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Interdisciplinary Approaches to Learning Informatics

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ABSTRACT[1]

This paper discusses new challenges in learning informatics from an interdisciplinary perspective. As topics of learning informatics must cover very wide ranges, this paper will provide an overview with a combination of several ideas and applications. From a methodological point of view, the challenges include the concepts of 'knowledge networks', 'learner personas', and 'visualization of the experience'. From the viewpoints of educational applications, they contain the concepts of 'class design', 'peer review' and 'case learning'. The introduction of various concepts from fields such as computer sciences, marketing research, and design thinking of soft systems domains, whose areas are far from education applications, would add new insights to learning informatics research.

Keywords: knowledge networks, persona, experience mapping, case learning.

1. INTRODUCTION

This paper discusses new interdisciplinary approaches to learning informatics in education domains. The term "informatics" is used here rather than "analytics" because it describes not only quantitative analysis but also qualitative representations for sharing information. Thus, several approaches in this paper also challenge the cross-disciplinary nature of quantitative and qualitative methods.
However, the content of such learning informatics must cover a very wide range of each domain concepts. Therefore, I would like to select only several methodological topics that present interesting research approaches with their applications. The topics include knowledge networks, personas, and experience mapping. These methodologies originate from the domains of computer sciences, marketing research, and design thinking of soft systems domains. Interdisciplinary applications in education research will also be discussed, including classroom design, peer review, and case learning.
This paper discusses knowledge networks in Section 2, personas in Section 3, and experience mapping in Section 4.

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2. KNOWLEDGE NETWORKS

Here, I would like to explain the first topic, knowledge networks. This concept is used in discrete mathematics and computer science. A knowledge network is a type of graph structure. In a knowledge network, each node represents an individual piece of knowledge. Edges represent the relationships or associations between two knowledge nodes. These relationships are not only represented visually, but the entire relationship can also be treated quantitatively. This is because individual networks have mathematically equivalent adjacency matrices and data in linked list form.
Knowledge networks have long been used in educational research. A classic and well-known example is the work by Chi, who let expert and novice students draw knowledge networks for a pair of similar but different physics problems [2]. Unlike the novice students, the expert students drew networks that correctly reflected the principles and procedures. (See **Figure 1**.) They were able to distinguish between similar but different problems. This shows that knowledge networks can be used as a tool for estimating comprehension.

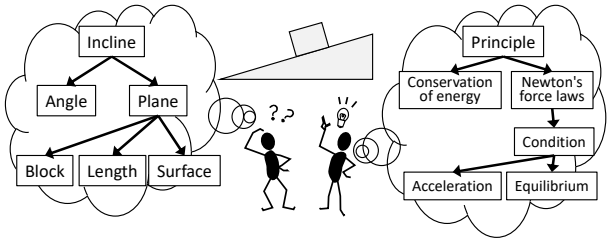

Figure 1. The difference in understanding of physics problems between experts and novices is reflected in the different knowledge networks they draw on. (Drawn by the author based on [2].)

Concept maps and Mind maps are well-known knowledge network formats used to represent understanding. Mind mapping is a visual representation of multiple ideas connected by mutual associations [1]. A mind map helps us find creative relationships between ideas. On the other hand, A concept map connects multiple concepts through precise relationships between them [17]. Compared with mind maps, concept maps represent the layered structures of concepts. (See **Figure 2**.)

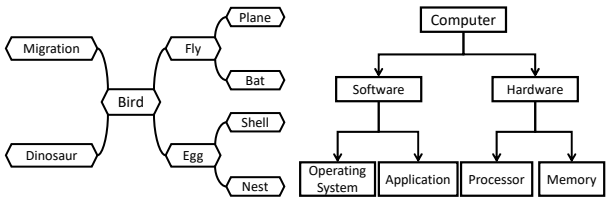

Figure 2. Mind mapping (left) creatively discovers relationships between ideas. Concept mapping (right) organizes the structure of ideas.

Both mind maps and concept maps are used as teaching aids in education and are also used to assess understanding. For instance, Hay reported that prior use of concept maps increased meaningful learning, significantly improving university teaching quality [4].

2.1 Pictogram Network for Peer Review

As an interesting application, let us introduce a study that links knowledge networks with peer review in an essay writing class. Many probably saw pictograms at Olympic games or at airports. Yoshizawa applied this pictogram-based knowledge network to peer review in an essay writing class [25].

The Pictogram Network is a network of pictograms in which each pictogram represent a topic or an idea, and each connection indicates the relationship between of the pictograms. This network visualizes the gap between the writer's ideas and the reviewer's understanding. The visualized gaps help writers recognize ambiguities in their own essays. Writers and reviewers compare their respective pictogram networks drawn for the writer's essay. After comparing the pictogram networks, the writer revises the essay. The writer and reviewer then create their pictogram networks again for the revised essay. (See **Figure 3**.)

