Advanced Information Data-interactive Learning System Effect for Creative Design Project

Sangwoo Park[1], Inseop Lee[1], Junseok Lee[1] and Sanghun Sul[1]*
[1] Department of Service Design Convergence, Sungkyunkwan University
College of Engineering, Suwon, Gyeonggi-do, KR 16419
[e-mail: psw1108@g.skku.edu, liszzm@naver.com, bigmatt@naver.com, sanghunsul@skku.edu]
*Corresponding author: Sanghun Sul

Received April 25, 2022; revised June 24, 2022; accepted June 30, 2022; published August 31, 2022

Abstract

Compared to the significant approach of project-based learning research, a data-driven design project-based learning has not reached a meaningful consensus regarding the most valid and reliable method for assessing design creativity. This article proposes an advanced information data-interactive learning system for creative design using a service design process that combines a design thinking. We propose a service framework to improve the convergence design process between students and advanced information data analysis, allowing students to participate actively in the data visualization and research using patent data. Solving a design problem by discovery and interpretation process, the Advanced information-interactive learning framework allows the students to verify the creative idea values or to ideate new factors and the associated various feasible solutions. The student can perform the patent data according to a business intelligence platform. Most of the new ideas for solving design projects are evaluated through complete patent data analysis and visualization in the beginning of the service design process. In this article, we propose to adapt advanced information data to educate the service design process, allowing the students to evaluate their own idea and define the problems iteratively until satisfaction. Quantitative evaluation results have shown that the advanced information data-driven learning system approach can improve the design project - based learning results in terms of design creativity. Our findings can contribute to data-driven project-based learning for advanced information data that play a crucial role in convergence design in related standards and other smart educational fields that are linked.

Keywords: E-learning, Data-driven, Service Design, PBL, Advanced Data, Process Mining

A preliminary version of this paper appeared in ICONI 2021, December 12-14, Maison Glad Jeju, Korea.
This version includes an additional analysis of log data and detailed verification on experimental verification.

http://doi.org/10.3837/tiis.2022.08.021 **ISSN : 1976-7277**

1. Introduction

COVID-19 Pandemic is accelerating the discussions on fostering creative future talents. Even before COVID-19, the task of fostering creative future talents in the era of the 4th industrial revolution was being discussed, but COVID-19 is advancing it [1]. In the World Economic Forum, "Future of Jobs" report points out Complex Problem Solving, Critical Thinking, Creativity, People Management, Collaboration, Emotional Intelligence, Judgement and Decision Making, Service Orientation, Negotiation and Cognitive Flexibility as the top 10 core competencies important to talent in the era of 4th industrial revolution [2].

In line with such trend of the times, educational institutions are actively conducting PBL(Project-Based-Learning) in the form of convergence of humanities and arts, including engineering fields [3]. PBL is a method in which students generate questions on their own for a certain period of time and use related knowledge and experience to produce results for questions in the form of specific outputs [4].

In PBL, the service design methodology is mainly applied. Service design is the act of planning and constructing related people, infrastructure, communication, and physical elements to improve service quality, customer experience, and service interaction, and it readjusts the service provider's actions or reconstructs the place and time of service delivery [5]. The British Service Design Company, Design Council, proposed a double diamond model in the process of Discover, Define, Develop, and Delivery, which are service design methodology (Councill, 2005). This aims to innovate service improvement through expansion of thinking by repeating divergence and convergence. User interviews are accompanied at the Discover stage of service design. However, as in-person activities were restricted due to COVID-19, it became difficult to conduct interviews. As in-person interviews become more difficult, quantitative investigations have become important in the Discover stage [6]. Data has three advantages in service design. First, it is possible to grasp the hidden needs of the user. Second, effective visualization can be achieved through data, leading to insight. Finally, by visualizing data, a cooperative system with various fields can be established [7]. However, since using data is accompanied by university education, global tech companies such as Microsoft and Google introduces SaaS business models with expanded Business Intelligence (BI) funciton that can easily analyze and visualize big data. According to Gartner, the number of cases of using SaaS with extended BI functions is expected to increase [8].

This study proposes a Project based Learning model based on service design by utilizing advanced data. Then, PBL is verified through the experiement. The experiment conducts service design education on university students with various majors. Patent data is provided to students as advanced data for utilization. Patent data has the characteristics of various data such as inventors, technology summary, citation information, detailed technology, drawings, etc. [9], and it is the fastest data to reflect current technology trends, so it is possible to develop new products and predict technology through patent analysis [10]. Since there is a gap in programming level between students and collaboration is important due to the nature of PBL education, the patent data visualization platform Build BI service was used and the usage log file was collected in order to verify our PBL model. Ultimately, the purpose of this study is to verify the effect of PBL education on students when deriving creative design thinking from advanced data.

2. Related Work

2.1 Data Driven Study

The amount of data is gradually increasing due to the development of Internet and smart devices, and the rapid spread of social networks. As a result, data has many strengths, such as accuracy of decision-making, prediction of the near future, and possibility of creating new businesses. In particular, these strengths are being used in various research fields [11]. In the manufacturing field, there is a research case that improves product quality and service by applying collectable customer experience data including manufacturing data, product use information and usage reviews to product design and process [12]. In addition, in the design field, research was conducted on ZARA's service design case, which created a system that enables sales prediction based on sales and inventory data, and immediate product supply by analyzing real-time sales status [11]. From these research cases, it can be confirmed that data can be used in various fields and possess a high value.

