Course Space: The Observatory of Course Selection for Interdisciplinary Departments

Daiki Shiozawa, David F. Hoenigman, Yoshiaki Matsuzawa

HAL Id: hal-03519210
https://inria.hal.science/hal-03519210

Submitted on 10 Jan 2022

Course Space: The Observatory of Course Selection for Interdisciplinary Departments

Daiki Shiozawa[1], David F. Hoenigman[2], and Yoshiaki Matsuzawa[2]

[1] Graduate School of Social Informatics, Aoyama Gakuin University, Kanagawa, Japan
C8119009@aoyama.jp
[2] School of Social Informatics, Aoyama Gakuin University, Kanagawa, Japan
{hoenigman, matsuzawa}@si.aoyama.ac.jp

Abstract. University departments designed for interdisciplinary fields such as social informatics inevitably have curricula covering broad disciplinary areas. Such curricula generally allow students to choose from a wide variety of electives. In this research, we developed a system that visualises selected courses by applying methodologies from the network sciences. The proposed system includes functionality supporting user visualisation as follows: (1) a filter-by-grade function that filters out nodes on student network graphs; (2) a visualisation of student attributes function that shows student attributes by colouring nodes on student network graphs; and (3) a cross-filter function that filters out nodes on two connected networks (student and course networks). We conducted an empirical study involving approximately 100 students majoring in social informatics, with visualisations analysed by curriculum designers. We found that student network visualisations indicate that the student major affects course selection and that clusters form in course network graphs, clearly illustrating course selection in an interdisciplinary curriculum.

Keywords: Visualisation · Network Sciences · Interdisciplinary · Studies

1 Introduction

University departments designed for interdisciplinary fields of study such as social informatics inevitably have curricula covering broad disciplinary areas. Such curricula generally allow students to choose from a wide variety of electives. For example, the curriculum at the School of Social Informatics (SSI) at Aoyama Gakuin University comprises three major study fields: informatics; social sciences; and humanities. The SSI curriculum offers choices from among over 160 classes for approximately 200 students per grade. Students must receive at least 60 credits (i.e., 30 courses worth 2 credits each) to graduate [1] . Therefore, patterns of course selection are very diverse. However, no visualisation system has been applied to demonstrate the actual circumstances of course selection diversity. This research was an attempt to reveal the actual circumstances of course selection at the university level. The results are anticipated to support curriculum designers in curriculum development and course selection for students.

We propose the "Course Space" system for visualisation of courses in interdisciplinary departments. The system features include a visualisation scheme from the network sciences [2] and a user interface for observations by manipulating interactive operations.

Research applying methodologies from the network sciences has resulted in important discoveries in various fields. Hidalgo [3] coined the term "economic complexity" which describes the transitions of gross domestic product (GDP) in the long term by economic analysis using networks. He observed that the transitions of GDP can be described by not only economic indicators but also calculation of the complexity of each country's industries from product exchanges in international trade.

Some research in the education field has applied networks to, for example, syllabuses or bodies of knowledge. Mima [4] proposed the MIMA Search system to obtain structured knowledge, demonstrating use of the system for analysis of the curriculum at the School of Engineering, the University of Tokyo. The MIMA Search system visualises relationships by creating a network based on input words, and has been used as part of the syllabus search system for students there.

Masunaga et al. [5] and Yabuki [6] attempted to validate the formulation process of a body of knowledge (BOK). Their proposed methods were used in efforts to build structured BOKs by reverse engineering unstructured individual class materials in non-traditional, interdisciplinary fields. They successfully built a BOK tree unit in the formulation process by making semantic links between syllabuses.

An experiment by Pentland [7] demonstrated application of the network sciences to data collected on two occasions at a Massachusetts Institute of Technology conference. The data described who talked with whom, attendance, and behaviour throughout the day, and was sufficient to reveal participant affiliations (they belonged to the same institutions). Thus, behaviour was demonstrated as useful in predicting group affiliation. Specifically, Pentland found that the sum of times that two people spent together was related to whether they belonged to the same institution.

A similar concept can be applied to membership in the same social network. Social networks are networks of people who are connected through jobs or social activities. The characteristics of a social network rely on the behaviour of its members. Social networks in this research are formed by networks of students connected via course selection, or by course networks connected via students who have taken the course. Such networks are expected to reflect social aspects of the course selection, thereby revealing network clusters showing, for example, majors or laboratory activities in student networks connected by course selection.

