	0	0	0	0	40	0	0	0	25	0	0	0	0	0	0	0	0	100	2
27. Japanese History	10	0	0	0	20	0	0	0	0	0	10	0	40	0	0	10	0	10	0	100	1
28. Modern Sociology	35	0	0	0	0	0	25	20	0	0	0	20	0	0	0	0	0	0	0	100	2
29. Economics	20	0	0	20	30	30	0	0	0	0	0	0	0	0	0	0	0	0	0	100	7
30. Clinical Psychology	0	30	0	0	30	0	20	0	0	0	0	0	20	0	0	0	0	0	0	100	1
31. Human Relations Theory	0	0	24	0	0	24	0	0	0	0	0	0	24	0	0	0	0	24	4	100	1
32. Education	0	0	24	0	0	24	0	0	0	0	0	0	23	0	0	0	0	24	5	100	1
33. Collaboration with Community I	60	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	20	0	100	2
34. Collaboration with Community II	0	10	0	0	0	0	0	0	0	0	50	0	0	0	10	10	10	0	10	100	3
35. Disaster and Community Development	0	0	0	0	0	0	0	25	25	0	0	0	0	0	0	25	25	0	0	100	3
36. Community Design	0	0	0	15	15	15	0	10	0	0	0	25	20	0	0	0	0	0	0	100	1
37. Life Design	0	0	0	15	15	0	10	10	0	0	0	35	15	0	0	0	0	0	0	100	1
38. Constitutional Law of Japan	35	0	0	0	20	0	0	0	0	0	20	0	10	0	0	10	0	5	0	100	2
39. Philosophy	0	0	0	0	25	0	50	0	0	0	0	0	25	0	0	0	0	0	0	100	1

(From Takamatsu et al., "A New Way of Visualizing Curricula using Competencies:

Cosine Similarity, Multidimensional Scaling Methods, and Scatter Plotting," 2017)

courses. Each teacher developed an evaluation rubric to include in their syllabi, showing the relationships among the 19 competencies in the rubric (Table 3).

To improve the visualization of the network or graph, we tried using threshold graphs[32]. When we used threshold graphs, we reduced the number of edges.

Group 4: Information and communication technology for education

As already described in the dynamic curriculum map, information technology is useful to support education. In the field of education, this technology is commonly called Information and Communication Technology, or ICT. Because we understand that ICT is useful, we applied and developed an ICT tool to support higher education.

As already described above, starting this year, Kobe Tokiwa University began offering common liberal and general education courses. Mini seminars are a part of the common liberal and general education at Kobe Tokiwa University, and are similar to graduate research. Twenty-eight academic faculty teach 4 to 8 students per class. Three hundred fifty students simultaneously submitted their most preferred teacher choices (first through fourth) for their first and second semesters. We developed a versatile ICT support system to match students with their preferred teachers for chosen seminars[33].

Next, we developed a web-based support system for students to select courses using the Tokiwa competencies[34]. Usually, students chose courses based on content but, no matter how the students use the system, their course selections were here based on the Tokiwa competencies.

In addition, this year, a tutoring program has begun in the Department of Medical Technology. During the period when students modify their course registrations, teachers can advise them based on their competencies. Accordingly, five teachers advised students based on their competencies while 15 faculty members advised a control group based on conventional course content. The five faculty members reflected on their advisory practice and experience; we have included their considerations as well[31)35].

Group 5: Evidence-based education

Evidence-Based Medicine[36], EBM, proposed by Professor Guyatt and Sckett et al. in 1992, is one of the central concepts of twenty-first century medicine. A key concept of EBM is data management—in EBM, the researcher must show evidence. In many cases, the evidence is shown using statistical methods based on data.

This trend is not limited to medicine. In the field of medical technology, The International Federation of Clinical Chemistry and Laboratory Medicine constructed Evidence Based Laboratory Medicine, EBLM. Because Florence Nightingale dealt with statistics, there is an evidence-based concept in the field of nursing, as well.