2.2 Service Design

The existing service design applies a double diamond model presented by the design company, Council, consisting of four stages, Discover, Define, Develop and Delivery. First, Discover stage understands customers through social, cultural, industrial, market and trend research. Basically, it is data research, market research and user research which can be categorized into two types, quantitative and qualitative research. Qualitative research collects data through interviews and field studies, and quantitative research focuses on data and expresses users' actions and thoughts in numbers through measurable data. Second, Define stage filters expanded information through research to identify problems and presents directions and strategies. Third, during Develop stage ideas are spread, tested, and gradually developed through brainstorming, scenarios, and prototyping. Finally, the final results are derived at Deliver stage [9].

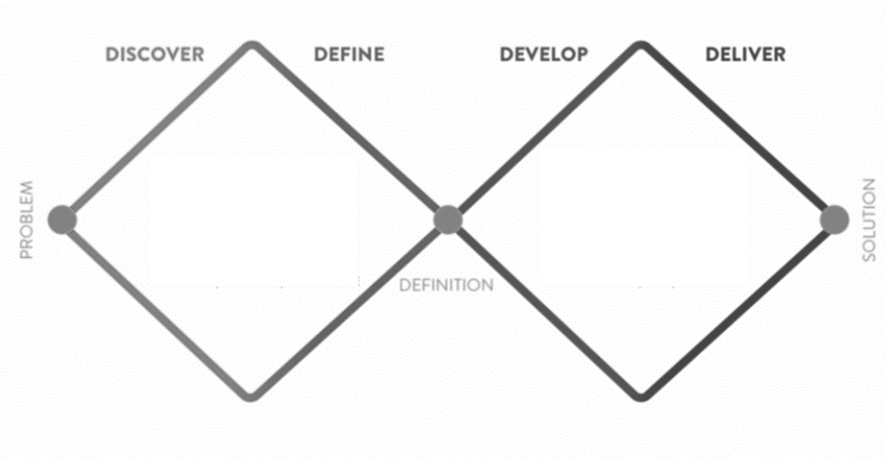

Fig. 1. Double diamond model of service design

2.3 PBL(Project-Based-Learning)

PBL is a learning method in which students execute projects independently while forming teams and collaborate with members to solve problems and create results on their own through the process of goal setting, planning, execution and evaluation [13]. Through PBL, it was confirmed from prior research that students have a significant effect on improving communication skills [14] and creativity in the process of exchanging opinions with members and generating new ideas to solve problems [15]. In addition, it was found that students contributed to enhancing learning interest [16] and effectively enhancing cooperative self-efficacy, which indicates awareness of the team's ability to successfully perform tasks [17].

2.4 Advanced Data

As the scope of data opening and sharing expands, movements to analyze and utilize data are actively progressing. As a result, the importance of data quality, which is a basic resource, is being emphasized [18].

Due to the development of information and communication technology, many knowledge and information materials held by the government are converted into data formats and used as public goods, and therefore people can use the converted digital knowledge information without restrictions in time and place [19].

Patent data includes a variety of information such as application and registration date, technology summary, detailed technology, and drawings, and its utilization value is very high as it has a large number of cases worldwide [20]. In addition, patent data is used as key data not only by companies but also by government agencies because the overall flow of related industrial market trends and technology trends can be seen depending on the analysis method [21]. In fact, various studies have been conducted using patent data, and have searched patent application status through network analysis where one example is research that examines the trend of technology convergence by comparing patents in foreign countries [22].

2.5 Process Mining

Process mining refers to a series of processes in which meaningful information is found by analyzing event log occurring in the information system [23]. The event log used in process mining consists of an event representing a specific activity, a timestamp where the activity occurs, and a case that binds the event. Analysis of discovery, fitness test, and improvement may be performed through these event logs [24]. There are three methods for existing process mining. First, there is the process discovery that extracts information from an existing process and finds a new process. Second, there is the conformity test that checks how much conformity the discovered process has with the originally intended process. Third, when it is determined that the suitability is low, there is the expansion that increases suitability by expanding the original process [25]. This is to identify the user's journey through log data-based process mining and to identify a specific usage pattern. Fuzzy mining, which can simplify and express complex process models, and heuristic mining, which is used in situation where there is noise in the data or to generalize, are widely used, and Fuzzy mining technique based on log data is applied in this research [26, 27]. In this study, the discovery was applied in the process mining analysis, and the usage pattern of students was extracted by performing process log clustering-based process mining. Moreover, an index for usability evaluation was derived by extracting students' usage patterns from a visualization result by compressing the path of process model in the tool used by students.