2   Course Space

We propose the Course Space system as a support system for comparing curricula to reveal actual circumstances and for students considering which courses to choose. The system aims to visualise not only the number of students in classes forming a curriculum, but also connections between students and courses.

The system visualises course-taking patterns with metadata such as major, laboratory activities, and career after graduation. Students can find courses they might not have otherwise found by the course name or syllabus. Students can also adjust their course selections after reviewing courses they have already taken.

2.1 Design

Main view. Fig. 1 shows the main view of the Course Space system. The network on the left is a student network connected by co-occurrence of courses they have taken. The network on the right is a course network connected by co-occurrence of students taking the same course. Each network graph was drawn using a force-directed algorithm.
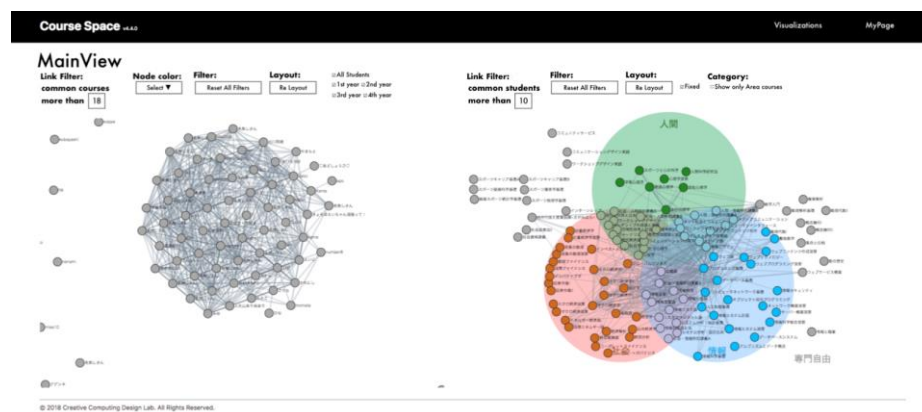

Fig. 1. Main view of the Course Space system.

Functions for analysis. We implemented the following functions for analysis:
1. Link-adjuster function
   When graph density becomes high, the system shows all links between co-occurrence nodes. The user must therefore control link density to interpret the network structure. This function hides links with values below a threshold, which users can set using a slider bar or text box.
2. Highlight connections function
   Use of this function prompts the system to highlight the links of selected nodes, thereby supporting exploration of the network structure.
3. Cross-filter function
   This function connects the student co-occurrence network and the course co-occurrence network. When users select a node in one network, the links and related nodes in the other network are highlighted. This allows users to explore the network by focusing on one student or course.

4. Student attribute visualisation function
   This function colours nodes in the student co-occurrence network according to attribute, namely student metadata such as major, laboratory, or career path after graduation. It supports visual analysis by projecting metadata on the graph.

5. School year filter function
   This function filters nodes by the school year of the students in the student co-occurrence network. This decreases differences between the number of courses taken, which increases with each school year. Users need this function for analysis of each school year because of the fewer number of courses taken by the younger school year students connected by the link-adjuster function.

2.2 Implementation

Course Space is implemented as a web application written in JavaScript with the D3.js [8] and crossfilter.js libraries. D3.js draws network graphs based on data from a database. Crossfilter.js filters the data before D3.js processing. The database server interface is a PHP: Hypertext Preprocessor (PHP)-based application programming interface that allows JavaScript to issue structured query language (SQL) database commands via POST requests.

3 Experiment

3.1 Curriculum of the School of Social Informatics

The SSI at Aoyama Gakuin University aims to develop people with broad insights who will contribute to resolving complex, real-world problems by communicating with people of various backgrounds and who can be active in interdisciplinary fields. Based on this aim, the SSI has three study areas: social sciences; informatics; and humanities.
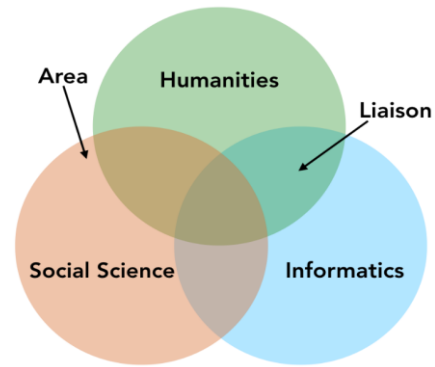
Fig. 2. Three SSI study areas.