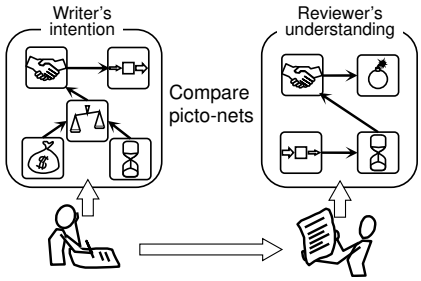

Figure 3. Comparing two pictogram networks on an essay, one written by the writer and the other drawn by the reviewer, visualizes the gap in understanding the essay. (Drawn by the author based on [25].)

Yoshizawa reported that the quantitative distance between the writer's and reviewer's networks before and after the review is reduced. The results show that the pictogram network helps learners clarify the arguments of their essays. This approach is expected to be effective for essay writing by non-native speakers. Not only that, the dual-coding theory [18] suggests that stimulating the interactions between verbal and nonverbal systems (Logogens and Imagens) in our brains contributes to overall cognitive improvement.

2.2 Knowledge Network Simulation for Class Design

Since the year 2000, there has been an outburst of research on networks. Numerous studies have been published on the generation of complex networks, various types of network centrality, and interesting dynamical processes on networks. Newman's review article was a source of inspiration for many researchers [16].

A type of complex network we call a doubly structural network is a network of networks. This network simultaneously represents a social network of connections between individuals and the knowledge network of each individual. The model can be applied to various social learning problems by implementing the interactions (such as idea exchanges) between the knowledge network and social networks [11].

Kuniyoshi used a doubly structural knowledge network model to simulate learning design in the classroom. In this model, the knowledge network represents the students' learning content, and its similarity to the teacher's teaching content is quantitatively evaluated. The social network represents the interaction between students: the process of collaborative learning among students based on their seating arrangements in the class.

Using this simulation, Kuniyoshi examined the combined effects of different teaching strategies by the teacher and the effects of classroom layout on students' collaborative learning in different educational environments. This methodology is expected to be effective not only in the design of face-to-face classrooms but also in the design of online learning systems [14][15]. (See **Figure 4**.)

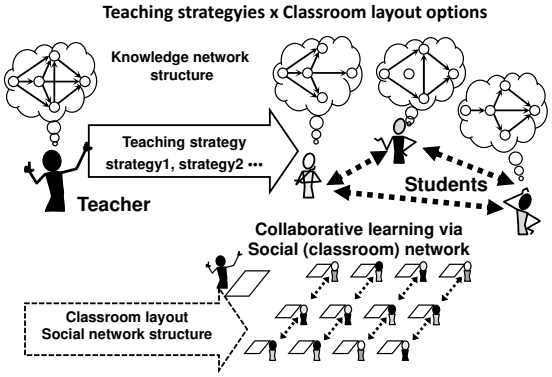

Figure 4. The learning network simulation helps to explore and evaluate combinations of teaching strategies and class layouts. (Drawn by the author based on [14].)

3. PERSONA WITH THE DESIGN OF EXPERIMENTS

Personas in service design were proposed by Cooper, a developing member of Microsoft Visual Basic. Cooper considered why software is unfriendly to users. He believed that comes from a gap in the development staff's understanding of the user. Personas were created to close such perception gaps [3].

Personas are virtual archetypes of the users that the development staff should target. A persona is given virtual but concrete attributes, preferences, and behaviors. These help align the perceptions of the design team members with the values of the specific customers to be targeted. Personas are now widely used as an important tool in human-centered design. (See **Figure 5**.)

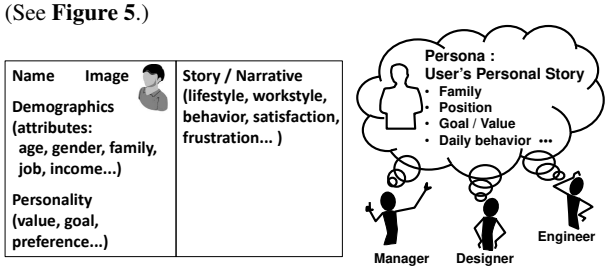

Figure 5. A persona is an archetype of a customer image that focuses the design team's perception on that embodied customer.

Persona creation is a highly qualitative process. It begins with a survey of potential users, followed by focused interviews and

the creation of persona skeletons and sketches. It is a task that depends on the creator's sense and art [19].
Here, we introduce an unorthodox persona method for education. They use semi-quantitative approaches such as the design of experiments and conjoint analysis.