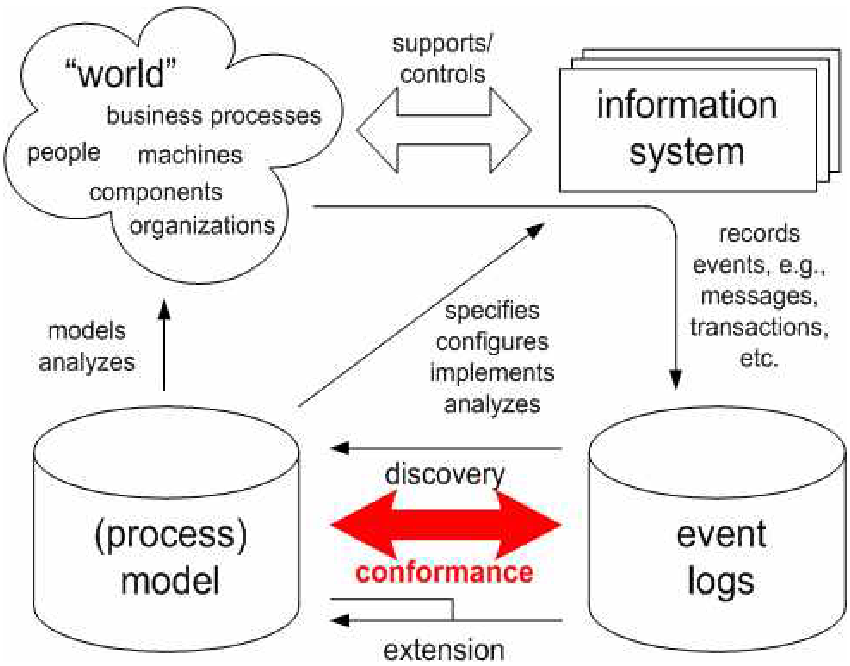

Fig. 2. Process mining structure

3. Advanced Data Driven Service Design Model

This research proposes Advanced Data Driven Service Design Model. **Fig. 2** is a schematic of the Advanced Data Driven Service Design Model, and there is a formula for this. In the existing service design model, the stages of Discovery, Defense, Develop, and Delivery are matched by Exploration, Intervention, Design, and Share in Advanced Data Driven Service Design. The above model can solve problems faster and more efficiently than the existing service design model. The Y-axis of the service design model means an idea [9]. Repeating the expansion and reduction of ideas takes time, effort, and money. Advanced Data reduces the input of money, effort, and time and enables efficient problem solving [28]. In this paper, Advanced Data applies the Service Design model to verify the Advanced Data Driven Service Design model through PBL education. In this paper, Patent Data is used as Advanced Data. In business, Patent Data is primarily used to verify problems. However, Patent Data is data that is at the forefront of technology trends and can play an important role in understanding technology trends and industry trends [21]. These roles fit into the Service Design model, the process of exploring and solving problems. advanced Data and Platform are the basis of all processes of Exploration - Interpretation - Design - Share of Advanced Data Driven Service Design. Although Advanced Data reduces cost, effort and increases efficiency in Service Design, it is difficult for all students to use Advanced Data in PBL. Basically, if you do not have data literacy capabilities, even if you have Advanced Data, the value of use decreases. SaaS-based data visualization platform supports it to enhance utilization, but even this requires prior education. Therefore, in this paper, the Advanced Data Driven Service Design model is applied to the PBL where prior education is possible.

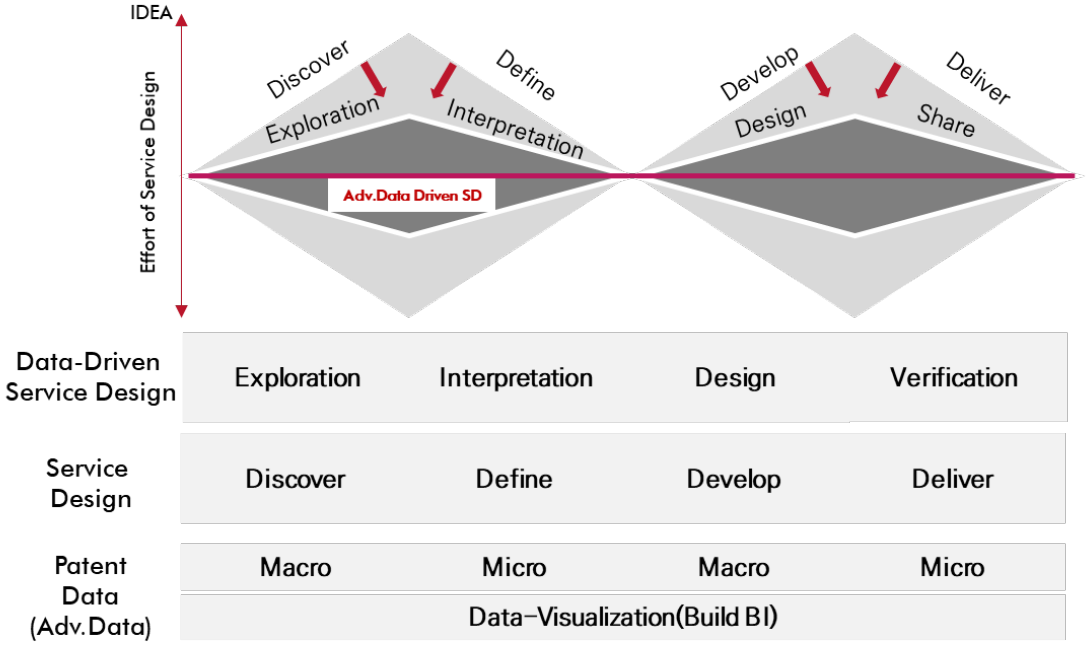

Fig. 3. Advanced data driven service design model

$$\int \mathit{Service\ Design\ Process} - \int \mathit{Advanced\ Data\ Driven\ Service\ Design} = \mathit{efficiency\ of\ Advanced\ Data\ Driven\ Service\ Design} \tag{1}$$

3.1 Exploration

The Exploration stage is the stage where the problem is explored. Patent Data is the most sensitive data to technology trends and industry trends, so it helps to understand current technology and industry problems and expand ideas. Students participating in PBL education use the function of the Patent Data-based SaaS platform Build BI to utilize the data and explore issues focusing on the overall trend of patents.