Fig. 2 shows the SSI study areas. Circles in the figure indicate study areas. Courses within a circle are called **area courses**, such as the "Informatics Area Course". Courses in the intersection between two areas are called **liaison courses**, such as the "Social Science-Informatics Liaison Course". All students select a major programme comprising two areas, namely the **Social Science-Informatics Programme**, the **Social Science-Humanities Programme**, or the **Humanities-Informatics Programme**.

3.2   Data Collection Experiment

We conducted an experiment to collect data using the developed system. The input items are as follows:

- Elective courses students had taken, from among 168 specialty and English courses in the SSI.
- Students' personal information (optional)
    - System display name
    - Gender
    - Student year (first, second, etc.)
    - Major programme
    - Laboratory
    - Desired career after graduation
    - Decided career after graduation
    - High school course of studies: humanities or science
    - Participating in a teacher accreditation programme

We recruited fourth-year students belonging to any laboratory. All participating students were volunteers.

3.3   Data

We collected valid data from 120 students: 51 in the Social Science-Informatics Programme; 11 in the Social Science-Humanities Programme; 32 in the Humanities-Informatics Programme; and 26 who registered no programme data. We included 114 subjects in the analysis.

3.4   The Method of Analysis

Using Course Space, we analysed the following points:
1. Correlations between student attributes and courses, indicated by coloured nodes with attributes in the student co-occurrence network,
2. Relations between courses using two course co-occurrence network layouts, and
3. Each student's course selections, using a crossfilter function.

Note that the number of nodes will not be equal to the number of students or courses in the network graph due to the threshold function excluding some nodes. The next section describes this in detail.

4   Results

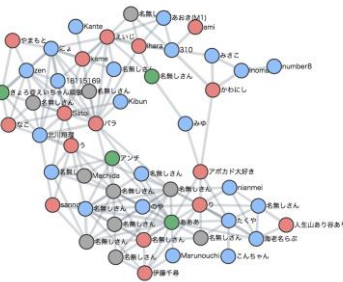### 4.1   Student Co-Occurrence Network

Major in the School of Social Informatics programme. Figure 3(a) shows links in the student co-occurrence network co-occurring with more than 23 courses, coloured according to major. Pink nodes indicate the Social Science Informatics programme, green nodes indicate the Social Science Humanities programme, blue nodes indicate the Humanities Informatics programme, and grey nodes indicate no programme data. The programme colours clearly show three clusters, indicating that the programmes influence course selection. The network shape reveals that although the programmes comprise two areas, most students select courses in one particular area. Fig.3 shows that the Social Science Informatics programme forms two clusters, one at the top formed by students mainly taking information courses, the other at the bottom formed by students mainly taking social science courses. We can verify this phenomenon by using the crossfilter function to check the selections of each node (student).
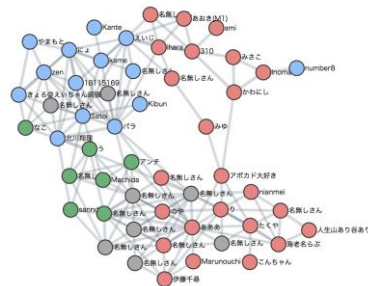
(a) Coloured according to major in the School
of Social Informatics programme.
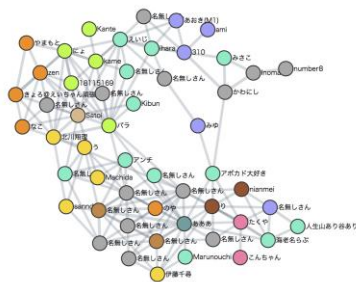
(b) Coloured according to laboratory
activities.

(c) Coloured according to high school
course of study.

Fig. 3. Student co-occurrence networks.

Furthermore, the network shape shows that nodes are dense at the circumference and sparse at the centre. We call this the "donut phenomenon", and consider it to be due to the course selection design. As mentioned above, the programmes include two areas, and students do not need to take classes from the third area. This course-selection system decreases the number of third-area courses that students take, so the link adjuster function disables co-occurring links with third-area nodes, because their number is below the threshold.

Laboratory. Fig. 3(b) shows a student co-occurrence network in which links co-occur with more than 23 courses, coloured according to laboratory activity. Colours in the network indicate laboratory affiliation. Although the laboratory clusters are less clear than the SSI major clusters, they are observable, and we confirm the features of each laboratory. Figures for each laboratory can be analysed to indicate the research field of each laboratory. For example, the blue-green nodes representing Laboratory M are scattered throughout the graph, indicating that that laboratory emphasises diversity in course selection.