3.1 Personas for Educational Goal Gap Detection

The same difficulties that Cooper experienced in software development also occur in the world of education. For example, consider the situation of educating future business leaders. When educating business leaders, the various stakeholders do not always share the same vision of what a leader should be.
Sasaki sought to identify the competencies that stakeholders expect from business leaders [20][22]. To do so, they introduced persona creation using the orthogonal design of experiments. Stakeholders were asked to evaluate a set of personas characterized by an orthogonal design. From the scores of the ratings, the importance of the leader's competencies to each stakeholder can be estimated. According to their experiments, the importance of a leader's competencies depend not only on the stakeholders but also on the firm's state. (See **Figure 6**.)

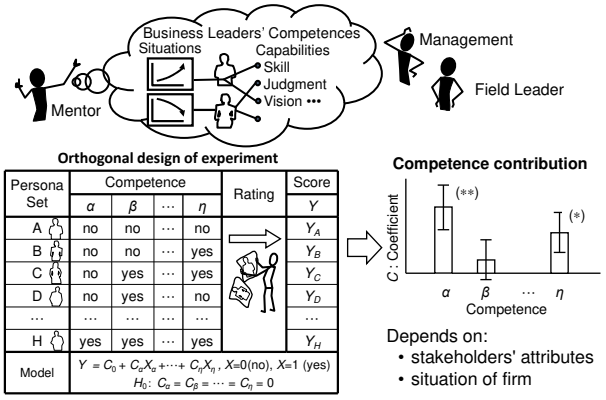

Figure 6. A set of personas generated using the orthogonal experimental design method uncovers stakeholders' perceptions. (Drawn by the author based on [20].)

3.2 Persona for the Case Learning Evaluation

Here, I would like to illustrate the application of personas to case learning. The personas helped detect differences in perceptions among stakeholders about the leaders' competencies. It should also be possible to detect changes in the perception of the identical learner before and after the case learning.

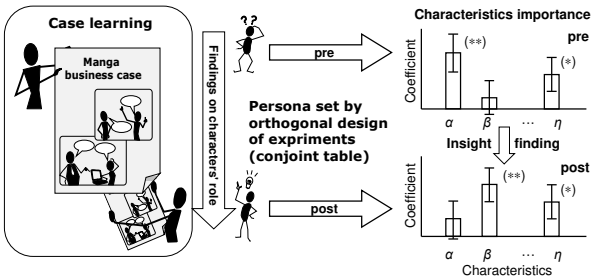

Figure 7. The difference between the results of the pre-test and post-test assessing the set of personas of the characters in the manga case learning represents a change in the learner's insights. (Drawn by the author based on [23].)

Uchida considered using personas to detect changes in learners' perceptions in business Manga-case-based education [23]. In this method, each learner rates a set of virtual personas appropriate for the manga characters in the Manga-case before and after the case learning. Between the pre-test and the post-test, the differences in their rating of the characteristics reflect the learners' insights and discoveries in the case learning. (See **Figure 7**.)
In manga-based business cases, the storyline revolves around the characters, and a lot of non-verbal information is embedded in and around the characters. Case learning also requires learners to decode such visual information [21]. Persona-based analysis, which focuses on characters, is an appropriate method for Manga-based business cases.

4. EXPERIENCE MAPPING IN EDUCATION

In this section, I would present the application of experience mapping in education. Experience mapping is a methodology for finding value in customer experience and sharing it within a service-providing organization. Various customer experience mapping approaches have been proposed. Kalbach calls them collectively an alignment diagram [6].
Among the typical alignment diagrams, customer journey maps and experience maps represent the customer experience in chronological order by stage. (See **Figure 8**.) In Howard's study, customer journey maps and experience maps were applied to the curriculum design of a graduate program. These mappings help students graduate on time through the alignment of perceptions between the students and faculty [5].

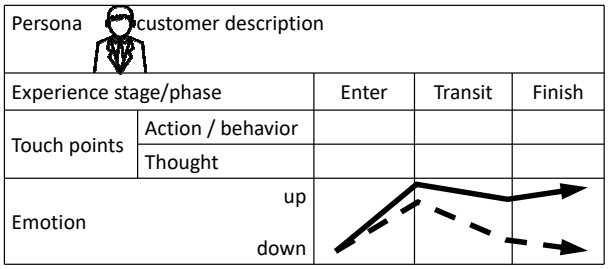

Figure 8. A customer journey map is a chronological description of the user's experiences of the service: touch points, pain points, and emotional movements.

The following subsections describe the application of experience maps in education, including their use of experience maps in case learning and the generation of simulation-based experience maps for educational purposes.