3.2 Interpretation

When you complete the idea search, you need to interpret the idea. If you look at Patent Data macroscopically, you can see technology and industry trends, but microscopically, it helps you understand ideas through details. However, microscopically viewing Patent Data requires the structure or expertise of patent documents. Therefore, at this stage, students participating in PBL education need to apply to patent experts to help them understand the details of patent data.

3.3 Design

After the interpretation of the idea problem is completed, design work is needed to implement an idea. The idea of the design method should be expanded by comparing the actual technology implementation degree, technology, and industrial trends of the idea.

3.4 Verification

The final step is Verification. Patent's basic property is to verify the technology. Verification of whether the ideas presented to solve the problem through patent data are effective and feasible is possible through a microscopic approach of Patent data.

4. Experimental Verification

In this study, to verify the Advanced Data Driven Service Design presented in Chapter 3, the performance of the PBL project results, quantitative use of Advanced Data, and the path of use of SaaS platform Build BI are identified. The results of the project are calculated by two evaluations: the first expert evaluation and the second expert evaluation. Then, the Advanced Data Driven Service Design Model is verified by analyzing the quantitative usage and usage path of the upper and lower groups by the lower group.

4.1 Method

In this research, service design PBL was conducted on 72 university students. Since in-person lectures were restricted due to COVID-19, lectures were conducted online using real-time video platform (Zoom). In the target lecture, education on the service design methodology was conducted, and after that, students were formed into a team of 6 to 7 to carry out the project in a total of 11 teams. In addition, each team discovered topics on its own and generated service design results based on ideas derived through discussion. Then, a total of 3 peer reviews and 10 experts' evaluations were conducted for each presentation as the last course of the PBL. In this process, students used patent data. Since it is a convergence project in which students of various aptitudes participate, there are variations depending on their major in dealing with data. To reduce data literacy deviations, the patent data visualization platform, Build BI, was made to be used. From the platform, the students' log data was extracted, which consists of 7 columns and the total amount of data for students is 5,149 as shown in **Table 1**. Among them, User_ID distinguishing users for process mining analysis was mapped with Case id, Time indicating usage time was mapped with Timestamp, and Using_record representing usage events was mapped with Activity.

4.2 Log data-based quantitative analysis

Using the Build BI platform, it was planned to collect students' log data three times. However, due to issues on the platform, the data collection was performed two times. The first set of log data was collected for 3 days. During this period students were exposed to the platform for the first time and identify technology market trends through the patent data evaluation. In addition, service design targets were selected through team discussions and project plans were established accordingly. A total of 4235 logs were collected from the first data collection. The second set of log data was collected for 18 days. During this period, students shared ideas and developed them to generate results while proceeding with the Ideation stage. As a result of a total of 914 logs were collected from the second data collection.

Table 1. Examples of log data columns and attributes

Column	Value(example)	# Case
User_ID	trial2021062301	72
User_Name	Sam	72
Service	BI	4
Category	Data selection	10
Sub_Category	Build data	12
Using_record	BI > Data selection > Build data > Chart Explorer	55
Time	2021-06-23 22:51	-

Table 2 shows the number of logs counted and its average per team for each collection. The average counts of log data are 385 and 83.1 for the first and second collection respectively. When calculating the total log data ratio for each team, it can be seen from **Table 2** that students utilized more patent data in the initial exploratory stage during the first data collection. The average counts of log data from the first collection are 80% which is 4 times greater than that of the second collection. **Table 3** shows the project scores consisting of peer reviews of 72 students and evaluations from 10 experts. Team 4 ranked 1st, Team 5 and 7 ranked 2nd and 3rd respectively, and Team 6 awarded with 'Unique Idea Award' in recognition of the uniqueness of the idea. **Fig. 4** shows the BI platform activity log data and team performance in **Table 2**. The average number of logs per team was 468.1. It was found that Team 1, 2, 3, 4, 5 and 8 showed above average usage whereas Team 6, 7, 9, 10 and 11 showed below average usage.

Table 2. Log data collection of each team

Team	1st counts of log data (percentage)	2nd counts of log data (percentage)
1	215 (58%)	155 (42%)
2	288 (81%)	67 (19%)
3	70 (92%)	6 (8%)
4	544 (98%)	12 (2%)
5	555 (77%)	165 (23%)
6	469 (93%)	36 (7%)
7	880 (98%)	19 (2%)
8	86 (51%)	83 (49%)
9	574 (84%)	111 (16%)
10	310 (95%)	18 (5%)
11	244 (50%)	242 (50%)
Avg	385 (80%)	83.1 (20%)

Table 3. Team Score and Log Data

Team	Score	Ranking	Counts of log data	Award
1	78.3	6	370	-
2	75.2	10	355	-
3	67.8	11	76	-
4	86.0	1	556	Gold
5	82.3	2	720	Silver
6	77.1	8	505	Unique Idea
7	81.4	3	899	Bronze
8	77.4	7	169	-
9	78.8	5	685	-
10	75.7	9	328	-
11	80.5	4	486	-
avg	78.2	-	468	-