High school course of study. Figure 3(c) shows a student co-occurrence network in which links co-occur with more than 23 courses and node colours indicate high school course of study. Pink nodes indicate humanities, blue nodes indicate sciences, green nodes indicate others, and grey nodes indicate no data. Coloured nodes are randomly distributed in this network, indicating that course selection is unaffected by students' high school course of study.

4.2   Course Co-Occurrence Networks

Fixed layout. Fig. 4(a) shows a course co-occurrence network with a fixed layout in which links co-occur with more than 20 students. This network indicates courses that tend to be taken simultaneously. For example, "Database Basics" and "Programming Basics" in the informatics area and "Microeconomics I" and "Macroeconomics I" in the social science area tend to be taken at the same time. In contrast, "Introduction to Mathematics" links with courses in each area, such as "Programming Basics", "Cultural Humanities" or "Macroeconomics I". It can therefore be considered as a basic course.

Force layout. Fig. 4(b) shows a course co-occurrence network with a forced layout and links co-occurring for more than 10 students. Dark blue nodes indicate the informatics area, brown nodes indicate the social sciences area, dark green nodes indicate the humanities area, light blue nodes indicate the humanities-informatics liaison area, purple nodes indicate the social sciences-informatics liaison area, and light green nodes indicate the social sciences-humanities liaison area. This network indicates that students take courses following the aim of their study area's curriculum, because liaison course nodes fall between area course nodes.
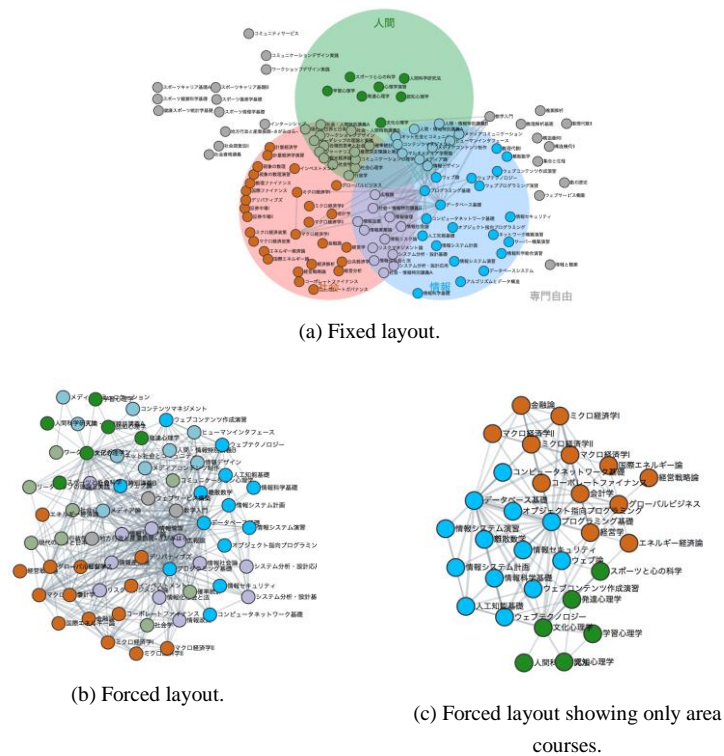
(a) Fixed layout.

(b) Forced layout.

(c) Forced layout showing only area courses.

Fig. 4. Course co-occurrence networks.

Figure 4(c) shows a course co-occurrence network showing only area courses with a forced layout in which links co-occur for more than 10 students. Blue nodes indicate the informatics area, brown nodes indicate the social sciences area, and green nodes indicate the humanities area. This network shows clusters for each area because students seem to take courses in the same area.

5   Evaluations

5.1   Student Evaluations

In trials, students used the main view of the proposed system. We conducted a questionnaire survey after the trial, asking if the system offered useful information for course selection, along with any comments or suggestions for improvement. Table 1 shows excerpts of the answers we received.

Response S1 mentions bias in their course selections, and response S2 suggests that visualising courses taken provided useful information for future course selections. The proposed system could thus support course selection decisions.

Table 1. Excerpts from student comments.

ID	Comment
S1	Viewing the data, I could clearly see bias in my course selections and <u>which areas I didn't realize I was interested in</u>.
S2	I thought my course selections might have some bias, but I didn't realize how biased I had been. It is interesting to see <u>which courses I should take to maintain balance or specialize in my major</u> by visualizing the courses I've taken just by selecting them.