4.1 Experience Mapping for Case Learning Informatics

In the case method, learning outcomes are usually shared in the form of classroom discussions and debriefings. Recently, we have attempted to formally describe our understanding of case content [12][13]. **Figure 9** shows an example of describing a business innovation process using an experience map on the customer side and a decision description model on the company side.
There are also many case learning occasions on the business case in other classrooms separated by time and place. Using the formal description, facilitators can compare different possibilities of understanding the case with other facilitators across time and place. (See **Figure 10**.)

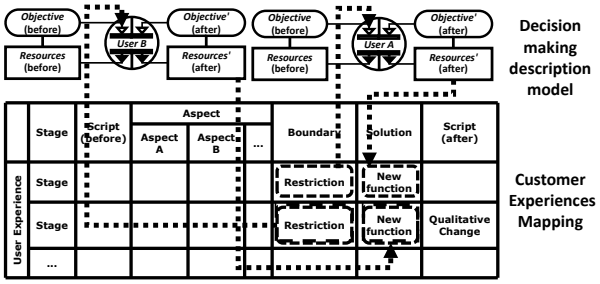

Figure 9. A type of experience map and decision model ([13][12]) can represent a series of interactions between firms and users in the business case of user-driven innovation [24].

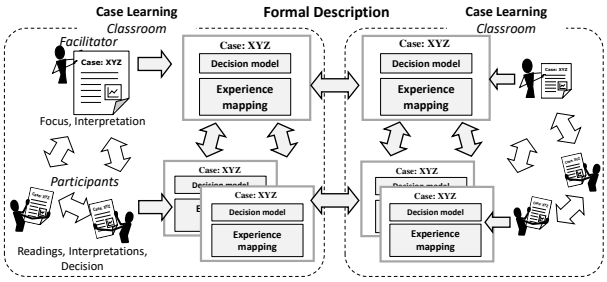

Figure 10. Formal models allow us to share information about understanding a case across other case learning classes in distant time and place.

4.2 Simulation-based Experience Map Generation

Finally, as the latest research, I will present the generation of personas and experience mappings using large-scale data and simulations. Previous attempts have been made attempts to generate individual business cases from the results of virtual organizational simulations [10]. Using large-scale survey data and a simulation on asset formation among the elderly, Kikuchi attempts to generate personas, experience mappings, and decision models for related staff education [7][8][9].

Simulations using large-scale survey data can generate personas and customer experiences based on quantitative future projections based on real-world data. This is its advantage over previous methodologies. (See **Figure 11**.)

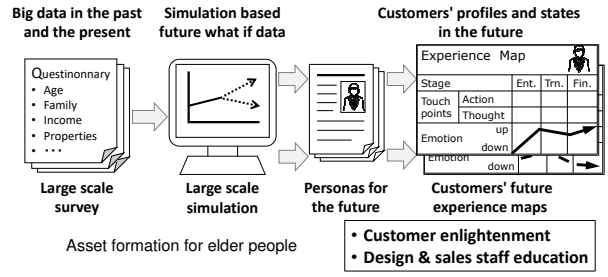

Figure 11. Simulations based on large-scale surveys provide a quantitative "what-if in the future" for persona and experience mapping.

Future assets are delayed-benefit goods with utility that can only be obtained 10 or 20 years from now, and understanding their value now is difficult not only for the customer but also for the provider. Therefore, it is important to educate and enlighten clients and sales staff on asset formation services. Simulation-based experience mapping based on reliable data is expected to contribute to such education.

5. CONCLUSIONS

In this paper, I introduced several budding interdisciplinary approaches to educational informatics in terms of knowledge networks, personas, and experience mapping. With regard to knowledge networks, I introduced a method of visual review in essay writing using pictogram networks and a simulation study of classroom design strategies to promote cooperative learning among students. On persona methods used in service design, I introduced a study to measure the perceptions of educational stakeholders and the insights of learners by combining persona methods with the design of experiments (conjoint analysis) used in marketing research. As for experience mapping, I introduced its use as a formal model for sharing learning data in the case method and the generation of experience maps for educational purposes based on large-scale simulations.

Many of these approaches are still experimental and have not yet been applied in practical education. However, the individual methods combined in these approaches have been proven in other areas. Therefore, such a trans-disciplinary combination of methodology and application is an approach worth challenging.

As a remark for the future, we add the possibility of a new generation of artificial intelligence, such as large-scale language models (LLMs). The knowledge networks introduced in this paper are strongly related to conventional artificial intelligence. On the other hand, personas and experience maps, which are methodologies involving descriptions based on natural language and human interpretation, are considered to have high applicability to LLMs. We will report on the new possibilities of using LLMs for these approaches in other papers, as they are still in progress.

6. ACKNOWLEDGMENTS

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