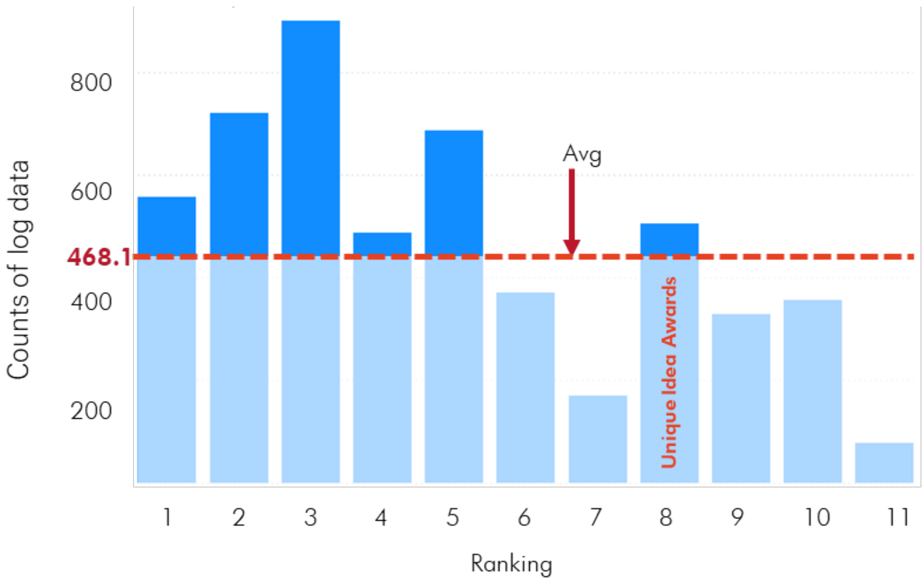

Fig. 4. Log data by ranking

4.3 Process mining analysis

Quantitative comparison was performed between the first and second data collection. Then, the relationship between team performance and patent data usage was analyzed. The following analysis was conducted to confirm the differences in patent data usability through process mining. The entire process was implemented based on the student log data of each collection period. **Fig. 5** represents the process mining of the first data collection period and **Fig. 6** corresponds to the second data collection. As shown in **Table 4**, two paths in usage of the first data collection were denoted as Path A and B. Path A is a general route in using the patent data. Whereas Path B includes User Manual activity, which informs on how to use patent data and the BI platform. It was confirmed that students were scanning both the patent data and BI platform during the exploration. In the process mining of the second data collection, two paths of data usage denoted as Path A′ and B′ were observed. Unlike Path A′, Path B′ contains Keyword Network activity at the beginning. It was found that students were much more comfortable in data usage during the second data collection. Thereby, activities related to idea expansion were carried out.

Table 4. Path of process mining by data collection period

Data collection	Path	Order of activities
1st collection	Path A	Start → Dashboard → User Data → Chart Explorer → Keyword Network → End
	Path B	Start → User Manual → User Data → Keyword Network → Chart Explorer → End
2nd collection	Path A´	Start → Dashboard → User Data → Patent Key Mapping → End
	Path B´	Start → Keyword Network → Chart Explorer → User Data → Patent Key Mapping → End

11 teams were grouped based on the number of log data extracted in the data collection. The teams were separated into two groups where the upper group consists of the six teams with the above average data usage. The upper group's average log count is 641.8. The lower group consists of the five teams with below average data usage. The average number of logs is 259.6 for the lower group. In the case of the upper group, the average team ranking was 3.8. On the other hand, the average team ranking of the lower group was 8.6. It was confirmed that the data usage has an impact on team performance. Process mining analysis was performed on these two groups to verify the difference between them.