5.2 Faculty Evaluations

We showed course selections as visualised by the proposed Course Space system to five SSI curriculum design committee members and discussed the results. Table 2 shows some remarks made during that discussion.

Table 2. Excerpts from comments from curriculum committee faculty.

ID	Comment
T1	I expected the node density to be gathered <u>closer to the center</u>. I thought my laboratory has only students with scattered course selections, but in fact only students with biased course selections are in the SSI. I don't think this is a good situation.
T2	<u>Some students are somewhat in the middle of the Informatics-Humanities or Social Sciences-Informatics areas</u>. I don't know whether the faculty aims for this, but I think it is good, curriculum-wise. I don't know if I should think of this number of students who are in the middle as a lot or a little, but it's better than if nobody chooses courses that cross study areas.

Comment T1 suggests that fewer students than expected select courses from across all three study areas. Comment T2 shows that faculty think highly of students taking a balance of courses in two study areas because the aim of the SSI is for students to not take courses from all three areas. These comments confirmed that from this viewpoint, the goals of the current curriculum are being met. The results of the discussion confirmed that the proposed system is useful for curriculum evaluation, which is one of its aims.

6 Discussion

We propose Course Space for visualising course selections by applying methodologies from the network sciences. We demonstrated the system using data collected from 114 subjects in an interdisciplinary department. The generated network structures provided clear evidence that students select courses based on their majors, supporting what department faculty members already feel. However, the visualisations in this research confirmed such feelings and revealed the extent to which this phenomenon holds - information that can be used for curriculum development.

The system could interactively change network link thresholds for analysing student attributes or course selections in the network visualisations. It allowed exploratory observation by functions allowing users to change node positions by drag and drop or to switch the network layout algorithm. These processes demonstrated the usefulness of the system as an interactive application.

Course co-occurrence networks showed courses taken simultaneously and that course selections reflect the curriculum for interdisciplinary learning. We also found that student majors could be predicted from the network structure.

We thus consider that faculty will be able to formulate curricula based on data visualised in systems like Course Space. We reported the results of this research to the curriculum development committee at the SSI. Such information is necessary for school development, not only at the SSI, but also at other schools focusing on interdisciplinary studies, to observe and understand student course selections.

By having students register their data, they could view Course Space as part of the trial, allowing them to find biases and subconscious interests in their course selections. We believe such discoveries will help students choose courses in the future.

One limitation of this research is the small amount of student attribute data we collected, and therefore few student attributes with biases were shown. However, this does not affect bias effects because new findings are based on the network architecture. Further development of the system and detailed analyses are required in future studies.

References

1. Class Handbook 2015: School of social informatics of Aoyama Gakuin University, https://www.aoyama.ac.jp/wp-content/uploads/2018/02/ssi_2015.pdf, last accessed 30/1/2019.
2. Newman, M.: Networks: An Introduction. Oxford University Press, Oxford (2010).
3. Cesar, H., Chiba, T.: Why Information grows: The Evaluation of Order from Atoms to Economics. Hayakawa Publishing, Tokyo, Japan (2017).
4. Mima, H.: MIMA search: a structuring knowledge system towards innovation for engineering education. In: Proceedings of the COLING/ACL 2006 Interactive Presentation Sessions, pp. 21–24. ACL, Stroudsburg, PA (2006).
5. Masunaga, Y., Ishida, H., Ito, K., Ito, M., Shimizu, Y., Shoji, Y., Takahashi, T., Chiba, M., Nagata, H., Fukuda, T., Muramasa, T., Morita, T., Yabuki, T.: Experiment of formulation of Social Informatics Body of Knowledge using WikiBOK. In: The 5th Forum on Data Engineering and Information Management, C3-5. (2013).
6. Yabuki, T., Morita, T., Masunaga, Y.: Formulation and verification of the body of knowledge of new discipline using WikiBOK. In: Proceedings of the 9th International Conference on Ubiquitous Information Management and Communication, pp. 1–8. ACM, New York, NY (2015).
7. Pentland, A., Shibata, H.: Honest Signal: How they shape our world. Misuzu Shobo, Topkyo, Japan (2013).

12

8. Bostock, M., Ogievetsky, V., Heer, J.: D3 data-driven documents. IEEE Transactions on Visualization and Computer Graphics 17(12), 2301–2309 (2011).