We think that, in higher education, the concept of evidence is important; CCE actually requires evidence-based analysis from universities[28]. In this study, we showed our two pieces of research about

evidence-based higher education.

Our first piece research regards statistical education. As we described above, the evidence-based concept has spread to many fields and, in the future, statistics may be required in many fields. In Japan, high school curricula were changed by MEXT in 2012. In mathematics, for example, all students in high school are required to study basic statistics including topics such as regression line, correlation coefficients, and basic statistics such as mean, variance, standard deviation, and coefficient of variation. Before 2012, high school students were not required to stidiestatistics. If they had studied it, the competency level of statistics studied was much lower than that offered after 2012. After 2012, the high school level of statistics was equivalent to nearly a full year of university content before 2015.

At the university, we were required to change the content of statistics curricula after 2015. In order to do this, we used evidence-based methods. We investigated the basic statistics competency of students, showing that the ability to understand basic mathematical concepts was very low for the matriculation cohorts of 2015 and 2016, in the Department of Medical Technology at Kobe Tokiwa University. These results emphasized the importance of efforts to improve students' knowledge of mathematical fundamentals through statistics education[37], and we included data from the Department of Nursing for analysis[38]. Moreover, we applied ANOVA, or the Kruskal-Wallis test, for multiple comparisons[39].

Our second piece of research was about Institutional Research (IR) for Enrollment Management (EM), so called EMIR. Kobe Tokiwa University created an IR promotion department (IRPD) in 2016. The aim of IRPD is not simply IR for management strategy but also to collect, arrange, and manage various data of students for EM. In addition, Kobe Tokiwa University created an IR promotion unit, IRPU. All members of IRPD are members of the administration, and IRPU consists of both academic faculty and administrative staff. We do not belong to either IRPU or IRPD. IRPU examines evidence-based data analysis about leaving the university during a term.

In preceding research, most analyses used statistics to investigate withdrawal factors. We are unsure as to whether the model of withdrawal is linear, so we hypothesized that the model of withdrawal is nonlinear. We then used machine learning for analysis. Our results showed that we can predict withdrawal at around 90% accuracy by using machine learning methods[40].

Group 6: First year experience

In this section, we describe the first-year experience at Kobe Tokiwa University and the relationship between it and ICT. As described in the first section, Kobe Tokiwa University started offering common liberal and general education courses this year as a part of university reform. For example, we provide a freshman course, called *Manaburu*, which is a portmanteau of the words *manabu* (to learn) and *dekiru* (able), meaning that students learn to learn by themselves.

Kobe Tokiwa University has about 360 first-year students. A total of twenty teachers teach the *Manaburu I* course for 180 minutes (90 minutes, twice) each week for 15 weeks. That is, teachers provide 45 hours to 360 first-year students in *Manaburu I*. We provide *Manaburu II* for 180 minutes (90

minutes, twice) each week for 8 weeks. That is, teachers provide 22.5 hours for 360 first-year students in *Manaburu II*.

In September 2017, we finished *Manaburu I* [41]. As you can imagine, close coordination on *manaburu* is difficult, so we provided some ICT support for the twenty teachers. The ICT support system involved a task list for teachers, materials for students every week, information on student attendance, an academic rubric for grades, a managing system for reports on students, and so on[42].

Discussion

In this study, we reflected on our three years of research and classified it into six groups by context analysis. Now, we are conducting a new university reform. In this reform, collaboration between academic faculty and administrative staff is very important. Because the RCD at Kobe Tokiwa University already emphasizes collaboration between academic faculty and administrative staff, we can easily use this kind of collaboration during the reform. In 2008, the Kobe Tokiwa University was opened in Japan. The Director-General of University Cooperation, Tadashi Nakamura, established the Research Cooperative Division, RCD, as a means of collaboration between academic faculty and administrative staff. Since the collaboration team already had built a congenial relationship between academic faculty and administrative staff, based on the RCD, it was very easy for us to encourage them to work together. Director-General Tadashi Nakamura also demonstrated good foresight.