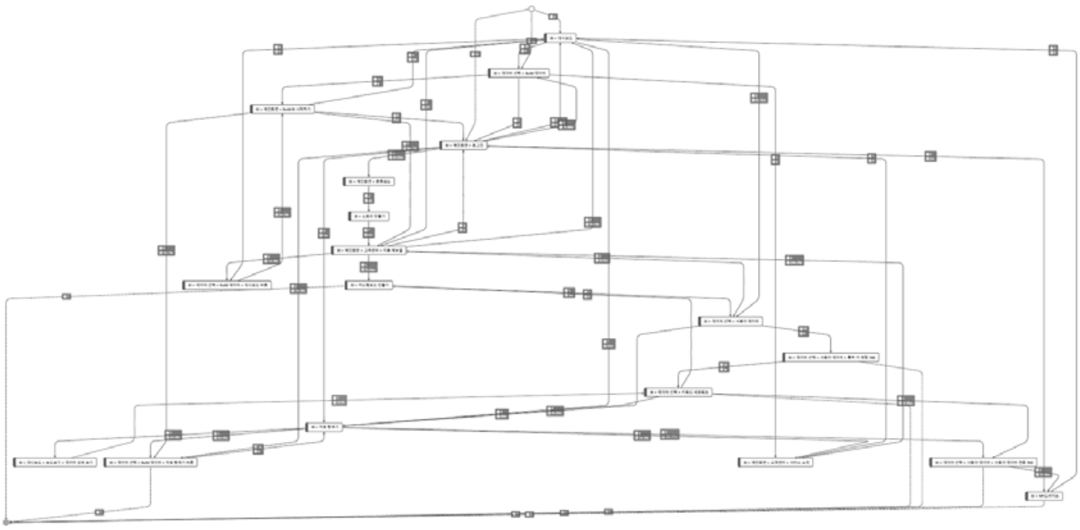

Fig. 5. 1st collection process mining

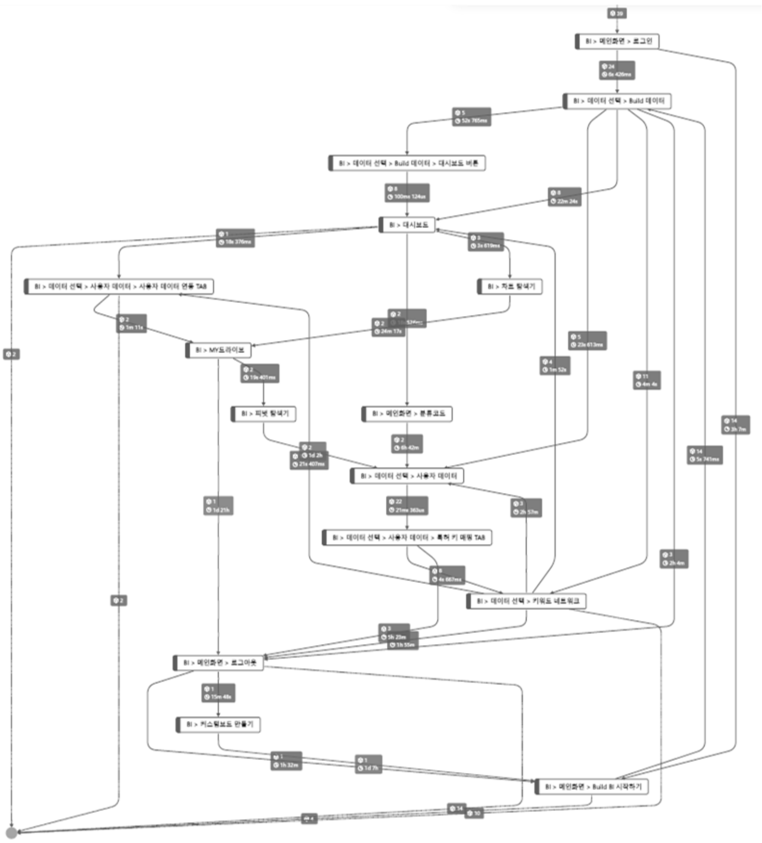

Fig. 6. 2nd collection process mining

Fig. 7 is the process mining of the log data upper group (Team 7, 5, 9, 4, 6, 11), and **Fig. 8** refers to the process mining of the log data lower group (Team 1, 2, 10, 8, 3). There are two paths to the upper group. Path 1 consists of Start → Chart Explorer → Service Introduction → Dashboard and Path 2 consists of Start → Chart Explorer → Keyword Network → Custom Board Creation → My Drive. On the other hand, the lower group goes through Start → Dashboard → Chart Explorer → Keyword Network → Service Introduction. It was found that the upper group utilized data in two pathways whereas the lower group utilized in a single pathway. Furthermore, the experience continued after the service introduction event on Path 1 of the upper group, whereas the experience ended at the service introduction event of the lower group.

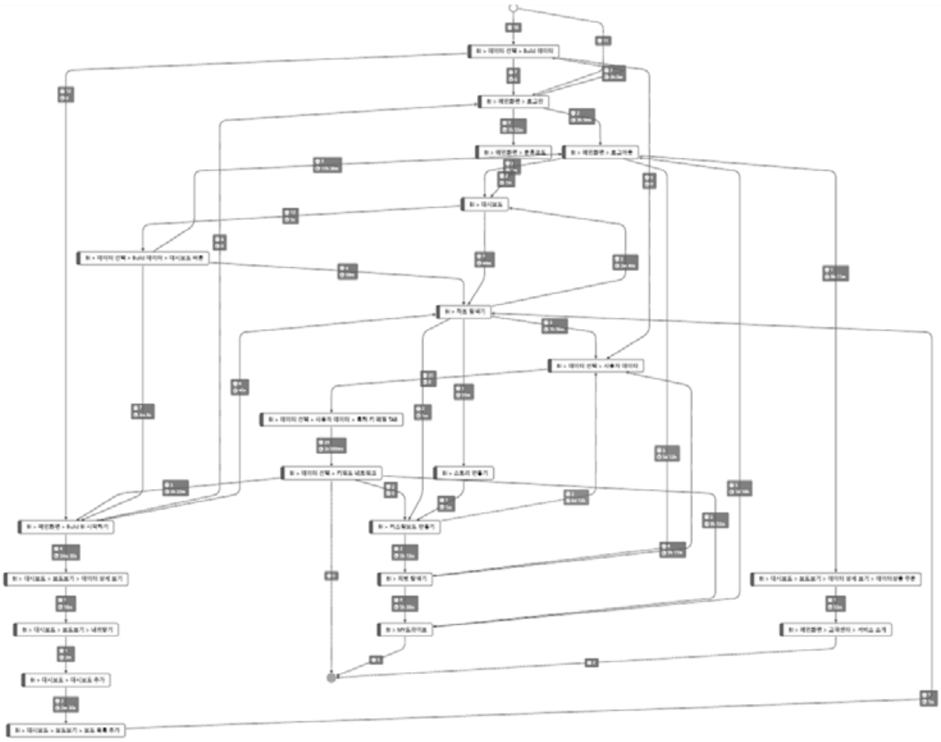

Fig. 7. Log data upper group process mining

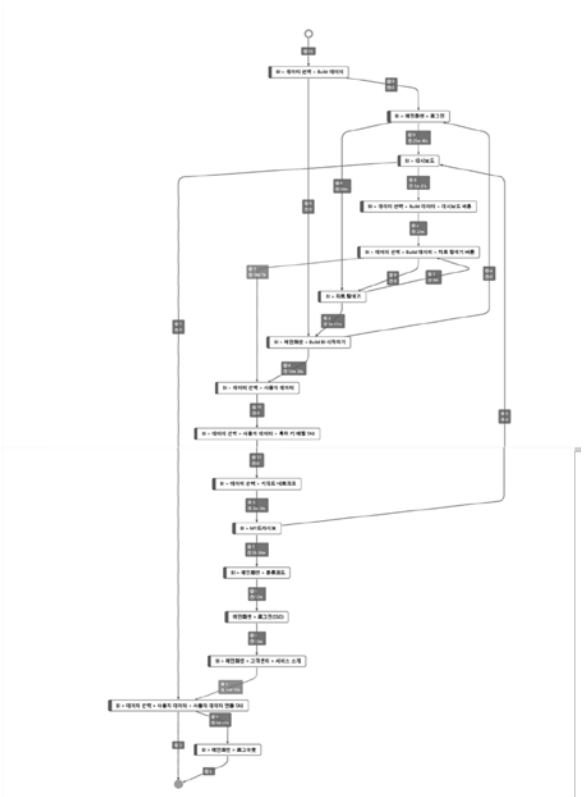

Fig. 8. Log data lower group process mining

There are two differences between the upper and the lower group. First, the paths of the upper group are more diverse than that of the lower group. In business, user and customer experience, process mining should be simplified, and the customer journey ideally consists of a single path. However, it is different in the field of education. In education, diversifying process mining paths has a positive impact on learning effects since exploration and learning processes are accompanied. Second, in the case of the upper group, event is continued after service introduction, but in the lower group, the event is terminated after the service introduction. Furthermore, the upper group stores more data in the shared BI drive than the lower group. This is the evidence that data is not simply viewed, but utilized and shared.

5. Conclusion

PBL education and service design methodology are becoming hot topics as fostering creative future talent has become a major issue due to COVID-19. However, the existing PBL and service design methodology have limitations. Due to COVID-19 in-person activities are limited and data utilization have become more significant. Overall, the data usage is essential in business, education, and talent nurturing. As the data quality improves, the competitiveness of companies and individuals increases especially with advanced data utilization.

This research study proposed Advanced Data Driven Service Design model and verified the model through the PBL project. Advanced Data has a high utilization value in PBL which is a service design methodology centered on education. There are three conclusions reached through this experiment. First, when using data in PBL education, most students used a large amount of data in the early stages. Second, the data utilization has an impact on team performance. Lastly, when looking at the data usage path through process mining, the applicability of data utilization in the service design methodology was proved. Thereby, the use of advanced data during the exploration and learning stage, which has a positive impact on education. In this research, patent data was used as Advanced Data. Future research could utilize other types of Advanced Data and a thorough Advanced Data Driven Service Design model can be proposed.

Acknowledgement

Following are results of a study on the “Convergence and Open Sharing System” Project, supported by the Ministry of Education and National Research Foundation of Korea.

References

[1] S. Hong, “Policies for nurturing innovative talents in the post-corona era,” *FUTURE HORIZON*, Vol. 47, pp. 4-22, 2020. Article(CrossRef Link)

[2] World Economic Forum, “The future of jobs: Employment, skills and workforce strategy for the fourth industrial revolution, Global Challenge Insight Report,” in *Proc. of World Economic Forum*, 2016. Article(CrossRef Link)

[3] J. Nam, “A Case Study on the Creative Convergence Project Based on Design Thinking,” *Korean Association for Learner-Centered Curriculum And Instruction*, Vol. 20, No. 5, pp. 289-303, 2020. Article(CrossRef Link)

[4] P. C. Blumenfeld, E. Soloway, R. W. Marx, J. S. Krajcik, M. Guzdial, and A. Palincsar, “Motivating Project-Based Learning: Sustaining the Doing, Supporting the Learning,” *Educational Psychologist*, Vol. 26. No. 3&4, pp. 369-398, 1991. Article(CrossRef Link)