For increased quality in higher education, we think it is important to connect five policies: AP, CP, DP, SSP, and ASP. To evaluate and connect the aforementioned policies, a common evaluation indicator is needed, and we used the 19 Tokiwa competencies to develop novel visualization. Using this visualization, we developed and performed an advising system for students regarding competencies for to increase learning.

ICT support has an important role in new visions in education. We showed three ICT support systems for higher education. Evidence-based education is important, too. In this study, we have given two examples for evidence-based education, statistics education and EMIR. Finally, we showed how we introduced the first year experience in our university reform.

We think that the current environment surrounding higher education is similar to an older era of life sciences. After the creation of bioinformatics, the life sciences became more evidence-based, emphasizing collaboration between biology and informatics. Member of our team have many different specialties such as higher education, nursing, mathematics, bioinformatics, dentistry, and so on; we can collaborate and apply new methods for education. Recently, we encouraged collaboration between many researchers at Kobe Tokiwa University; our pedagogy is already an interdisciplinary field. So, more abstractly, with our six groups, we unite our research into a novel concept that we call “eduinformatics.” Eduinformatics connects artistic and scientific fields (Figure 4). Artistic fields include education and scientific fields include institutional research, statistics, machine learning, evidence-based education, informatics, and so on. This means that eduinformatics applies scientific fields to education. Based on this research, we

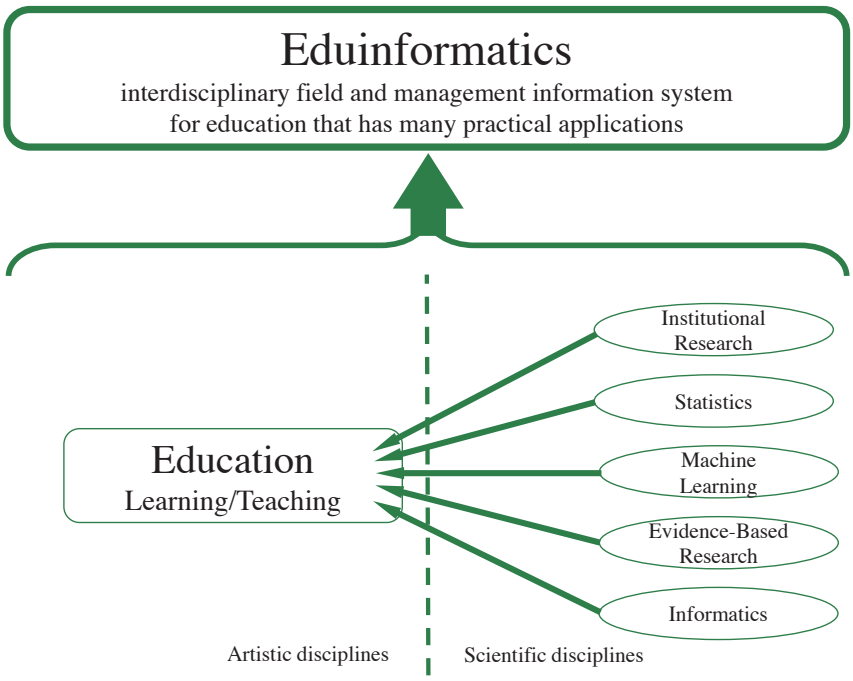

Figure 4. Concept of Eduinformatics: Eduinformatics combines artistic and scientific disciplines. Scientific disciplines include institutional research, statistics, machine learning, evidence-based research, informatics, and so on.

believe that eduinformatics in higher education will lead to a higher quality of education for students.

Part of this research was orally presented at the 14th International workshops on Higher Education Reform (HER) and was poster presented at the 24th Kyoto University Conference on Higher Education.

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