[5] D. G. Amalia, N. Morelli, and F. Grani, "Challenges and Perspectives in Service Design Curricula: The Case of the Service Systems Design Master of Aalborg University in Copenhagen," in *Proc. of the fourth Service Design and Service Innovation Conference*, Lancaster University, United Kingdom, pp. 394-400, 2014. Article(CrossRef Link)
[6] L. Lee and M. Cho, "A Study of Double Diamond Design Process Stylized in Korean Form," *JOURNAL OF THE KOREAN SOCIETY DESIGN CULTURE*, Vol. 17, No. 2, pp. 416-428, 2011. Article(CrossRef Link)
[7] S. Kang, "A Study on Direction for Application of Big Data in Design," *JOURNAL OF THE KOREAN SOCIETY DESIGN CULTURE*, Vol. 19, No. 3, pp. 1-12, 2013. Article(CrossRef Link)
[8] B. Cha, H. Lee, S. Sim, and J. Kim, "Idea proposal of InfograaS for Visualization of Public Big-data," *Journal of Advanced Navigation Technolog*y, Vol. 18, No. 5, pp. 524-531, 2014. Article(CrossRef Link)
[9] D. Hunt, L. D. Nguyen, and M. Rodgers, *Patent Searching Tools & Techniques*, Wiley, 2012. Article(CrossRef Link)
[10] S. Jun, "A Big Data Learning for Patent Analysis," *Journal of Korean Institute of Intelligent Systems*, Vol. 23(5), pp. 406-411, 2013. Article(CrossRef Link)
[11] I. K. Oh and D. B. Lee, "A Study on the Application Methods of Big Data in the Design Field," *Journal of Digital Design*, Vol. 13, No. 4, pp. 665-674, October 2013. Article(CrossRef Link)
[12] Y. J. Jang, "Utilization of big data technology in manufacturing field," *The Journal of the Korean Institute of Communication Sciences*, Vol. 29, No. 11, pp. 30-35, October 2012. Article(CrossRef Link)
[13] S. H. Han, "The Effect of the Project-Based Learning on LIS Education: Focused on Students' Problem-Solving and Self-Directed Learning Ability," *Journal of the Korean Library and Information Science Society*, Vol. 42, No. 3, pp. 81-101, September 2008. Article(CrossRef Link)
[14] S. O. Kim and S. M. Kim, "Effects of team-based learning applying for nursing students on critical thinking ability, problem solving ability and communication ability," *Journal of the Korean Data Analysis Society*, Vol. 18, No. 2, pp. 1151-1161, April 2016. Article(CrossRef Link)
[15] Y. S. Lee, "The effects of project learning of pre-service teachers on self-directed learning ability and creative personality," *Journal of Korean Society of Earth Science Education*, Vol. 12, No. 2, pp. 141-150, August 2019. Article(CrossRef Link)
[16] M. J. Sim and H. S. Oh, "Influence of self-efficacy, learning motivation, and self-directed learning on problem solving ability in nursing students," *The Journal of the Korea Contents Association*, Vol. 12, No. 6, pp. 328-337, June 2012. Article(CrossRef Link)
[17] H. J. Kim, "The effects of project-based learning on self-efficacy for group work in LIS education: a case study," *Journal of the Korean Library and Information Science Society*, Vol. 51, No. 2, pp. 95-116, May 2017. Article(CrossRef Link)
[18] S. H. Kim, "A study on patent data quality assessment methods based on data profiling," *Korean Institute of Industrial Engineers*, pp. 2008-2011, April 2019. Article(CrossRef Link)
[19] Y. S. Kim, "A study on legal issues of public data management as records: Focused on analysis of the act on provision and use of public data," *Journal of Korean Society of Archives and Records Management*, Vol. 14, No. 1, pp. 53-73, February 2014. Article(CrossRef Link)
[20] S. H. Jun, "A Big Data Learning for Patent Analysis," *Journal of Korean Institute of Intelligent Systems*, Vol. 23, No. 5, pp. 406-411, October 2013. Article(CrossRef Link)
[21] Y. H. Tseng, C. J. Lin, and Y. I. Lin, "Text mining techniques for patent analysis," *Information Processing & Management*, Vol. 43, No. 5, pp. 1216-1247, September 2007. Article(CrossRef Link)
[22] H. M. Baek and M. S. Kim, "Technological Convergence Trend through Patent Network Analysis: Focusing on Patent Data in Korea, U.S., Europe, and Japan. Asia-Pacific," *Journal of Business Venturing and Entrepreneurship*, Vol. 8, No. 2, pp. 11-19, June 2013. Article(CrossRef Link)
[23] W. M. P. van der Aalst, H. A. Reijers, A.J. M. M. Weijters, B. F. van Dongen, A. A. De Medeiros, M. Song, and H. M. W. Verbeek, "Business process mining: An industrial application," *Information Systems*, Vol. 32, No. 5, pp. 713-732, 2007. Article(CrossRef Link)

[24] W. M. P. van der Aalst, *Process mining: data science in action*, Heidelberg, Germany: Springer, 2016. Article(CrossRef Link)
[25] J. Yoon, "PROCL : A Process Log Clustering System," *Society for e-Business Studies*, Vol.13, No. 2, pp. 181-194, 2008. Article(CrossRef Link)
[26] C. W. Günther and W. M. P. van der Aalst, "Fuzzy mining–adaptive process simplification based on multi-perspective metrics," in *Proc. of international conference on business process management*, pp. 328-343, 2007. Article(CrossRef Link)
[27] A. J. M. M. Weijters and J. T. S. Ribeiro, "Flexible heuristics miner (FHM)," in *Proc. of 2011 IEEE symposium on computational intelligence and data mining (CIDM)*, IEEE, pp. 310-317, 2011. Article(CrossRef Link)
[28] M. J. Kim, C. H. Lim, C. H. Lee, K. J. Kim, Y. S. Park, and S. H. Choi, "Approach to service design based on customer behavior data: a case study on eco-driving service design using bus drivers' behavior data," *Service Business*, Vol.12, pp. 203–227, 2018. Article(CrossRef Link)

Sangwoo Park is a M.A.Sc candidate at the Department of Service Design Convergence with the college of Engineering, Sungkyunkwan University, Suwon, Republic of Korea. His research interests include data analysis, e-learning, service design, business intelligence.

Inseop Lee is a Ph.D candidate at the Department of Service Design Convergence with the college of Engineering, Sungkyunkwan University, Suwon, Republic of Korea. His research interests include data analysis, digital content, service design, business intelligence. He is currently conducting content business research related to webtoon.

Junseok Lee received the B.A.Sc degree in the department of Mechanical Engineering from University of Toronto. He is currently a M.A.Sc candidate at the Department of Service Design Convergence with the college of Engineering, Sungkyunkwan University, Suwon, Republic of Korea. His research interests include modern business models with applied blockchain technology including but not limited to Non-fungible Tokens, Decentralized Finance and Metaverse.

Sanghun Sul received his Ph.D at the department of Mechanical Engineering from Sungkyunkwan University in 2016. He is currently an Adjunct Professor at the Department of Global Convergence at Sungkyunkwan University. His research interests include design strategy, branding, data analysis, product planning, etc.